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# Information Technology and the Firms' Organizational Scope and Structure

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# Information Technology and Firms' Organizational Scope and Structure

by

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**Information Technology and Firms' Business Scope and Organizational Structure**

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The dissertation consists of three essays that explore the relationship between information technology and firms' organizational and governance structure. The first essay examines how information technology (IT) moderates the impact of firms' assets on the level of vertical integration and horizontal diversification. The empirical analysis suggests that IT is associated with a decrease in vertical integration in firms with more tangible assets. The analysis also indicates that IT is associated with a greater increase in horizontal diversification in firms with more intangible assets. The general implication of this essay is that firms with more tangible assets may use IT to become more vertically specialized, whereas firms with more intangible assets may deploy IT to become more horizontally diversified.

The second essay uses a moral hazard model to examine the relationship between environmental uncertainty and decentralization in IT governance. It is shown that this relationship is determined by a trade-off between the need for processing local

information and the moral hazard problem. The trade-off results in an inverted-U-shaped relationship between environmental uncertainty and decentralization in IT governance. The increase in environmental uncertainty first increases and then decreases the likelihood of adopting decentralized IT governance, and thus decentralized IT governance is not likely to be desirable when the external environment is either highly stable or highly turbulent. An empirical study using a sample of 455 business sites of Fortune 1000 companies validates the theoretical results.

The third essay presents an analytical model to examine the design and management of partner relationships in IT service. The firm hires a manager to manage the partner relationship. However, the firm has to decide whether to delegate the design of the relational contract with the partner, to the manager. We find that when the firm and the manager have asymmetric information about the manager's inclination to maintain a long-term partner relationship for the firm, delegation in relational contracting can help the firm in screening the myopic manager from the farsighted manager.

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# Chapter 1: Introduction

It is well recognized in the Information Systems (IS) literature that the use of information technology (IT) influence firms' vertical and horizontal scope. Vertical scope refers to how many different activities along a firm's value chain are performed by the firm itself. The horizontal scope refers to how many different product markets a firm participates in. The literature in IS notes that as IT can reduce coordination costs in the value chain, IT may decrease the level of vertical integration and increase the level of horizontal diversification.

Strategy literature suggests that a firm's business scope is influenced by the different types of assets it possesses. Transaction cost theory argues that firms with more tangible assets (e.g., machine, plant, property, etc) tend to be more vertically integrated as vertical integration decreases transaction costs. On the other hand, resource-based view suggests that firms with more intangible assets (e.g., brand, technological capability, managerial knowledge, etc.) tend to be more horizontal diversified as firms can deploy their intangible assets across different product markets. However, how IT and firms' assets interact to affect firm scope has not yet been studied. In Chapter 1, we study how the interaction between IT and different assets influences firm scope and performance.

The study in Chapter 1 analyzes a panel dataset containing 745 unique Fortune 1000 companies, over a four-year period from 2001 to 2004. The empirical analysis suggests that IT has a moderating effect on tangible assets in decreasing the level of vertical integration, and a moderating effect on certain intangible assets in increasing the level of horizontal diversification. In other words, in the presence of more IT, tangible assets are associated with a greater decrease in vertical integration. However, in the presence of more IT, intangible assets such as brand name and managerial know-how are associated with a greater increase in horizontal diversification. The empirical analysis also suggests that for less vertically integrated firms, IT increases the performance contribution of tangible assets. The rationale is that firms can use IT to coordinate their activities in less vertically integrated structures, where they deploy their tangible assets to specialize in selected activities and achieve economies of scale. Similarly, the analysis indicates that for more diversified firms, IT may increase the performance contribution of intangible assets. The explanation here is that IT enables firms to leverage their intangible assets across different product markets and generate more value through economies of scope.

The use of IT impacts firms' business scope. However, managing IT in organizations is a challenge. In Chapter 2, we study IT governance. IT governance refers to the organizational pattern of decision-making for IT-related activities, such as the management of IT infrastructure, IT principles, application development, service delivery, and IT investment. A major focus of IS research on IT governance concerns with whether the decision authority regarding key IT-related activities should be delegated to business units or should they be centrally controlled by a corporate IT unit.

A major driver of decentralization in IT governance is environmental uncertainty. Past research has hypothesized a positive relationship between environmental uncertainty and decentralization in IT governance. However, empirical evidence is inclusive. The reason for these mixed empirical results, we argue, is that prior studies examining the relationship between environmental uncertainty and decentralization in IT governance overlook the potential moral hazard in managers' discretionary investments. Drawing upon the agency theory to reflect model hazard in IT governance, we build a principal-agent model to illustrate two conflicting forces caused by environmental uncertainty. First, the model captures how environmental uncertainty drives the firm (the principal) to delegate IT decision rights to business units (the agent) in order to leverage business units' information advantage. Second, the model captures how environmental uncertainty may amplify the agency cost associated with delegation of authority (where the manager may overinvest in IT). Considering these two forces, the model reveals that the relationship between environmental uncertainty and decentralization in IT governance is an inverted-U relationship. In either highly stable or highly uncertain environments, organizations tend to adopt more centralized IT governance.

To test the implication of the analytical model, we conduct an empirical investigation to study the existence of an inverted-U-shaped relationship between environmental uncertainty and the adoption of decentralization in IT governance. We analyze a panel dataset that captures the IT purchasing decisions at 455 divisional sites of Fortune 1000 companies from year 2001 to 2005. The empirical analysis examines the probability that these sites adopt decentralized decision-making in IT purchasing. We find that sites in highly stable or highly uncertain business environments are more likely to adopt centralized decision-making in IT purchasing. Decentralized decision-making in IT purchasing is more likely to be adopted for sites in the business environments with intermediate uncertainty.

In the contemporary business environment firms are increasingly using alliance partners to identify unexpected customer demand, develop new products, and customize and implement the firm's products. For example, major enterprise software vendors like Oracle-Siebel rely on hundreds of consulting partners to handle software implementation and related customer service tasks. In order to achieve effective partner relationship management, firms often assign dedicated relationship managers to manage different partner relationships. For example, Oracle-Siebel assigns either a Sponsor or a dedicated Alliance Manager to manage each partner relationship.

The reliance on middle managers for partner relationship management causes an agency problem. In many cases, senior managers design and negotiate the relational agreements with potential partners (relationship building) and let middle-level managers maintain the relational agreements in the day-to-day interactions (relationship management). Therefore, the firm often faces challenges in internal coordination. For instance, how should the firm align the relationship managers' incentives with the firm's long-term interests in managing the relationship with the partner? Also, how should the firm align relationship building with relationship management?

In Chapter 4, we present an analytical model to examine two issues. First, how should the firm design the relationship manager's compensation scheme to align the manager's incentives in partner relationship management with the firm's? Second, when the manager may be myopic about maintaining long-term partner relationships for the firm, should the firm delegate the right to build partner relationships to the manager?

We find that the firm can benefit by adopting a policy of contingent delegation, i.e., the firm delegates the relational contracting to the manager conditional on the manager self-selecting the compensation contract developed for the farsighted manager. We show that this approach benefits the firm in two ways. First, contingent delegation helps the firm in screening the myopic manager from the farsighted manager. In this way contingent delegation reduces the cost for the firm to elicit the manager's private information. Second, when the manager can also exert his own effort in contributing to firm's performance, we find that contingent delegation may help the firm in increasing the effort incentive for the farsighted manager. In this sense, delegation can also be justified from the perspective of incentive management.

# Chapter 2: Asset Characteristics and the Impact of IT on Firm Scope and Performance

## 2.1 Introduction

The choice of firms' vertical and horizontal scope is one of the most critical executive decisions. Thus, it is not surprising that there is a long stream of research on vertical integration and horizontal diversification (e.g., Poppo and Zenger 1998; Ramanujam and Varadrajan 1989; Wernerfelt 1984; Williamson 1975). This body of research explores how resource characteristics (e.g., resource specificity and relatedness) affect firm boundaries. Similarly, scholars studying the implications of information technology (IT) examine how the impact of IT on internal and external coordination cost affects firm scope (e.g., Clemons, et al. 1993; Clemons and Row 1992; Gurbaxani and Whang 1991; Malone, et al. 1987). In this research we investigate how the characteristics of firms' assets and IT interact to influence firm scope and performance.

The Strategy literature on vertical integration follows a variety of theoretical traditions including transaction cost economics, agency theory, and property rights theory, though transaction cost economics is probably the dominant perspective (e.g., Mahoney 1992; Poppo and Zenger 1998). Research in vertical integration suggests that transaction specific investments are associated with an increase in vertical integration (e.g., Dyer 1996; Leiblein and Miller 2003; Geysken, et al. 2006). Research also indicates that behavioral uncertainty (sometimes referred to as measurement uncertainty, see Leiblein and Miller 2003; Poppo and Zenger 1998) is associated with an increase in vertical integration (e.g., Anderson 1985; John and Weitz 1988), whereas technological uncertainty is associated with a decrease in vertical integration (e.g., Afuah 2001; Balakrishnan and Wernerfelt 1986; Harrigan 1986). Further, when vertical integration allows firms to leverage market power and increase revenue and capture value-add and margin, firms are likely to increase their level of vertical integration (Harrigan 1985).

Parallel to the work in the Strategy literature, the literature in Information Systems has also examined how IT may affect the level of vertical integration. This literature notes that as IT can reduce coordination costs in the value chain, IT may affect the level of vertical integration (Clemons, et al. 1993; Clemons and Row 1992; Gurbaxani and Whang 1991; Malone, et. al. 1987). Specialists generally have lower production costs due to economies of scale (Coase 1937; Williamson 1975). However, the coordination cost associated with a market exchange (sometimes referred to as external coordination cost) is usually higher than the cost of coordinating an exchange inside the firm (i.e., the internal coordination cost). Since IT can reduce coordination costs, researchers have argued that IT may lead to an overall shift towards more use of markets, as firms strive to take advantage of the scale and specialization of specialists (Brews and Tucci 2004; Brynjolfsson, et al. 1994; Gurbaxani and Whang 1991; Malone, et. al. 1987). Thus, IT may lead to a decline in the level of vertical integration. Brynjolfsson et al. (1994), for example, show that IT is associated with a decrease in firm size. Similarly, Brews and Tucci (2004), Dewan, et al. (1998), and Hitt (1999) provide evidence that IT is associated with a decrease in vertical integration.

Just like the literature in vertical integration, research in corporate diversification also follows a variety of theoretical approaches, though the resource-based view is probably the predominant one (Barney 1991; Mahoney and Pandian 1992; Peteraf 1993;

Wernerfelt 1984). The substantial body of research in corporate diversification, in spite of some inconsistent findings, largely suggests that valuable, rare, and inimitable resources are associated with superior performance in diversified firms. In other words, use of firm-specific resources to diversify across related businesses leads to improved performance (e.g., Farjoun 1994; Markides and Willaimson 1994; Tanriverdi and Venkatraman 2005). On the other hand, unrelated diversification is found to be associated with a discount (e.g., Berger and Ofek 1995; Lang and Stulz 1994), due to the agency costs involved in monitoring and coordinating unrelated businesses (Fulghieri and Hodrick 2006).

In the context of corporate diversification, scholars studying the implications of IT suggest that IT may be associated with an increase in horizontal scope as firms can use IT to coordinate across different product markets (e.g., Afuah 2003; Gurbaxani and Whang 1991). Hitt (1999), for example, provides evidence that IT is associated with an increase in diversification. Also, Dewan et al. (1998) find that firms use IT to coordinate across related businesses, i.e., firms that are diversified across related businesses use more IT than firms diversifying across unrelated product markets. Dewan et al. (1998)'s findings are consistent with Hill and Hoskisson (1987) and Hill et al. (1992)'s argument that related diversification requires more information processing than unrelated diversification.

The above discussion suggests that scholars have examined how asset characteristics such as asset specificity and asset relatedness affect firms' vertical and horizontal scope. Prior research has also investigated how IT-enabled reduction in coordination cost influences firm boundaries. However, there is little research that explicates how IT and firms' assets interact to impact the level of vertical integration and horizontal diversification. Thus, in this research we investigate how IT moderates the impact of different types of assets on firms' vertical and horizontal scope. Further, this research explores the implications of the interrelationships among asset characteristics, firm scope and IT, for firm performance.

A firm's assets can be classified as (i) tangible and (ii) intangible assets. The collection of raw materials, physical resources, and plant & equipment, comprise the tangible assets of a firm (Farjoun 1998). Intangible assets, on the other hand, include human capital (the skill, expertise, and insights of the workforce), organizational capital (e.g., organizational culture, norms, and routines), technological capital (patents, trademarks, innovation capability), and relational capital (reputation, brand name, relationships with customers and suppliers) (Fernandez, et al. 2000; Hall 1993; Pehrsson 2006).

This paper analyzes a panel dataset containing 745 unique Fortune 1000 companies, over a four-year period from 2001 to 2004. The empirical analysis suggests that IT has a moderating effect on tangible assets in decreasing the level of vertical integration, and a moderating effect on certain intangible assets in increasing the level of horizontal diversification. In other words, in the presence of more IT, tangible assets are associated with a decrease in vertical integration. However, in the presence of more IT, intangible assets such as brand name and managerial know-how are associated with a greater increase in horizontal diversification. The rationale is that tangible assets are firm- as well as usage-specific (Chatterjee and Wernerfelt 1991). Therefore, firms employ their tangible assets to specialize in a limited number of activities, and use IT to coordinate with external suppliers for the other activities in their value chain. In contrast to tangible assets, intangible assets such as customer base and brand name, though firm-specific, have multiple uses. Ghemawat and del Sol (1998) refer to such assets as being firm-specific but usage-flexible. Firms use IT to leverage their firm-specific but usage-flexible intangible assets across different product markets, thereby increasing their horizontal scope.

The empirical analysis also suggests that for less vertically integrated firms, IT increases the performance contribution of tangible assets. The rationale is that firms can use IT to coordinate their activities in less vertically integrated structures, where they deploy their tangible assets to specialize in selected activities and achieve economies of scale. Similarly, the analysis indicates that for more diversified firms, IT may increase the performance contribution of intangible assets. The explanation here is that IT enables firms to leverage their intangible assets across different product markets and generate more value through economies of scope.

At the theoretical level, this research explores common ground between transaction cost economics and the resource-based view of the firm (e.g., Madhok 2002). The transaction cost economics literature emphasizes the higher transaction costs associated with specialized assets and predicts higher levels of vertical integration in such circumstances. However, many researchers have argued that firms perform activities internally, not for transaction cost considerations, but because specialized assets provide a competitive advantage in production (e.g., Conner 1991; Ghosal and Moran 1996; Kogut and Zander 1996; Madhok 2002; Teece, et al. 1997). Thus, a key implication of transaction-specific assets is the advantage of specialization that they can provide. This implication of specialized assets is similar to the importance placed on firm-specific resources and capabilities in the resource-based view, to provide a competitive advantage. In this regard, this research explores how IT can enable firms to realize economics of specialization from their firm- and usage-specific tangible assets, and how IT can enable firms to realize economy of scope from their firm-specific but usage flexible intangible assets. The managerial implication of this research is that firms with more tangible assets may use IT to specialize vertically; whereas firms with more intangible assets may use IT to diversify into different product markets.

## 2.2 Hypotheses Development

### 2.2.1 Tangible Assets, Information Technology (IT), and Vertical Integration

Firms possess a combination of tangible and intangible assets. If a firm's key assets are specialized physical plant and machinery, the firm may use these tangible assets to produce one or more products. The firm- and usage-specific nature of these assets implies that firms have distinctive advantage when they focus on few activities and specialize to produce a narrow range of outputs. This is an issue about resource flexibility, i.e., how many different uses a firm-specific resource can be put to (Ghemawat and Sol 1998). The argument here is that tangible assets are less flexible and, therefore, are useful in a narrower range of industries. Chatterjee (1986), for example, found no evidence of manufacturing synergies in a collection of diversified firms. Farjoun (1998) also suggests that physical resources are usually more product-specific than other resources, and such resources are limited in the range of industries to which they can be applied to. Additionally, there are physical limits, such as capacity constraints, to reusing tangible resources (Chatterjee and Wernerfelt 1991).

Firms with tangible assets have the choice of coordinating more activities in vertically integrated organizations, or specializing in a narrow range of activities and coordinating more with external suppliers. Since inter-organizational information systems such as electronic data interchange (EDI) systems and Business-to-Business (B2B) electronic exchanges can be deployed to search for and coordinate with external suppliers, firms with tangible assets may focus on the activities supported by their specialized asset, and use IT to coordinate with external specialists for other activities (Afuah 2003; Brews and Tucci 2004; Malone et al. 1987). This is the impact of reduced external coordination costs. Thus, IT may interact with tangible assets to decrease the level of vertical integration. Zenger and Hesterly (1997) refer to this as the infusion of hierarchical elements such as monitoring and rich communication, into markets. In this way, IT may enable firms to receive the benefit of rich collaboration and tight coordination found within firms, and at the same time access the scale and specialization advantage of market suppliers. Afuah (2003) examines external coordination from the perspective of suppliers and suggests that IT can reduce the cost of asset specificity and make market exchanges more profitable. The logic here is that firms can invest in firm- and usage-specific tangible assets as IT can enable them to find more customers for their output. This is the impact of reduced external coordination cost from the point of view of suppliers.

In addition to the inter-organizational information systems that reduce external coordination costs and may lead to a decrease in vertical integration, intra-organizational information systems may reduce internal coordination costs in a way that also facilitates vertical specialization. Jacobides and Billinger (2006) and Billinger and Jacobides (2006) argue that architectural information systems such as enterprise resource planning (ERP) systems and supply chain management (SCM) systems that enable modularity and re-configurability of the value chain may facilitate vertical specialization. The rationale here is that architectural information systems provide information for calculating the transfer price for conducting an activity and thus allow a firm to benchmark internal units against market suppliers. Thus architectural information systems can help to decide if a firm should perform an activity internally or use an external specialist. Architectural information systems also provide information about capacity utilization so that the firm can decide if it has excess capacity and can offer its services to external customers. In this way, architectural information systems enable a permeable vertical architecture that allows matching of firms' capabilities and capacities with market needs (Jacobides and Billinger 2006). Organizations with firm- and usage-specific tangible assets, thus, may focus on the key activities enabled by their asset and use IT to find and coordinate with internal and external customers. The general implication here is that IT may enable firms to realize the production efficiencies associated with their firm- and usage-specific tangible assets to specialize vertically, instead of the asset specificity leading to an increase in vertical integration due to an increase in transaction costs.[1]

[1] Madhok (2002) argues that Williamson's focus on transaction costs resulted in a subsequent under-emphasis on production costs. Coase (1990) also suggests that "the dominant factor determining the institutional structure of production will in general no longer be transaction cost but the relative costs of different firms in organizing particular activities."

As an illustration, in the electronics manufacturing industry firms like Cisco specialize on design and coordinate manufacturing with contract manufacturers like Solectron (Lee and Hoyt 2001). Solectron uses capital intensive surface mount technology (SMT) to build printed circuit board (PCB) assemblies. In this case a web-enabled extranet allows coordination between Solectron and its customers like Cisco. This organization of the value chain is beneficial for Cisco as well as for Solectron. On one hand, it allows Cisco to specialize on design and outsource manufacturing to a specialist like Solectron. On the other hand, this organization of the value chain enables Solectron to use the extranet to find and coordinate with more number of customers that justifies the capital investment in the surface mount technology.

In summary, for organizations with firm- and usage-specific tangible assets, IT may facilitate vertical specialization in two different ways. First, IT may enable firms to concentrate on key activities supported by their tangible assets and coordinate with external specialists for other activities. This is the impact of IT (e.g., Electronic Data Interchange systems, Business-to-Business electronic exchanges) on external coordination costs. Second, architectural information systems (e.g., Enterprise Resource Planning systems) may enable vertical specialization by facilitating modularity and re-configurability to match productive capacity with market demand. The above discussion leads to the following hypothesis.

*Hypothesis 1: In firms with more IT, tangible assets are likely to be associated with a decrease in vertical integration.*

### 2.2.2 Intangible Assets, Information Technology (IT), and Diversification

In contrast to tangible assets, intangible assets are more flexible. Ghemawat and del Sol (1998) refer to intangible assets such as brand name and technological capabilities as being firm-specific but usage flexible. Such intangible resources can be more easily leveraged across different businesses. Thus, intangible assets such as brand name and technological capabilities form the basis for diversification (e.g., Delios and Beamish 2001; Lu and Beamish 2004). This is consistent with the resource-based argument that corporations may use firm-specific resources to diversify across different product markets (e.g., Barney 1991; Mahoney and Pandian 1992; Markides and Willaimson 1994; Peteraf 1993; Wernerfelt 1984). Farjoun (1994), for instance, examines human skills and expertise and suggests that human resource similarity can serve as a basis for diversification. Also, a distinctive characteristic of intangible assets, in comparison to tangible assets, is that they do not depreciate when employed in different markets (Lu and Beamish 2004). Chatterjee and Wernerfelt (1991), for example, suggest that intangible assets have softer capacity constraints. Thus, intangible resources can be used repeatedly with little cost or depreciation of the original resource. Moreover, an individual's skills and insights are also distinguished from tangible resources by the individual's ability to learn and transfer knowledge from one domain to many others and to combine them in increasingly productive ways (Farjoun 1998). Thus, intangible assets such as knowledge and expertise can in fact grow with use, recombination and sharing (Kogut and Zander 1992; Nahapiet and Ghoshal 1998).

In the contexts where key assets are firm-specific but usage-flexible intangible assets such as information and knowledge about products, technologies, or customers, firms can use IT to leverage these assets across different product markets. For example, in banking, finance, and insurance industries, a firm's key assets are the knowledge of, and relationships with, its customers (Nagar and Rajan 2005). A firm can use IT to leverage the knowledge about customers stored in its data warehouses to cross sell and up sell a variety of financial services to these customers (Nagar and Rajan 2005). The role of IT here is to provide a platform for the firm to leverage its assets across different product markets.

As an illustration, the customer base and the consumer brand equity are the key assets of Amazon.com. Using its electronic commerce technology platform, Amazon.com is able to diversify from book retailing to financial services (Leschly, et al. 2003). Similarly, by using the telecommunication infrastructure associated with OnStar, General Motors is able to leverage its brand and customer base to offer a variety of safety and concierge services to its customers (Koudal, et al 2004). In the same way, IT allows USA Today to leverage the news-gathering and reporting capabilities of its journalists across the print, online, and broadcast (video) media to reach new consumers and new markets (Tushman, et al. 2005). Thus, an IT infrastructure can enable firms to leverage their intangible assets and sell different products to their existing base of customers (as in the GM case). Alternatively, a firm could use an IT infrastructure to leverage its intangible assets to enter new product markets (as in the USA Today case).

In summary, an IT infrastructure with enterprise-wide information storage, analysis and communication capabilities may enable firms to leverage their firm-specific but usage flexible intangible assets across different product markets (Broadbent, et al. 1999). Specifically, an IT infrastructure with a customer database and analytical processing capabilities may allow firms to dissect transaction histories to predict new products that could be offered to different customers (Ryals 2005). Similarly, a standardized enterprise-wide IT-infrastructure may enable firms to share technological and managerial knowledge across diversified businesses (Tanriverdi 2005). These arguments lead to the following hypothesis:

> *Hypothesis 2: In firms with more IT, intangible assets are likely to be associated with a greater increase in horizontal scope.*

### 2.2.3 Performance Implications

An organization with firm- and usage-specific tangible assets may use IT to concentrate on selected activities when it is more advantageous to do so. In that case, though the firm performs fewer activities, it is likely to achieve higher performance than firms that do not organize their vertical chain in such a manner. This is because these firms are able to focus on activities in which they have a scale and specialization advantage, and deploy IT to coordinate with specialists for other activities (Prahalad and Hamel 1990). Thus, firms with firm- and usage-specific tangible assets may use IT to organize their activities in a less vertically integrated manner, and such an organization of the value chain is likely to be associated with an increase in firm performance.

In contrast to tangible assets, since intangible assets have softer capacity constraints and do not depreciate with repeated use (Chatterjee and Wernerfelt 1991), returns from intangible assets are higher when the scope of use of the asset is greater. Thus, one way to exploit intangible assets is to use them in a broader range of markets and industries (Teece 1980). Empirical studies show that intangible assets are associated with improved performance in multi-business firms (Carmeli and Tishler 2004; Delgado-

Gomez, et al. 2004; Tanriverdi and Venkatraman 2005). Roberts and Dowling (2002), for example, examine the impact of corporate reputation and find that good corporate reputation is associated with persistent above-average profits. Thus, if a firm is able to use IT to leverage its firm-specific but usage-flexible intangible assets across different product markets, its performance can improve. This is likely as the firm may be able to generate more value from its intangible assets through economies of scope, compared to firms that do not leverage their intangible assets in this manner. Thus, use of IT to exploit intangible assets across different product markets may give rise to increasing returns (Teece 1998). These arguments lead to the following hypotheses:

> *Hypothesis 3: The use of IT to coordinate tangible assets in less vertically integrated firms is likely to be associated with an increase in performance.*

> *Hypothesis 4: The use of IT to leverage intangible assets across different product markets is likely to be associated with an increase in performance.*

## 2.3 Methods

### 2.3.1 Data and Sample

In this study, we combine data from three primary sources. First, we derive a proxy for IT-intensity from the *CI Technology Database* from Harte-Hanks. This database contains information about the IT infrastructure in over 500,000 sites in the United States and Canada. Harte-Hanks maintains this database through over 7,000 phone-based interviews every month. The information in the database covers 10 key IT areas, including personal computing, systems and servers, networking, software, storage, and managed services. Based on this database, we adopt the number of Personal Computers (PCs) per employee as a proxy for the IT-intensity of the firm (Mahmood and Mann 1993).[2] Second, we obtain (tangible and intangible) assets and performance information from the COMPUSTAT database. Third, we measure firms' vertical integration and horizontal diversification using data from the COMPUSTAT segment database and the Input-Output tables from the Bureau of Economic Analysis (BEA). We also use COMPUSTAT segment database to calculate industry-level variables such as concentration and demand uncertainty. Our panel dataset contains 2183 observations, which cover 745 unique firms over a four-year period from 2001 to 2004. All of these firms are Fortune 1000 companies.

### 2.3.2 Variables

***Tangible and Intangible Assets.*** We adopt plant, property and equipment divided by sales (*Plant and Equipment*) as the measure for firm- and usage-specific tangible assets (Konar and Cohen 2001). These tangible assets are the key physical assets used in production operations.[3] We consider three different measures for firm-specific but usage-flexible intangible assets. First, we use *Advertising Intensity* as a proxy for brand name and goodwill (Lu and Beamish 2004). *Advertising Intensity* is calculated as advertising stock divided by sales. Advertising stock is assessed as the average advertising expenditure over the past 5 years. Second, we employ *R&D Intensity* as a proxy for technology and R&D capability of the firm (Hitt, et al. 1997; Stimpert and Duhaime

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[2] In order to check the robustness of the empirical analysis, we also use several alternative measures such as the number of servers per employee, number of LAN nodes per employee, etc. We also tried a measure of total IT capital (Hitt and Brynjolfsson, 1996). These alternative operationalizations of IT produce very consistent results.

[3] We do not consider inventory, short-term investment and receivables, which may also be considered as part of tangible assets in some situations (Konar and Cohen, 2001).

1997). *R&D Intensity* is calculated as R&D stock divided by sales. R&D stock is assessed as the average R&D expenditure over the past 5 years.[4, 5] Third, we adopt a measure to capture other intangible assets that are not included in *R&D Intensity* and *Advertising Intensity*. For this measure, we first calculate the difference between the firm's market value and its book value as a proportion of the book value of total assets as, (MV+PS+DEBT-TA)/TA, where MV=(Closing price of share at the end of financial year) × (Number of common shares outstanding), PS= Preferred stock, DEBT=Short term debt + Long term debt, TA=Book value of total assets. Note that this measure is essentially equivalent to the firm's Tobin's q (e.g., Bharadwaj, et al. 1999; Lang and Stulz 1994).[6] It captures the extra intangible value of the firm that is not included in the book value but is identified by the market. For instance, this measure captures firms' growth options (Dewan, et al. 1998; Smith and Watts 1992), managerial know-how (Pehrsson, 2006; Prahalad and Bettis 1986), and its organizational capital that includes its norms and routines and corporate culture (Fernandez, et al. 1999; Hall 1993). We call this measure the *Market-valued Intangibles*. However, since *Market-valued Intangibles* may already incorporate the impact of *Advertising Intensity* and *R&D Intensity*, we use

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[4] The advantage of using stock variables for R&D and advertising is that they capture the lag effects of capital expenditure as current R&D and advertising expenditure may produce future benefits. We also run the analysis using the flow variables for R&D intensity (annual R&D expenditure divided by sales) and advertising intensity (annual advertising expenditure divided by sales). Not surprisingly, the results are very consistent.

[5] As recognized in the literature (e.g., Brynjolfsson et. al., 1998; Bharadwaj, Bharadwaj, and Konsynski, 1999), a number of firms in COMPUSTAT have missing values for their advertising and R&D expenditures. Following this literature, we replace the missing values with their industry means. We also performed the analysis using several alternative approaches to address the missing value issue. For example, following Stimpert and Duhaime (1997), we normalize the advertising-to-sales ratio and R&D-to-sales ratio by subtracting their industry mean values and replacing all the missing values by zero. We also conducted the analysis by replacing missing values by zero as in Miller (2004). All of these analyses produce qualitatively similar results.

*residual Market-valued Intangibles* as the variable in the empirical analysis. That is, we remove the variation in *Market-valued Intangibles* contributed to by *Advertising Intensity* and *R&D Intensity*, and use the residual as a measure of intangible assets.[7] In this way, *Market-valued Intangibles* is a measure of firm-specific but usage-flexible intangible assets that are not captured by *Advertising Intensity* and *R&D Intensity*.

***Vertical Integration.*** To assess firms' vertical integration, we employ the measure used in Fan and Lang (2000). This measure uses the Input-Output (IO) Use table from Bureau of Economic Analysis to capture the input-output interdependencies between the firm's primary segment and its secondary segments. This measure of vertical integration is similar in nature to other measures used in prior studies (e.g. D'Aveni and Ravenscraft 1994; Maddigan 1981).[8] The following three steps are used to construct the measure for vertical integration. First, from the COMPUSTAT Segment database, we identify the primary segment (the 4-digit-NAICS segment with the highest sales) and all the secondary segments for each firm. Second, based on the Input-Output (IO) table from the Bureau of Economic Analysis, we calculate the vertical relatedness between each secondary segment and the primary segment. Specifically, the vertical relatedness between a secondary segment in industry *j* and a primary segment in industry *i*, denoted as $V_{ij}$, is calculated as

[6] Tobin's q has been used in many studies as a measure of firms' intangible assets (Hall 1993; Megna and Klock 1993).
[7] We run a regression of *Market-valued Intangibles* on *Advertising Intensity* and *R&D Intensity*, and use the residuals as a measure of market-valued intangible asset.
[8] One drawback of the measure of vertical integration in Maddigan (1981) is that it does not capture the level at which a firm participates in a specific industry. For example, a car manufacturer will report the same vertical integration value no matter whether its tire factory supplies 1% or 100% of the tires for its car factory. In contrast, the measure of vertical integration in Fan and Lang (2000) captures the industry share

$$V_{ij} = 1/2\left(a_{ij}/T_j + a_{ji}/T_i\right)$$

where $a_{ij}$ denotes the dollar value of industry *i*'s output required to produce industry *j*'s total output, and $T_j$ denotes the industry *j*'s total output. Similarly for $a_{ji}$. If the two segments have strong make-buy relationship according to the material flow data in the Input-Output table, they will have a high value of vertical relatedness. Third, based on the calculation from the first two steps, we assess each firm's vertical integration using the following formula:

$$\textit{Vertical Integration} = \textstyle\sum_j W_j V_j$$

where $W_j$ is the ratio of the *j*th secondary segment's sales to the total sales of all the secondary segments. If a firm's secondary segment(s) has (have) very strong vertical relatedness with its primary segment, e.g., a car manufacturer with a secondary segment that produces a substantial proportion of the tires that the primary (car) segment requires, then the firm will have a high value of *Vertical Integration*.

***Horizontal Diversification***. We consider three different measures for diversification: (i) *Horizontal Complementarity*; (ii) *Related Diversification*; and (iii) *Unrelated Diversification*. As in Fan and Lang (2000), *Horizontal Complementarity* is calculated using the following three-step processes. First, from the Input-Output Use table, for each industry *i*, we compute the percentage of its output supplied to each intermediate industry *k*, denoted as $b_{ik}$. Then, for each pair of industries *i* and *j*, we calculate the correlation coefficient between $b_{ik}$ and $b_{jk}$ across all *k* except for *i* and *j*.

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information in assessing the level of vertical integration. Therefore, we adopt the latter measure of vertical

Second, for each industry we calculate the percentage of its input from each intermediate industry *k*, denoted as $d_{ik}$. For each pair of industries *i* and *j*, we then calculate the correlation coefficient between $d_{ik}$ and $d_{jk}$ across all *k* except for *i* and *j*. The complementarity coefficient between industry *i* and *j*, denoted by $C_{ij}$, is calculated as the average of the two correlation coefficients, i.e.,

$$C_{ij} = 1/2\left(corr\left(b_{ik}, b_{jk}\right) + corr\left(d_{ik}, d_{jk}\right)\right)$$

Finally, we assess each firm's *Horizontal Complementarity* using the following formula:

$$Horizontal\ Complementarity = \sum_j W_j C_j$$

where $C_j$ is the complementarity coefficient between the *j*th secondary segment and the primary segment, and $W_j$ is the ratio of the *j*th secondary segment's sales to the total sales of all the secondary segments. Intuitively, *Horizontal Complementarity* measures the commonality between segments on the input and the output side. If two segments have common inputs, they can share common buying processes. Similarly, if two segments sell to common output markets, they can sell to the same sets of consumers and use the same distribution channels. Thus, if a firm has high *Horizontal Complementarity*, it implies that its various segments can share common buying and selling processes.

We employ the entropy measures as in Palepu (1985) to calculate *Related Diversification*, and *Unrelated Diversification*. *Related Diversification* captures the extent to which a firm's output is distributed within industry groups in the same 2-digit NAICS code. *Unrelated Diversification* captures the extent to which a firm's output is

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integration.

distributed across unrelated industry groups. If a firm participates in *N* 4-digit industries which can be grouped as *M* 2-digit industry groups, then the firm's diversification can be measured as

$$Related\ Diversification = \sum_{j=1}^{M} p^j \sum_{i=1}^{N_j} p_i^j \ln\left(1/p_i^j\right);$$

$$Unrelated\ Diversification = \sum_{j=1}^{M} p^j \ln\left(1/p^j\right)$$

where $N_j$ is the number of 4-digit industries within the 2-digit industry group *j* that the firm participates in, $p_i^j$ is the share of the segment *i* of group *j* in the total sales of the firm, and $p^j = \sum_{i \in j} p_i^j$ is the share of the *j*th group's sales in the total sales of the firm. One weakness of the entropy measures is that they do not directly capture the input-output interdependency between industries. Thus, our use of the *Horizontal Complementarity* measure bridges this gap.

***Firm Performance.*** We adopt *Return on Assets* measured as pretax income divided by total assets, as the measure for firm performance (e.g., Hitt and Brynjolfsson 1996; Hitt, et. al. 1997; Lu and Beamish 2004; Stimpert and Duhaime 1997). Table 1 presents the descriptive statistics and the correlations between the key variables.

***Control Variables***. In the firm scope models, we use several variables to control for industry- and firm-level effects. First, we include industry-level control variables such as *Concentration*, *Dynamism*, *Munificence*, and *Capital Intensity.* For example, firms in concentrated industries are likely to be more vertically integrated (Balakrishnan and Wernerfelt 1986). Similarly, industry-level characteristics such as dynamism, munificence, and capital intensity are also expected to influence firms' choice of diversification level (Chatterjee and Singh 1999; Keats and Hitt 1988). All of these industry-level control variables are calculated using the COMPUSTAT segment database. *Dynamism* and *Munificence* are calculated following the procedure in Keats and Hitt (1998). *Concentration* is measured as the ratio of the total sales of the top four firms in the industry to total industry sales. *Capital Intensity* is calculated as the total industry assets divided by total industry sales. For each multi-segment firm, the values of these variables are weighted by sales across all industries that the firm participates in. Second, we include firm-level control variables such as *Capital Investment* measured as total invested capital divided by total assets, and the firm's *Capital Age* measured as ((Gross Plant and Equipment – Net Plant and Equipment)/(Depreciation)). Firms with large capital investment may have more capabilities to diversify into different product markets (Stimpert and Duhaime 1997). Similarly, more established firms with high capital age may have more experience and accumulated capabilities to diversify into different businesses

| | Mean | Std. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Vertical Integration | 0.07 | 0.10 | 1 | | | | | | | | | |
| 2. Horizontal Complementarity | 0.55 | 0.41 | 0.55** | 1 | | | | | | | | |
| 3. Related Diversification | 0.17 | 0.31 | 0.08** | 0.22** | 1 | | | | | | | |
| 4. Unrelated Diversification | 0.15 | 0.26 | -0.09** | -0.07** | 0.01 | 1 | | | | | | |
| 5. Information Technology (IT) | 0.29 | 0.42 | 0.07** | 0.01 | 0.01 | -0.04* | 1 | | | | | |
| 6. Plant and Equipment | 0.37 | 0.49 | -0.06** | 0.01 | -0.02 | 0.04* | 0.09** | 1 | | | | |
| 7. Advertising Intensity | 0.02 | 0.07 | 0.06** | 0.03 | -0.00 | -0.06** | 0.25** | 0.03 | 1 | | | |
| 8. R&D Intensity | 0.03 | 0.07 | 0.05* | 0.01 | -0.02 | -0.02 | 0.12** | 0.04† | 0.20** | 1 | | |
| 9. Market-valued Intangibles | 0.39 | 1.03 | -0.11** | -0.09** | -0.08** | -0.08** | -0.10** | -0.12** | 0.02 | 0.19** | 1 | |
| 10. Return on Assets | 0.05 | 0.22 | -0.04* | -0.05* | -0.04* | -0.01 | 0.05* | -0.07** | -0.02 | -0.11** | 0.19** | 1 |

[a] Pearson correlation coefficients are reported. † $p<0.1$ * $p<0.05$ ** $p<0.01$

**Table 2.1: Descriptive Statistics and Correlations Between Key Variables**

(Dierickx and Cool 1989).

In the performance models also, we use several variables to control for industry- and firm-level effects. First, we include industry-level control variables such as *Concentration*, *Dynamism*, *Munificence*, *Capital Intensity* (Bharadwaj, et al. 1999; Keats and Hitt 1988), and exposure to foreign competition (*Exports and Imports*) measured as the total value of industry-level exports and imports. We also include *Industry Average Return on Assets* to control for other industry effects. Second, we include firm-level control variables such as *Capital Investment*; *Debt-to-Equity* ratio measured as the sum of long-term and short-term debt divided by the book value of total equity; and *Market Share* measured as firm sales as a percentage of industry sales at the primary four-digit NAICS industry level. As identified in prior studies (e.g., Hitt and Brynjolfsson 1996; Hitt, et. al. 1997; Lu and Beamish 2004; Stimpert and Duhaime 1997), these variables may affect firm performance.

Finally, in all the models, we use the number of *Employees* as a control variable for firm size and use three year dummy variable (*Year 2001*, *Year 2002*, and *Year 2003*) to control for year-specific effects.

***Instrument Variables***. As discussed below, we adopt a simultaneous equations model and conduct a 2-stage least squares (2SLS) analysis. Therefore, we use a set of instrument variables in our estimation of IT intensity and firm scope. First, to estimate IT intensity, we use an instrument variable that captures the average industry-level IT-intensity for the 3-digit NAICS industries that the firm participates in. The industry-level IT-intensity is calculated as the IT capital ratio of each industry the firm participates in, weighted by its sales in that industry. We obtain industry-level IT capital ratio information from the *Current-Cost Investment in Private Nonresidential Fixed Assets Table* from Bureau of Economic Analysis. Industry-level IT capital ratio is the ratio of computers and peripheral equipment and software, to the value of total assets. Second, we use a set of instrument variables that reflect the exogenous environment of IT investment, including industry-level operating surplus, tax on production, the ratio of the material input to energy input, and the ratio of the service input to energy input (Bartelsman, et al. 1994; Hitt 1999). This is due to the expectation that firms' IT investments are expected to be higher in industries with higher operating surplus, lower tax rates, and higher material and service inputs. All of these industry-level data is obtained from Bureau of Economic Analysis. For each multi-segment firm, the values of these variables are weighted by sales across all the industries that the firm participates in. Third, to estimate firm scope variables, we use a set of dummy variables for each 2-digit industry that the firm participates in (Hitt 1999; Wernerfelt and Montgomery 1988).

### 2.3.3 The Model

Vertical and horizontal scope and IT investments are firms' endogenous choices as firms may choose their IT level depending on their scope and their scope depending on their IT (Hitt 1999).[9] Miller (2006) provides an elaborate discussion regarding the endogeneity of firm scope and the possible approaches to address this issue. Thus, in this study, we estimate a simultaneous equations model (SEM) rather than an ordinary least squares (OLS) model, to incorporate the endogeneity of firm scope and IT. Hausman tests on our dataset also show that IT intensity and firm scope are endogenous, thus rejecting the ordinary least squares estimation in favor of two-stage least squares (2SLS). The simultaneous equation model is defined as follows.

$$\begin{aligned} \textit{Firm Scope} &= \alpha_0 + \alpha_1 \textit{ Plant and Equipment} + \alpha_2 \textit{ Advertising Intensity} + \alpha_3 \textit{ R\&D Intensity} + \alpha_4 \textit{ Market-valued Intangibles} + \alpha_5 \textit{ IT} + \alpha_6 \textit{ IT} \times \textit{Plant and Equipment} + \alpha_7 \textit{ IT} \times \textit{Advertising Intensity} + \alpha_8 \textit{ IT} \times \textit{R\&D Intensity} + \alpha_9 \textit{ IT} \times \textit{Market-valued Intangibles} + \alpha_{10} \textit{ Controls} + \varepsilon \end{aligned} \quad (2.1)$$

$$\begin{aligned} \textit{IT} &= \beta_0 + \beta_1 \textit{ Plant and Equipment} + \beta_2 \textit{ Advertising Intensity} + \beta_3 \textit{ R\&D Intensity} + \beta_4 \textit{ Market-valued Intangibles} + \beta_5 \textit{ Vertical Integration} + \beta_6 \textit{ Horizontal Complementarity} + \beta_7 \textit{ Related Diversification} + \beta_8 \textit{ Unrelated Diversification} + \beta_9 \textit{ Controls} + \varepsilon \end{aligned} \quad (2.2)$$

$$\begin{aligned} \textit{Return on Asset} &= \gamma_0 + \gamma_1 \textit{ Plant and Equipment} + \gamma_2 \textit{ Advertising Intensity} + \gamma_3 \textit{ R\&D Intensity} + \gamma_4 \textit{ Market-valued Intangibles} + \gamma_5 \textit{ IT} + \gamma_6 \textit{ Vertical Integration} + \gamma_7 \textit{ Horizontal Complementarity} + \gamma_8 \textit{ Related Diversification} + \gamma_9 \textit{ Unrelated Diversification} + \gamma_{10} \textit{ IT} \times \textit{Plant and Equipment} + \gamma_{11} \textit{ IT} \times \textit{Advertising Intensity} + \gamma_{12} \textit{ IT} \times \textit{R\&D Intensity} + \gamma_{13} \textit{ IT} \times \textit{Market-valued Intangibles} + \gamma_{14} \textit{ Controls} + \varepsilon \end{aligned} \quad (2.3)$$

where *Firm Scope* = {*Vertical Integration*, *Horizontal Complementarity*, *Related Diversification, Unrelated Diversification*}. Equation 2.1 captures how different assets and IT, individually and collectively, influence firm scope. The coefficients of the

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[9] Such an approach of examining endogenous choice of firm scope is also adopted in other empirical studies, e.g., Stimpert and Duhaime (1997) and Chatterjee and Singh (1999).

interaction between IT and different assets (i.e., *Plant and Equipment, Advertising Intensity, R&D Intensity,* and *Market- valued Intangibles)* capture how IT moderates the impact of different types of assets on firm scope. Equation 2.2 captures how firms' vertical integration and diversification level influence the choice of IT intensity. Note that although both *Horizontal Complementarity* and *Related Diversification* capture the level of related diversification, they capture different aspects of relatedness. *Horizontal Complementarity* captures process relatedness, i.e., whether the primary segment and secondary segments can share common buying and selling processes. In contrast, *Related Diversification* captures the relatedness of the product markets that the firm participates in. Thus, we incorporate both of these diversification measures in equation 2.2.

Equation 2.3 captures how firm scope, firm assets, and IT interact to influence firm performance. We split the sample into two groups by using the mean value of the scope variables. For example, we split the sample into *High Vertical Integration* and *Low Vertical Integration* groups. Observations in the *High Vertical Integration* (*Low Vertical Integration*) group have vertical integration values above (below) the mean value. We then examine the difference between the coefficients of the *IT* × *Plant and Equipment* interaction terms across the two groups to analyze how the IT and tangible asset interactions affect performance differently. Similarly, we also split the sample into High- and Low- diversification groups, and examine how the impacts of the IT and intangible asset interactions (i.e., *IT* × *Advertising Intensity, IT* × *R&D Intensity, and IT* × *Market-valued Intangibles*) on performance differ across the groups.

### 2.4 Results

### 2.4.1 Firm Scope

Table 2.2 presents the results of equation 1 of the simultaneous equations model. We first study the estimation results for *Vertical Integration*. The coefficient of the *IT* × *Plant and Equipment* interaction term is negative and significant ($p$<0.01). This suggests that IT enables firms with more tangible assets to decrease their level of vertical integration. This analysis provides support for hypothesis 1. In Figure 2.1 we plot how IT moderates the total impact of Plant and Equipment (i.e., $\alpha_1 + \alpha_6 \times IT$) on vertical integration. The Figure suggests that at lower levels of IT, *Plant and Equipment* are associated with an increase in vertical integration. This is consistent with the traditional transaction cost argument that specialized assets are associated with increased vertical integration. However, at higher levels of IT, *Plant and Equipment* are associated with a decrease in vertical integration. This suggests that IT may enable firms to mitigate some of the transaction costs associated with specialized assets so that firms can benefit from the economics of specialization.

Next we examine diversification. In the estimation results for *Horizontal Complementarity*, the coefficients of both the *IT* × *Advertising Intensity* interaction and *IT*× *Market-valued Intangibles* interaction are positive and significant ($p$<0.01). This provides evidence that IT enables firms with larger brand and market-valued intangible assets to further increase their horizontal complementarity. This is consistent with hypothesis 2. However, the coefficient of the *IT* × *R&D Intensity* interaction is negative and significant.

| | Vertical Integration | Horizontal Complementarity | Related Diversification | Unrelated Diversification |
|---|---|---|---|---|
| Plant and Equipment | -0.13** | -0.11** | -0.10** | 0.04 |
| Advertising Intensity | 0.17** | -0.12** | -0.19** | -0.19** |
| R&D Intensity | 0.12** | 0.09** | 0.24** | 0.06 |
| Market-valued Intangibles | -0.13** | -0.14** | -0.11** | -0.07** |
| Information Technology (IT) | -0.09† | 0.71** | 0.64** | 0.22** |
| IT × Plant and Equipment | -0.11** | -0.05* | 0.00 | 0.02 |
| IT × Advertising Intensity | 0.07* | 0.11** | 0.26** | 0.14* |
| IT × R&D Intensity | -0.11** | -0.18** | -0.37** | -0.07 |
| IT × Market-valued Intangibles | 0.05** | 0.07** | 0.10** | 0.07* |
| Employees | 0.07* | 0.72** | 0.86** | 0.24** |
| Capital Investment | -0.09** | -0.01 | 0.03 | 0.04 |
| Capital Age | 0.06** | 0.08** | 0.28** | 0.05* |
| Concentration | -0.55** | -0.27** | 0.21** | 0.10** |
| Dynamism | 0.53** | -0.14** | -0.28** | 0.04 |
| Munificence | 0.02 | -0.07** | -0.05* | 0.00 |
| Capital Intensity | 0.07** | 0.11** | 0.14** | -0.06* |
| Year 2001 | 0.18** | -0.07* | -0.03 | 0.08* |
| Year 2002 | 0.11** | -0.13** | -0.09** | 0.03 |
| Year 2003 | -0.04* | -0.02 | -0.02 | 0.03 |
| $R^2$ | 0.646 | 0.433 | 0.421 | 0.04 |
| *F* Statistic | 207.93** | 87.06** | 82.71** | 5.00** |
| *N* | 2813 | 2813 | 2813 | 2813 |

[a] Standardized coefficients are reported; t-statistics are in parenthesis.
$^{+}$ $p$<0.1 $^{*}$ $p$<0.05 $^{**}$ $p$<0.01

**Table 2.2: Impact of Assets and IT on Firm Scope**

In the estimation results for the *Related Diversification* model, the coefficients of the *IT* × *Advertising Intensity* and *IT* × *Market-valued Intangibles* interactions are positive and significant ($p$<0.01). This analysis provides evidence that IT enables firms with larger brand and market-valued intangible assets to further increase their related diversification. This is consistent with hypothesis 2. In Figure 2.2 we plot how IT moderates the total impact of *Advertising Intensity* (i.e., $\alpha_1 + \alpha_7 \times$IT) on related diversification. The Figure suggests that at average (and at lower) levels of IT, *Advertising Intensity* is associated with a decrease in related diversification. However, at higher levels of IT, *Advertising Intensity* is associated with an increase in related diversification. This suggests that IT may enable firms to leverage their brand across related product markets and thus realize economies of scope. Again, the coefficient of the *IT × R&D Intensity* interaction term is negative and significant.

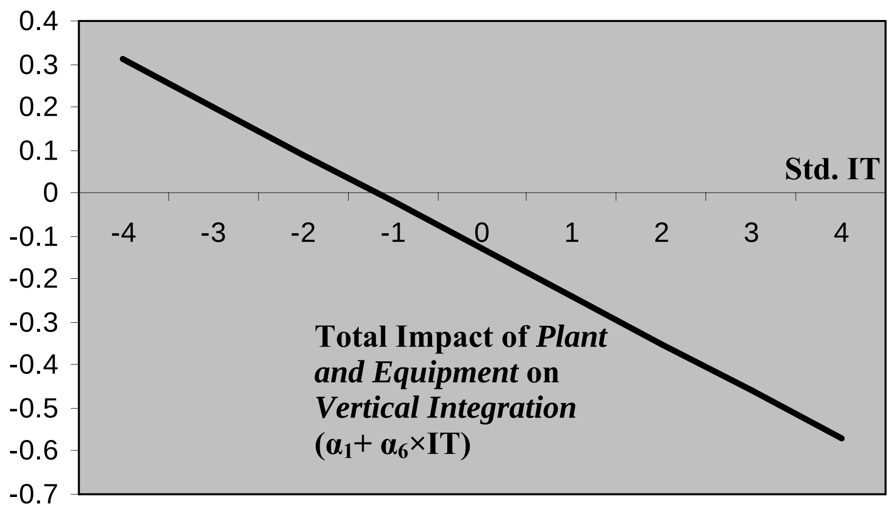


**Figure 2.1: Moderating Role of IT on the Impact of *Plant and Equipment* on *Vertical Integration*.**

Finally, in the *Unrelated Diversification* model, the coefficients of the *IT × Advertising Intensity* and *IT × Market-valued Intangibles* interactions are positive and significant ($p<0.01$ and $p<0.05$, respectively). However, the coefficient of the *IT × R&D Intensity* interaction is not significant. This analysis provides evidence that IT enables firms with larger brand and market-valued intangible assets to further diversify across unrelated businesses.

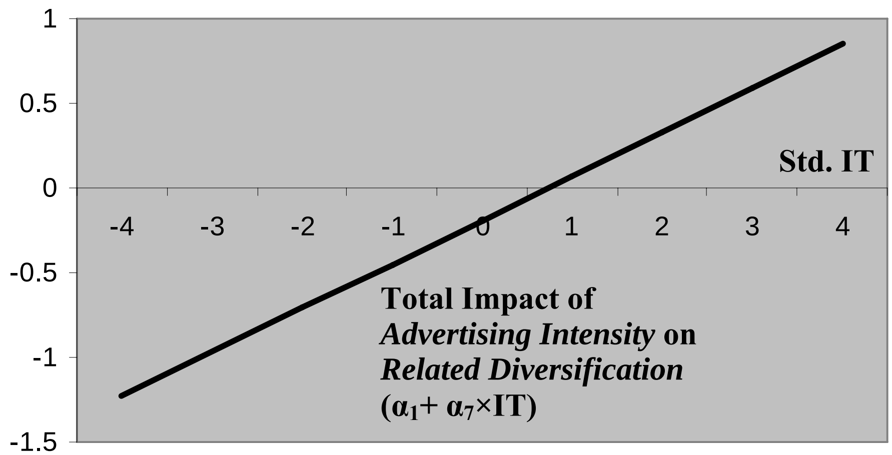


**Figure 2.2: Moderating Role of IT on the Impact of *Advertising Intensity* on *Related Diversification*.**

Table 2.3 presents the analysis of the impact of firm scope on IT (i.e., equation 2.2). First, the coefficient of *Vertical Integration* is negative and significant ($p$<0.01). This suggests that less vertically integrated firms use more IT. Second, the coefficients of *Horizontal Complementarity* and *Related Diversification* are positive and significant ($p$<0.01). This suggests that related diversified firms use more IT. Finally, the coefficient of *Unrelated Diversification* is positive but not significant.

| | Information Technology (IT) |
|---|---|
| Plant and Equipment | 0.02** |
| Advertising Intensity | 0.35** |
| R&D Intensity | 0.05** |
| Market-valued Intangibles | -0.08** |
| Vertical Integration | -0.10** |
| Horizontal Complementarity | 0.09** |
| Related Diversification | 0.05** |
| Unrelated Diversification | 0.01 |
| Employees | -0.68** |
| Capital Investment | -0.14** |
| Capital Age | 0.03** |
| Concentration | -0.26** |
| Dynamism | 0.21** |
| Munificence | 0.03† |
| Capital Intensity | 0.06** |
| Year 2001 | 0.04** |
| Year 2002 | 0.05** |
| Year 2003 | -0.02** |
| $R^2$ | 0.94 |
| *F* Statistics | 1911.74** |
| *N* | 2813 |

[a] Standardized coefficients are reported; t-statistics are in parenthesis.
† $p<0.1$ * $p<0.05$ ** $p<0.01$

**Table 2.3 Impact of Firm Scope on IT**

### 2.4.2 Performance

The analysis examining the performance implications of the IT and assets interactions (i.e., equation 2.3) is presented in Table 2.4A and Table 2.4B. We first study the subgroup analysis based on the sample split using *Vertical Integration* (see Table 2.4A). The coefficient of the *IT × Plant and Equipment* interaction term in the *Low Vertical Integration* group is positive and significant ($p<0.01$). In contrast, the coefficient of the *IT × Plant and Equipment* interaction term in the *High Vertical Integration* group is not significant. A t-test indicates that the difference between these two coefficients is significant ($p$<0.05). This suggests that the use of IT to coordinate activities in less vertically integrated firms enhances the performance contribution of tangible assets. This analysis provides support for hypothesis 3.

In the subgroup analysis based on the sample split using *Horizontal Complementarity*, the coefficient of the *IT* × *Market-valued Intangibles* interaction is negative and significant ($p$<0.1) in the *Low Horizontal Complementarity* group but is close to zero in the *High Horizontal Complementarity* group (please see table 2.4B). A t-test indicates that the difference between these two coefficients is significant ($p$<0.05). Therefore, the moderating role of IT on the performance contribution of market-valued intangible assets is higher for more diversified firms. This analysis supports hypothesis 4. However, the difference between the coefficients of the *IT* × *Advertising Intensity* interactions across the *High Horizontal Complementarity* group and the *Low Horizontal Complementarity* group is not significant. Thus, the analysis using advertising intensity does not support hypothesis 4. With regards to *R&D Intensity*, the coefficient of the *IT* × *R&D Intensity* is positive and significant ($p$<0.05) in the *Low Horizontal Complementarity* group. However, in the *High Horizontal Complementarity* group, the coefficient of the *IT* × *R&D Intensity* is positive but not significant. A t-test indicates that the difference between these two coefficients is significant ($p$<0.01). Therefore, the moderating role of IT on the performance contribution of R&D is higher for less diversified firms. This finding is opposite to hypothesis 4.

| | Sample Split by Vertical Integration | |
|---|---|---|
| | Low Vertical Integration | High Vertical Integration |
| Plant and Equipent | -0.15** | -0.12** |
| Advertising Intensity | 0.06 | -0.05 |
| R&D Intensity | -0.43** | -0.18** |
| Market-valued Intangibles | 0.50** | 0.09* |
| Information Technology (IT) | 0.09 | 0.11 |
| Vertical Integration | -0.03 | 0.00 |
| Horizontal Complementarity | -0.06 | 0.00 |
| Related Diversification | 0.04 | -0.00 |
| Unrelated Diversification | -0.03 | 0.01 |
| IT × Plant and Equipment | 0.13** | 0.06 |
| IT × Advertising Intensity | -0.20** | 0.01 |
| IT × R&D Intensity | 0.39** | -0.07 |
| IT × Market-valued Intangibles | 0.08* | -0.14** |
| Employees | 0.15 | 0.04 |
| Capital Investment | 0.14** | 0.32** |
| Deb-to-Equity | 0.00 | -0.01 |
| Market Share | 0.00 | 0.06 |
| Concentration | -0.03 | -0.01 |
| Dynamism | -0.05 | -0.01 |
| Munificence | 0.04 | 0.04 |
| Capital Intensity | -0.05† | 0.02 |
| Exports and Imports | 0.03 | -0.01 |
| Industry Average Return on Assets | 0.01 | 0.04 |
| Year 2001 | -0.17** | -0.10* |
| Year 2002 | -0.13** | -0.07 |
| Year 2003 | -0.06† | 0.04 |
| $R^2$ | 0.36 | 0.13 |
| *F* Statistic | 23.18** | 6.19** |
| *N* | 1094 | 1089 |

[a] Standardized coefficients are reported; t-statistics are in parenthesis.
† $p<0.1$ * $p<0.05$ ** $p<0.01$

**Table 2.4A: Sub-Group Analysis for Performance Implications**

In the subgroup analysis based on the sample split using *Horizontal Complementarity*, the coefficient of the *IT × Market-valued Intangibles* interaction is negative and significant ($p<0.1$) in the *Low Horizontal Complementarity* group but is close to zero in the *High Horizontal Complementarity* group (please see table 2.4B). A t-test indicates that the difference between these two coefficients is significant ($p<0.05$). Therefore, the moderating role of IT on the performance contribution of market-valued intangible assets is higher for more diversified firms. This analysis supports hypothesis 4. However, the difference between the coefficients of the *IT × Advertising Intensity* interactions across the *High Horizontal Complementarity* group and the *Low Horizontal Complementarity* group is not significant. Thus, the analysis using advertising intensity does not support hypothesis 4. With regards to *R&D Intensity*, the coefficient of the *IT × R&D Intensity* is positive and significant ($p<0.05$) in the *Low Horizontal Complementarity* group. However, in the *High Horizontal Complementarity* group, the coefficient of the *IT × R&D Intensity* is positive but not significant. A t-test indicates that the difference between these two coefficients is significant ($p<0.01$). Therefore, the moderating role of IT on the performance contribution of R&D is higher for less diversified firms. This finding is opposite to hypothesis 4.

In the *Related Diversification* model, the coefficient of the *IT × Advertising Intensity* interaction in the *Low Related Diversification* group is negative and significant ($p<0.01$). The coefficient of the *IT × Advertising Intensity* interaction in the *High Related Diversification* group is positive and significant ($p<0.1$). A t-test indicates that this difference is significant ($p<0.01$). This suggests that in firms with higher related diversification, IT may increase the performance contribution of brand. This analysis supports hypothesis 4.

| | Sample Split by Horizontal Complementarity | | Sample Split by Related Diversification | | Sample Split by Unrelated Diversification | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| Plant and Equipment | -0.03 | -0.13** | -0.07 | -0.18** | -0.12** | -0.17** |
| Advertising Intensity | 0.01 | -0.11 | -0.02 | -0.23** | -0.07 | -0.01 |
| R&D Intensity | -0.27** | -0.24** | -0.39** | -0.15** | -0.26** | -0.37** |
| Market-valued Intangibles | 0.16** | 0.25** | 0.20** | 0.28** | 0.20** | 0.39** |
| Information Technology (IT) | -0.15 | 0.32* | -0.02 | 0.40* | 0.16 | 0.23† |
| Vertical Integration | 0.06 | 0.07 | 0.09 | 0.09* | 0.15† | 0.12* |
| Horizontal Complementarity | -0.03 | 0.03 | -0.09 | 0.01 | 0.01 | -0.07 |
| Related Diversification | 0.14* | -0.02 | 0.07† | 0.05 | 0.05 | -0.05 |
| Unrelated Diversification | -0.02 | 0.01 | 0.02 | 0.01 | -0.04 | 0.03 |
| IT × Plant and Equipment | -0.00 | 0.09** | 0.01 | 0.15** | 0.05 | 0.13** |
| IT × Advertising Intensity | -0.08 | -0.00 | -0.22** | 0.17† | -0.14† | -0.12** |
| IT × R&D Intensity | 0.18* | 0.05 | 0.39** | -0.10 | 0.19** | 0.23** |
| IT × Market-valued Intangibles | -0.09† | -0.00 | -0.05 | -0.01 | -0.06† | -0.02 |
| Employees | -0.22 | 0.23** | -0.10 | 0.37** | -0.03 | 0.27* |
| Capital Investment | -0.07 | 0.49** | 0.01 | 0.65** | 0.29** | 0.24** |
| Debt-to-Equity | 0.01 | -0.03 | 0.01 | -0.04 | -0.01 | 0.01 |
| Market Share | -0.00 | 0.03 | 0.01 | -0.07† | 0.02 | 0.02 |
| Concentration | -0.14 | 0.06 | -0.10 | 0.19** | 0.08 | -0.04 |
| Dynamism | -0.01 | 0.03 | -0.04 | -0.03 | -0.06 | 0.01 |
| Munificence | 0.02 | 0.03 | 0.02 | -0.03 | 0.02 | 0.04 |
| Capital Intensity | -0.07 | 0.04+ | -0.05 | 0.05† | 0.00 | 0.04 |
| Export and Import | -0.07 | -0.02 | -0.01 | -0.04 | -0.07 | 0.02 |
| Industry Average Return on Assets | -0.00 | 0.04† | -0.02 | 0.05 | 0.02 | 0.01 |
| Year 2001 | -0.09 | -0.07† | -0.10** | -0.10** | -0.10* | -0.13* |
| Year 2002 | -0.05 | -0.06† | -0.09† | -0.05 | -0.06 | -0.15** |
| Year 2003 | 0.03 | 0.01 | 0.03 | -0.02 | 0.03 | -0.05 |
| $R^2$ | 0.07 | 0.32 | 0.08 | 0.41 | 0.13 | 0.31 |
| $F$ Statistic | 2.49** | 23.47** | 3.70** | 35.82** | 7.97** | 12.42** |
| $N$ | 861 | 1322 | 1139 | 1044 | 1433 | 750 |

[a] Standardized coefficients are reported; t-statistics are in parenthesis.
† $p$<0.1 * $p$<0.05 ** $p$<0.01

**Table 2.4B: Sub-Group Analysis for Performance Implications**

However, the coefficient of the *IT × R&D Intensity* interaction in the *Low Related Diversification* group is positive and significant ($p<0.05$), and that in the *High Related Diversification* group is negative (but not significant). A t-test indicates that these two coefficients are significantly different ($p<0.01$). This suggests that in firms with lower related diversification, IT may increase the performance contribution of technological capability. This finding is opposite to hypothesis 4. Also, the coefficients of the *IT × Market-valued Intangibles* interactions across the *High Related Diversification* and the *Low Related Diversification* groups are not significantly different. Thus, the analysis with *R&D Intensity* and *Market-valued Intangibles* does not support hypothesis 4.

In the subgroup analysis based on the sample split using *Unrelated Diversification*, the coefficients of the *IT × Advertising Intensity, IT × R&D Intensity,* and *IT × Market-valued Intangibles* interactions in the *High Unrelated Diversification* group are higher than those in the *Low Unrelated Diversification* group. However, the differences are not statistically significant. Thus, the analysis using *Unrelated Diversification* does not support hypothesis 4.

In summary, the empirical results provide clear support for hypothesis 1 and hypothesis 3. It is found that IT enables firms with more tangible assets to become vertically specialized and such vertical specialization is associated with increased performance contribution of tangible assets. The analysis, however, provides mixed support for hypothesis 2 and hypothesis 4. The analysis suggests that IT enables firms with more brand and market-valued intangible assets to become more diversified. And IT increases the performance contribution of brand and market-valued intangibles for more related diversified firms. However, in contrast to hypothesis 2 and hypothesis 4, for firms with more IT, R&D capability is associated with a decrease in horizontal scope.

### 2.5 Discussion and Conclusion

The goal of this research is to examine how IT interacts with firms' assets interact to shape vertical and horizontal scope. The analysis in this paper suggests that the negative relationship between IT and vertical integration discussed in the literature (e.g., Brews and Tucci 2004; Hitt 1999) is largely attributable to the role of IT in coordinating firms' tangible assets in vertically specialized firms. This finding is also in line with Jacobides and Hitt (2005) who show that productive capabilities lead to vertical specialization. The analysis also indicates that the positive relationship between IT and firms' horizontal diversification discussed in the literature (e.g., Dewan, et. al. 1998; Hitt 1999) is mainly attributable to the role of IT in leveraging firms' intangible assets across diversified businesses. Consistent with the above analyses, and the findings of prior research, this study also suggests that less vertically integrated firms and more related diversified firms invest more in IT. Thus, the primary contribution of this study is that it complements the existing literature by offering a structural explanation of the relationship between IT and firm boundaries.

The second contribution of this research is to examine the impact of the interrelationships among IT, assets, and firm scope on performance. We investigate whether IT moderates the performance contribution of tangible and intangible assets differently in firms with different levels of vertical integration and horizontal diversification. The analysis suggests that in less vertically integrated firms, IT is likely to increase the performance contribution of tangible assets. The implication here is that firms can realize the economics of specialization by focusing on the activities enabled by their firm- and usage-specific tangible assets and better internal and external coordination using IT. Also, the analysis indicates that in more diversified firms, IT is likely to increase the performance contribution of brand and market-valued intangibles. The implication here is that firms can realize economies of scope by using IT to leverage their firm-specific but usage-flexible intangible assets across different product markets.

The theoretical contribution of this research is that it builds on the work of Chatterjee and Wernerfelt (1991) and Ghemawat and Sol (1998) regarding asset flexibility to explore the impact of IT on firms' vertical and horizontal scope. The paper also describes the IT applications and infrastructure that would be needed to benefit from IT-enabled economics of specialization and economies of scope. Most significantly, by focusing on the implications of specialized assets for production efficiency, rather than on transaction costs, this research explores the common ground between transaction cost economics and the resource-based view of the firm. In traditional transaction cost reasoning, specialized assets lead to increase in vertical integration as the literature emphasizes the transaction cost implications of specialized assets. However, the hypotheses suggest that tangible assets lead to a decrease in vertical integration as IT can enable firms to realize economics of specialization from their firm- and usage-specific tangible assets. Similarly, this research explores how IT can enable firms to realize economy of scope from their firm-specific but usage-flexible intangible assets. These implications of specialized assets are similar to the importance placed on firm-specific resources and capabilities in the resource based view, to provide a competitive advantage.

The managerial implication of this research is that firms with more firm- and usage-specific tangible assets may use IT to specialize vertically; whereas firms with more firm-specific but usage-flexible intangible assets may use IT to diversify into different product markets. However, in order to benefit from IT-enabled economics of specialization and economies of scope, firms need to make appropriate investments in IT assets and applications. Vertical specialization may require investment in inter-organizational information systems such as Electronic Data Interchange systems and participation in Business-to-Business electronic exchanges, and the implementation of architectural information systems like Enterprise Resource Planning systems. On the other hand, to generate greater value from intangible assets, firms may need to invest in an enterprise-wide data, applications, and communications infrastructure that enable them to leverage intangible assets such as customer knowledge and brand reputation, across different product markets.

The analysis (in Table 2.2) also enables us to compare the main effects of different assets on firm scope, with the moderating influence of IT on the impact of assets on firm scope. On average, brand has a negative impact on diversification. However, in general, the interaction between IT and brand has a positive impact on diversification. This suggests that IT may allow firms to leverage their brand across diversified businesses. This effect also holds in the case of market-valued intangible assets. In general, market-valued intangible assets have a negative impact on horizontal diversifications. However, the interaction between IT and market-valued intangible assets has a positive impact on horizontal diversification. This suggests that IT may enable firms to leverage their brand and market-valued intangible assets across different product markets.

The analysis (in Table 2.4A and Table 2.4B) allows us to compare the performance implications of the main effects of different assets with the performance implications of the interaction between IT and different assets. The main effect of tangible assets indicates that the performance contribution of tangible assets is lower in more diversified firms. This result is consistent with the extant literature (e.g., Chatterjee 1986; St. John and Harrison 1999) that suggests that tangible assets are firm- and usage-specific, and when they are leveraged across more diversified businesses, their impact on performance decreases. However, the impact of the IT and tangible asset interaction on performance is higher for more diversified firms. This suggests that IT also enables firms to leverage their tangible assets across different product markets. Afuah (2003) offers a plausible explanation for this finding. The argument is that IT can reduce asset specificity and enable firms to find more customers for their output.

Similar to tangible assets, when brand is leveraged across related businesses, performance decreases (i.e., the main effect of brand on performance decreases as related diversification increases). However, the interaction between IT and brand has a positive impact on performance in more related diversifications. On the contrary, technological capability has a relatively positive impact on performance when related diversification increases. However, the interaction of IT and technological capability is associated with a decrease in performance as related diversification increases. This analysis finds that technological capabilities behave differently from brand and market-valued intangibles.

Technological capabilities are more valuable when IT is used to coordinate R&D activities in less diversified firms, whereas brand and market-valued intangibles are more valuable when IT is used to leverage them across more diversified markets. A plausible explanation here is that technological capability is more firm- as well as usage-specific. As Bettis (1981), Montgomery and Wernerfelt (1988), and Miller (2004) indicate, technological capabilities are more profitable when they are used to diversify in a narrow range of related industries. Since IT may enable firms with more technological capabilities to coordinate with external partners, such firms choose narrow vertical and horizontal specialization. This issue is an interesting avenue for further research.

# Chapter 3: Reexamining Environmental Uncertainty and Decentralization in IT Governance: A Moral Hazard Perspective

## 3.1 Introduction

IT governance refers to the organizational pattern of decision-making for IT-related activities, such as the management of IT infrastructure, IT principles, application development, service delivery, and IT investment (Sambamurthy and Zmud 1999; 2000; Weill and Ross 2005). A major focus of IS research on IT governance concerns with whether the decision authority regarding key IT-related activities should be delegated to business units or should they be centrally controlled by a corporate IT unit. Sambamurthy and Zmud (1999) identify three primary modes of IT governance: *centralized* governance (where the decision authority for most IT activities resides primarily with corporate IS managers), *decentralized* governance (where the decision authority for most IT activities resides primarily with divisional IS managers and line managers), and *federal* governance (where both corporate IS managers and divisional IS managers (or line managers) assume authority for different types of IT activities). Weill and Ross (2005) identify six archetypal approaches to IT decision making, ranging from the highly centralized to highly decentralized as *business monarchy*, *IT monarchy*, *federal system*, *IT duopoly*, *feudal system*, and *anarchy*. As it is well recognized that there is no single best IT governance structure since IT needs to fit distinct organizational contexts and respond to diverse environments (e.g., Zmud 1984; Agarwal and Sambamurthy 2002), understanding how the choice of IT governance is influenced by various organizational and environmental contingency factors is important for designing effective IT organizational structure.

Prior research has studied a variety of internal organizational factors and external environmental factors that influences IT governance. Internal organizational factors include: firm size (Ahituv et al. 1989; Brown and Magill 1994; Clark 1992; Ein-Dor and Segev 1982; Tavakolia 1989), corporate strategy (Brown and Magill 1994; Tavakolia 1989), and corporate governance structure (Ahituv et al. 1989; Brown and Magill 1994; Tavakolia 1989). External environmental factors include industry type and environmental turbulence (Brown and Magill 1994; Brown 1997; Hann and Weber 1996). Various arguments have been made to explain how these factors influence IT governance. The main argument here is that IT governance is a trade-off between cost-efficient operations and the need for processing local information. When the potential benefits of cost-efficiency are large, firms are more like to adopt centralized IT governance. For example, it is well-accepted that centralized governance may be less cost-efficient in large, multidivisional corporations. As a result, large firms are more likely to adopt decentralized IT governance (Ein-Dor and Segev 1982). Also, the need for processing local information influences IT governance. As specialized knowledge about how to response to the environment often resides with business units, organizations may decentralize IT governance to enable business units to better process external information. For example, it has been shown that decentralized IT governance is more likely to be adopted in organizations with decentralized corporate governance, as division units are more informed about their specific business processes (Brown and Magill 1994; Ein-Dor and Segev 1982; Tavakolian 1989). Likewise, firms with unrelated businesses are more likely to adopt decentralized IT governance (Boynton et al. 1994) due to the information asymmetry between the headquarters and business units.

A major driver of decentralization in IT governance is external environmental uncertainty. Past research has hypothesized a positive relationship between environmental uncertainty and decentralization in IT governance (e.g., Allen and Boynton 1991). The rationale is that in uncertain environments, organizations tend to have increased needs for information processing (Galbraith 1973). Thus the argument is that in unstable environments decentralized IT governance enables responsiveness by improving business units' information processing capabilities (Allen and Boynton 1991). However, the results of empirical studies are mixed. For example, in a case study, Brown (1997) finds that unstable industry environment drives the organization to adopt decentralized governance in system development. On the other hand, Hann and Weber (1996) do not find significant empirical evidence that higher level of environmental uncertainty is associated with higher levels of delegation of IS decision rights to IS managers. Our research data on IT purchase decision at 455 business sites of Fortune 1000 companies shows a similar pattern. An analysis of the correlation between decentralization in IT purchasing decisions and environmental uncertainty reveals that firms tend to adopt centralized, rather than decentralized IT governance in more turbulent and complex business environments (the correlation table is in Section 4 of this paper).

The reason for these mixed empirical results, we argue, is that prior studies examining the relationship between environmental uncertainty and decentralization in IT governance overlook the potential moral hazard problem. While environmental uncertainty increases the value of decentralization from the perspective of information processing, it also exaggerates the moral hazard problem as it is harder for headquarters to monitor business units' decisions in more uncertain environments. Thus the objective of this paper is to reexamine the relationship between environmental uncertainty and decentralization in IT governance, in the presence of moral hazard problem.

Drawing upon the agency theory to reflect model hazard in IT governance, we build an analytical principal-agent model to illustrate two conflicting forces that environmental uncertainty exhibits. First, the model captures how environmental uncertainty drives the firm (the principal) to delegate IT decision rights to business units (the agent) in order to leverage business units' information advantage. Second, the model captures how environmental uncertainty may amplify the agency cost associated with delegation of authority. Considering these two forces, the model reveals that the relationship between environmental uncertainty and decentralization in IT governance is an inverted-U relationship. In either highly stable or highly uncertain environments, organizations tend to adopt more centralized IT governance. Decentralized IT governance is the optimal choice only when the level of environmental uncertainty is in an intermediate range. The explanation is as follows. In a stable environment, the headquarter's information disadvantage is not critical and therefore the firm prefers centralized IT governance. As environmental uncertainty increases, firms seek to achieve more responsiveness by delegating decision-making to business units. However, decentralization inevitably introduces agency cost when unit managers' interests are not aligned with that of the organization. The agency cost manifests itself as the business units' discretionary investment that is not monitored by the headquarters (moral hazard).

Our model shows that agency cost may escalate in uncertain environments. Therefore, when the environment is highly unstable, the agency cost associated with decentralization can exceed the information benefit brought about by decentralization. As a consequence, decentralized IT governance is not an optimal choice for organizations in highly uncertain environments. Our study also reveals that the net benefit of decentralization, i.e., the benefit of processing local information net of agency cost, first increases and then decreases with environmental uncertainty. That is, the relationship between the likelihood of adopting decentralized IT governance and environmental uncertainty exhibits an inverted-U-shaped relationship.

To confirm the implication of the analytical model, we conduct an empirical study to test the existence of an inverted-U-shaped relationship between environmental uncertainty and organizations' adoption of decentralized IT governance. We analyze a panel dataset capturing the IT purchasing decisions at 455 divisional sites of Fortune 1000 companies from year 2001 to 2005. The empirical analysis considers the probability that these sites adopt decentralized decision-making in IT purchasing. We find that sites in highly stable or highly uncertain business environments are more likely to adopt centralized decision-making in IT purchasing. Decentralized decision-making in IT purchasing is more likely to be adopted for sites in the business environments with intermediate uncertainty.

The contribution of this paper is twofold. First, this research adopts the moral hazard perspective in studying the relationship between environmental uncertainty and IT governance. Existing literature on IT governance largely recognizes the information advantage of local decision makers in unstable environments, and therefore focuses on the positive relationship between environmental uncertainty and decentralization. However, prior literature has not sufficiently considered the moral hazard problem in IT governance. We introduce moral hazard into the IT governance model and show that environmental uncertainty can increase agency cost in uncertain environments. Thus, our approach provides a new perspective in understanding IT governance.

Second, we provide an explanation for the discrepancy between prior theoretical prediction and empirical findings on the influence of environmental uncertainty on decentralized IT governance. We show that the relationship between environmental uncertainty and IT governance may follow an inverted-U-shaped curve. Prior literature did not capture this nonlinear relationship. The examination of this nonlinear relationship also follows the call of Sambamurthy and Zmud (1999) to study multiple effects of contingency factors on IT governance. Sambamurthy and Zmud (1999) note that existing literature on IT governance has focused on the singular effects of the contingency factors, and therefore they apply the theory of multiple contingencies to examine the interaction effects (e.g., amplifying, dampening, or overriding) between multiple contingency factors. This paper takes another perspective and extends the research on IT governance by examining multiple conflicting forces (i.e., information processing versus agency cost) of the environmental uncertainty contingency factor.

The rest of this chapter is organized as follows. Section 3.2 reviews the related literature on IT governance and agency theory. Next, section 3.3 presents an analytical principal-agent model to illustrate the relationship between environmental uncertainty and decentralized IT governance. Section 3.4 describes the empirical study that tests the relationship between environmental uncertainty and decentralized IT governance. Section 3.5 concludes the paper and discusses directions for future research.

### 3.2 Related Literature

Prior literature on IT governance has identified an array of contingency factors, which can be divided into two broad categories: internal organizational factors and external environmental factors. Sambamurthy and Zmud (1999) summarize internal organizational factors into three sets of forces: corporate governance, economies of scope, and absorptive capacity. *Corporate governance* concerns whether organizations adopt centralized or decentralized decision-making in their general business management. Since companies tend to align their IT governance with their corporate governance, IS researchers have found that centralized (decentralized) IT governance are more likely to be adopted in companies with centralized (decentralized) corporate governance (Brown and Magill 1994; Ein-Dor and Segev 1982; Olson and Chervany 1980). Moreover, since large firms tend to divisionalize their operations and adopt decentralized corporate governance, they are more likely to decentralize their IT governance (Ein-Dor and Segev 1982).

*Economies of scope* concerns whether organizations focus on a narrow range of businesses or diversify into a wide range of businesses. When firms focus on a set of related businesses, they tend to possess more unified business processes which allow them to adopt more centralized IT governance. When firms diversify into more unrelated business areas, the dissimilarity between business processes in different businesses tend to drive firms to adopt more decentralized IT governance (Boynton et al. 1992; Brown and Magill 1994). *Absorptive capacity* concerns whether an organization's employees possess sufficient IT knowledge and are able to make appropriate IT decisions. An organization with high absorptive capacity is more likely to delegate IT decisions to local managers, while organizations with low absorptive capacity tend to centralize IT governance (Boynton et al. 1994; Brown and Magill 1998).

Existing literature has examined the impact of environmental uncertainty on different organizational characteristics (e.g., Ghemawat and Richart I Costa 1993; Boyd 1995; Keats and Hitt 1988; Palmer and Wiseman 1999). Dess and Beard (1984) use factor analysis to characterize environmental uncertainty into a parsimonious set of three variables: dynamism, munificence and complexity. Dynamism captures the variance in industry sales and identifies difficult-to-predict industry changes (Palmer and Wiseman 1999). Munificence captures the growth in industry sales and identifies availability of resources to support growth (Dess and Beard 1984; Palmer and Wiseman 1999). Complexity captures the change in firms' market shares and identifies the competition-driven complexity (Keats and Hitt 1988). Studies in strategic management and organization science suggest that environmental uncertainty is associated with the increased need for information processing (e.g., Ghemawat and Richart I Costa 1993; Jensen and Meckling 1992). In this regard, business organizations in highly unstable and complex environments may have more decentralized governance structure.

The potential influence of environmental factors on IT management has also received much attention in recent IS literature. For example, Agarwal and Sambamuthy (2002) note that firms need to organize IT to nurture external relationship networks such as multisourcing agreements, strategic alliances and joint ventures. Complex and turbulent environments impose a challenge for this type of IT organization. The study of Mitchell (2006) on IT project performance finds that the timely completion of EAI (enterprise application integration) project is contingent on the management's integration of both internal knowledge and external knowledge. Environmental factors such as competition and uncertainty can significantly affect the organization's import of knowledge from external communication networks, and thus impact the success of IT projects.

Despite the recognition of the potential impact of environmental uncertainty on IT governance, the literature provides inadequate understanding of how environmental uncertainty affects the organization's choice of IT governance. The existing empirical evident is inconclusive with respect to the relationship between environmental uncertainty and IT governance. For example, Brown (1997) used a single case study to suggest that business units in highly unstable industries are more likely to have decentralized IT governance. However, in order to generalize this argument, empirical studies with larger samples are needed. Hann and Weber (1996) conducted a survey to study the decision of delegation in IS planning. They did not find significant evidence that higher senior manager uncertainty is associated with higher levels of delegation of decision rights to IS managers. Ahituv et. al. (1989) examined hardware distribution in 303 organizations across 5 economic sectors (manufacturing, commerce, service, non-profit, and horizontally integrated conglomerate). They found that there is no significant relationship between the adoption of decentralized decision-making in hardware distribution and firms' economic sectorial association. Olson and Chervany (1980) studied information services within organizations and found that there is no significant industry effect on the adoption of decentralized information services. Considering the results from all these studies, it is clear that there is a need to further investigate whether and how environmental factors impact IT governance.

There is also research that explores how IT governance affects other organizational factors and business performance. For example, Weill and Ross (2004) report that firms with effective IT governance garner profits that are 20% higher than those of other companies pursuing similar strategies. Pawlowski and Robey (2004) investigate knowledge brokering as an aspect of the work of information technology professionals. Their research suggests that knowledge brokering by IT professionals is conditioned by the use of decentralized or federal structure in IT governance. Tanriverdi (2006) examines IT synergies in multibusiness organizations. The study finds that IT synergies improve business performance and that the IT governance mode of the firm (centralized, decentralized, or federal) does not affect the performance implications of IT synergies.

Our analytical model incorporates features from two streams of literature. First, the adoption of principal-agent framework to study the information and agency problems in centralized/decentralized governance has its root in economics and management literature. For example, Harris and Raviv (1998) and Marino and Matsusaka (2004) use a similar principal-agent model to study the problem of capital budget allocation. In IS literature, agency-theory analysis has also been used in some studies concerning the issue of IT governance (e.g., Gurbaxani and Whang 1991; Hann and Weber 1996). Second, our approach of modeling environmental uncertainty is also consistent with the existing models of organizational information processing. For example, Ghemawat and Richart I

Costa (1993) use a similar modeling setup to study the organization's pursuit of two sorts of efficiency: static efficiency (improvement on existing processes) and dynamic efficiency (search for new opportunities).

### 3.3 The Analytical Model

We posit that the organization is comprised of a headquarter and a business unit. The headquarter is considered as the principal and the business unit is considered as the agent. The state of the world faced by the business unit is represented by an unknown random variable $\theta$. $\theta$ is drawn from a normal distribution with mean $\mu$ and variance $v$. Note that the value of $v$ captures the degree of environmental uncertainty. Both the principal and the agent can learn the state of the world. Specifically, the principal can observe a noisy signal $S$, which is normally distributed with mean $\theta$ and variance of $d$. The agent, in contrast, observes the value of $\theta$. Therefore, the term $d$ captures the degree of information asymmetry between different levels of management, or the degree of information advantage of the agent. The purpose of acquiring information about the state of the world is to assist IT investment decision at the business unit level. Suppose the IT investment is $I$, the payoff of the principal is represented as

$$U_P = \theta\sqrt{I} - I \tag{3.3.1}$$

where the term $\theta\sqrt{I}$ is defined as the return of the IT investment. Note that (3.3.1) implies that the payoff of the principal is a concave function of the investment. This functional form has been used to model investment return in many other studies (e.g., Agrawal 1996). The principal's objective is to maximize the profitability of IT investment. The payoff of the agent is represented as

$$U_A = \theta\sqrt{I} - I + aI = \theta\sqrt{I} - (1-a)I \tag{3.3.2}$$

Note that compared with (3.3.1), the agent derives extra utility (captured by $aI$) in making excess investment. Such private interest in excess investment can be explained from various perspectives, such as empire-building (Harris and Raviv 1998).

We first examine the case when the principal pursues centralized IT governance. In this case, the principal, rather than the agent, chooses the IT investment. The principal will choose an IT investment $I^C \in \max_I E(U_P)$ (the superscript $C$ denotes the case of centralization). Given the normal prior distribution of $\theta$ and the normal signal, the posterior distribution of $\theta$ is normal with mean $(vs + d\mu)/(v+d)$ and variance $vd/(v+d)$ (Cyert and DeGroot 1987). Therefore, given the signal observed by the principal, its expected payoff can be represented as $E(U_P) = E(\theta|S)\sqrt{I} - I$. The first-order condition (FOC) $\partial E(U_p)/\partial I = 0$ yields the optimal IT investment in the case of centralization,

$$I^C = \frac{[E(\theta\,|\,s)]^2}{4} = \frac{1}{4}\left(\frac{vs + d\mu}{v+d}\right)^2$$

The principal's expected payoff in the case of centralization can be represented as (more details are in Appendix A1)

$$E\left[U_P^C\right] = E\left[\theta\left(\frac{1}{2}\left(\frac{vs+d\mu}{v+d}\right)\right) - \frac{1}{4}\left(\frac{vs+d\mu}{v+d}\right)^2\right] = \frac{\mu^2}{4} + \frac{v^2}{4(v+d)} \tag{3.3.3}$$

Second, we examine the case when the principal pursues decentralized IT governance. In this case, the agent decides the level of IT investment. Since the agent maximizes its own payoff, the IT investment satisfies $I^D \in \max_I E(U_A)$ (the superscript $D$ denotes the case of decentralization). Also, since the agent always observes $\theta$, its payoff conditional on observing $\theta$ can be represented as $U_A = \theta\sqrt{I} - (1-a)I$. The FOC $\partial U_A / \partial I = 0$ yields the optimal IT investment

$$I^D = \left[\frac{\theta}{2(1-a)}\right]^2$$

Therefore, the principal's expected payoff in the case of decentralization can be represented as

$$E\left[U_P^D\right] = E\left[\frac{\theta^2}{2(1-a)} - \frac{\theta^2}{4(1-a)^2}\right] = \frac{(1-2a)}{(1-a)^2}\left(\frac{\mu^2+v}{4}\right) \tag{3.3.4}$$

Comparing (3.3.3) with (3.3.4), the principal will choose centralized IT governance when $E\left[U_P^C\right] \geq E\left[U_P^D\right]$, and choose decentralized IT governance if $E\left[U_P^C\right] < E\left[U_P^D\right]$. To understand the trade-off between the need for information processing and the moral hazard problem, let us rewrite the principal's expected payoff in the centralization case as

$$E\left[U_P^C\right] = \frac{\mu^2+v}{4} - \frac{v}{4}\left(\frac{d}{v+d}\right) \tag{3.3.5}$$

and the principal's expected payoff in the decentralization case as

$$E\left[U_P^D\right] = \frac{\mu^2+v}{4} - \left(\frac{a}{1-a}\right)^2\left(\frac{\mu^2+v}{4}\right) \tag{3.3.6}$$

Note that the first term in (3.3.5) and (3.3.6), $\frac{\mu^2+v}{4}$, represents the principal's expected payoff if it always observes the state of the world $\theta$ and adopts centralized IT governance. The second term in (3.3.5), $\frac{v}{4}\left(\frac{d}{v+d}\right)$, represents the cost of information disadvantage, i.e., the cost induced by the principal's inability to always observe the state of the world. The second term in (3.3.6), $\left(\frac{a}{1-a}\right)^2\left(\frac{\mu^2+v}{4}\right)$, represents the agency cost, i.e., the cost induced by the agent's incentive to overinvest. The choice between centralization and decentralization can then be determined by the comparison between the cost of information disadvantage associated with centralization and the agency cost associated with decentralization. Proposition I summarizes the optimal solution for the principal.

**Proposition 3.1** *1) When the agent has too much private incentive to overinvest ($a \geq \frac{1}{2}$), the principal chooses centralized IT governance;*

*2) When the agent has limited private incentive to overinvest ($a < \frac{1}{2}$), principal's choice of IT governance depends on its information disadvantage and environmental uncertainty. When his information disadvantage is small ($d \leq \frac{\mu^2 a^2}{1-4a(1-a)}$), the principal chooses centralized IT governance. When his information disadvantage is significant ($d > \frac{\mu^2 a^2}{1-4a(1-a)}$), the principal's choice of IT governance depends on environmental uncertainty:*

*2.1) when environmental uncertainty is small ($v \leq v^1$), the principal chooses centralized IT governance;*

*2.2) when environmental uncertainty is of an intermediate value, ($v^1 < v < v^2$), the principal chooses decentralized IT governance;*

*2.3) when environmental uncertainty is large ($v^2 \leq v$),, the principal chooses centralized IT governance.*

Proposition 3.1 indicates that it is always optimal for the principal to centralize the IT governance when the agent has too much private incentive to overinvest or when it has little information disadvantage compared to the agent. In these two cases, the level of environmental uncertainty does not affect the principal's decision. Therefore, we focus on the more interesting and relevant case illustrated by Proposition 3.1.2.1-3.1.2.3 where the level of environmental uncertainty affects the principal's decision.

As Proposition 3.1.2.1 states, when the degree of environmental uncertainty ($v$) is small enough, the principal chooses centralized IT governance. This is consistent with the suggestion in prior literature that centralized IT governance is more likely to be adopted in stable environments (Allen and Boynton 1991). In this case, the cost of information disadvantage is smaller than the agency cost. The gain of decentralization, represented by $E\left[U_P^D\right]-E\left[U_P^C\right]$, is negative and decentralization is dominated by centralization. However, as stated in Proposition 3.1.2.3, in a highly uncertain environment where $v$ is sufficiently large, it is also optimal for the principal to choose centralized IT governance. In this case, the agency cost is large enough to exceed the cost of information disadvantage. Proposition 3.1.2.2 reveals that the principal chooses decentralized IT governance only when the environmental uncertainty is of an intermediate value, i.e. $v^1 < v < v^2$. The key implication here is that when $v$ is large, the agency cost associated with decentralized IT governance can also be high and eventually offset the benefit of local information brought about by decentralization. Proposition 3.2 further characterizes the benefit of decentralization.

**Proposition 3.2** *The gain of decentralization, defined by* $E\left[U_P^D\right]-E\left[U_P^C\right]$*, first increases and then decreases in environmental uncertainty v.*

Proposition 3.2 indicates that there is an inverted-U-shaped relationship between the benefit of decentralization and environmental uncertainty. Using a numerical example with $a = 0.3$, $\mu = 1$, and $d = 2$, Figure 3.1 presents how the gain of decentralization changes with environmental uncertainty *v*. As Figure 3.1 illustrates, when *v*<0.26, the gain of decentralization is negative. In this case, it is optimal for the principal to choose centralization. When *v*<2.67, the gain of decentralization is increasing in *v*. However, when *v* exceeds 2.67, the gain of decentralization starts to decrease in *v*. When *v*>7.6, the gain of decentralization is also negative. In this case, it is also optimal for the principal to adopt centralization. Only when 0.26<*v*<7.6, the gain of decentralization is positive and thus the principal finds it optimal to delegate decision-making to the agent.

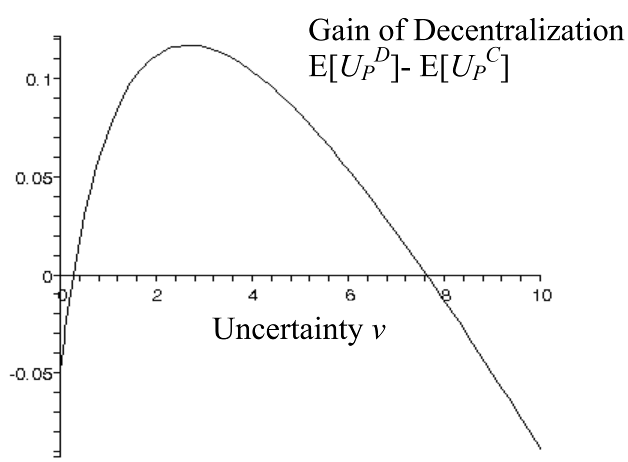


**Figure 3.1: The Gain of Decentralization as a function of Uncertainty *v***

Figure 3.2 compares the principal's cost of information disadvantage (the second term in Eq. 3.5) and the agency cost (the second term in Eq. 3.6). When *v*<0.26, the cost of information disadvantage is smaller than the agency cost. That is why the benefit of decentralization is negative. When $0.26<v<7.6$, the cost of information disadvantage is higher than the agency cost. Moreover, the agency cost increases slower (faster) than the cost of information disadvantage when $v$ < (>) 2.67. When $v>7.6$, the agency cost exceeds the cost of information disadvantage again. This explains why decentralized IT governance is not favored in this case.

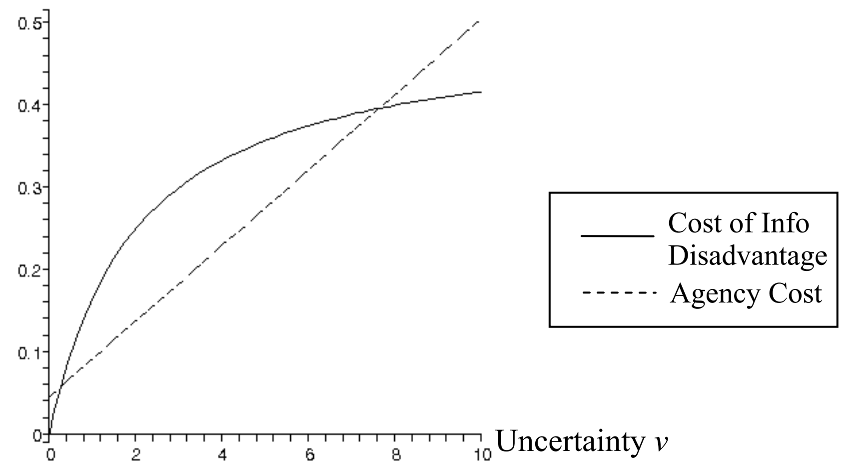


**Figure 3.2: Cost of Information Disadvantage (of the Principal) Versus Agency Cost**

### 3.4 Empirical Evidence

The analytical model in the previous section indicates that the relationship between environmental uncertainty and decentralization in IT governance exhibits as an inverted-U-shaped relationship. To test this theoretical implication, we conduct an empirical analysis using a unique dataset on IT purchase decision at the business unit level.

The data on IT governance is obtained from the *CI Technology Database*. This database contains information about the IT infrastructure in over 500,000 sites in the

United States and Canada. Harte-Hanks maintains this database through over 7,000 phone-based interviews every month. The information in the database covers 10 key IT areas, including personal computing, systems and servers, networking, software, storage, and managed services. This database has been used in existing IS literature (e.g., Dewan and Min 1997; Hitt 1999). *CI* database also records three types of IT decision at each business site: PC purchasing decision, server purchasing decision, and network purchasing decision. For each decision, the database indicates whether this decision is made by the headquarters (represented as "Parent") or by the business units (represented as "Local"). In other words, the *CI* database captures the degree of centralization/decentralization in IT purchasing decision at the site-level. Our dataset covers all business unit sites that belong to Fortunate 1000 companies between 2001 and 2005. From this database, we build our data sample based on the following criteria. Since our measures of environmental uncertainty are based on data over a 5-year period from 2001 to 2005 (see below for details), we select those business unit sites with no significant change in their IT governance pattern within this 5-year period. Our final dataset contains 455 business unit sites, all of which belong to Fortunate 1000 companies.

Using data at the site level has some advantages. Brown (1997) suggests that for large enterprises with different IT governance patterns across business units, factors at the business unit level, rather than at the enterprise level, provide a better explanation of the governance pattern within individual business units. The companies included in our sample are all large, multidivisional companies. There is enough variation in IT governance patterns across business units of the same firms. Therefore, analyzing the data at the business unit level is more appropriate.

We also complement our dataset with two other data sources. First, we use *Compustat* Segment database to measure environmental uncertainty for each business site. Following strategy literature, we measure environmental uncertainty using three variables: dynamism, munificence, and complexity (details are provided below). Second, we measure the business relatedness between each site and the primary segment of the corresponding company. If a site's business is highly related to its headquarter site's business, then the information asymmetry between the site and the headquarter should be relatively low. Also, following prior literature (e.g., Fan and Lang 2000), we measure the business relatedness using three variables: vertical relatedness (*StVI*), horizontal relatedness (*StHC*), and product market diversification (*StDiv*). Vertical relatedness captures the degree of vertical integration between the division and the headquarter in terms of buying and selling activities. Horizontal relatedness captures commonality between the division site's and the headquarter site's buying and selling processes. Product market diversification is measured by the difference between the division's and the headquarter's participation in different NAICS industries. The measurement details of vertical relatedness, horizontal relatedness, and product market diversification are provided in Appendix A2.

### 3.4.1 Operationalization

We use a binary variable *ITDec* to indicate whether a business site adopts more centralized decision-making or more decentralized decision-making in IT purchasing. Since there are three types of IT purchase decision (i.e., PC, server, network) recorded for each site, if at least two decisions are made by local managers, we set *ITDec*=1, which means that the business site adopts a more decentralized decision-making in IT purchasing. Otherwise, if at least two decisions are made by the headquarter site, we set *ITDec*=0, which means that the business site adopts a more centralized decision-making in IT purchasing.

We measure 3 environmental variables: dynamism (*Dyn*), munificence (*Mun*), and complexity (*Cmpx*) (Keats and Hitt, 1988). Dynamism captures the uncertainty in demand, munificence captures the sales growth in an industry, and complexity captures the uncertainty caused by competition. Following Keats and Hitt (1988), industry dynamism and industry munificence are measured using a two-step procedure. First, the natural logarithm of the total sales of four-digit NAICS industries is regressed against an index variable of years over a period of five years. Then the antilog of the standard error of the regression coefficient is used as the measure for dynamism, and the antilog of the regression coefficient is used as the measure for munificence. To measure complexity, we first run a regression of market shares of all firms in an industry against their market shares five years ago. Then the regression coefficient of the independent variable is taken as the measure of complexity.

We have the following control variables. First, we use the ratio of IT employees to total employees as a control variable for the IT knowledge at the site-level. Second, we use the site's total employee as a control variable for the site's size. Table 3.2 presents the correlation between the key variables. As Table 3.2 illustrates, the degree of decentralization has a negative correlation with all of the three environmental factors. This suggests that more decentralized IT governance is not adopted in highly uncertain environments.

| | *ITDec* | *StVI* | *StHC* | *StDiv* | *Dyn* | *Mun* | *Cmpx* | *ITEmp* | *StEmp* |
|---|---|---|---|---|---|---|---|---|---|
| *ITDec* | 1 | -.092 | -.053 | .070 | -.127** | -.094* | -.107* | -.063 | .190** |
| *StVI* | -.092 | 1 | .390** | -.317** | .406** | -.261** | .031 | .160** | -.014 |
| *StHC* | -.053 | .390** | 1 | -.756** | .186** | .042 | .096* | .010 | .047 |
| *StDiv* | .070 | -.317** | -.756** | 1 | -.204** | -.074 | -.169** | .077 | -.158** |
| *Dyn* | -.127** | .406** | .186** | -.204** | 1 | -.405** | .129** | .088 | -.041 |
| *Mun* | -.094* | -.261** | .042 | -.074 | -.405** | 1 | .420** | -.117* | .028 |
| *Cmpx* | -.107* | .031 | .096* | -.169** | .129** | .420** | 1 | .084 | -.004 |
| *ITEmp* | -.063 | .160** | .010 | .077 | .088 | -.117* | .084 | 1 | -.344** |
| *StEmp* | .190** | -.014 | .047 | -.158** | -.041 | .028 | -.004 | -.344** | 1 |

** $p < 0.01$ (2-tailed); * $p < 0.05$ (2-tailed); N=455

**Table 3.2 Correlation Table**

### 3.4.2 The Existence of Agency Behavior

We first conduct a test to check whether the delegation of IT purchasing decision to local managers leads to more volatile IT investment. Such a test can help us confirm the validity of the principal-agent analysis. Note that according to the principal-agent theory, delegation of the decision leads to discretionary investment by managers. Therefore, we expect that decentralized IT governance leads to higher volatility in IT investment.

To measure the volatility of a site's IT investment, we first calculate a site's IT capital for each year in the following way. We estimate the total value of PCs and servers as (# of PCs)×960+5×(# of servers)×960. This calculation is based on the industry estimation that the average PC price is $960 (Zdnet 2005) and the average price of server is five times that of PC (Edwards and Tiley 2004). Also, following existing literature (e.g., Hitt and Brynjolfsson 1996; Dewan and Min 1997), we estimate a site's IT capital as the sum of total value of PCs and servers (deflated using Index for Investment in

Private Nonresidential Fixed Asset obtained from BLS and converted into year 2001 values) and 3 times of IT labor cost. IT labor cost is measured by multiplying the number of a site's IT employees with industry-average labor compensation, deflated using the Index of Total Compensation Cost. Next, early industry research reports that the total-ownership-cost (TOC) of all networked LAN PCs each year is \$11900×# of LAN Nodes (Cappuccio and Kirwin 1996). We consider the deflated value of this TOC measure (deflated using general GDP discount factor). We estimate that the total IT asset value for a site as the average value of these two measures, i.e., (IT capital + TOC)/2. Note that the use of the second measure is to partially address the potential issue of missing expenditure on software in the first measure.

Next, for each site, we conduct a regression of the change in IT asset value for each year against the site's previous year's revenue, and take the standard error of this regression as the measure of IT investment volatility (*ITV*). The rationale is as follows. A high standard error of regression means that the site's IT budget is less predictable by the site's revenue. In other words, the IT budget is based less on a routine pattern (e.g., a certain percentage of revenue) and there are more discretionary investments. Then we conduct the following regression.

$$ITV_i = \beta_0 + \beta_1 ITDec_i + \beta_2 Dyn_i + \beta_3 Mun_i + \beta_4 Cmpx_i + \beta_5 ITEmp_i + \varepsilon_i \qquad (3.4.1)$$

Table 3 presents the results of the estimation model in (3.4.1). As Table 3.3 indicates, the coefficient of *ITDec* is positive and significant. This implies that the adoption of more decentralized IT purchases decision significantly increases the volatility of IT investment. This result is consistent with the argument of agency theory that the agents (i.e., divisional managers) are more adaptive to the changes in the environment.

| Variable | Coefficient | t | *p*-value |
|---|---|---|---|
| *ITDec* | $.130^{**}$ | 2.718 | .007 |
| *Dyn* | -.022 | -.398 | .691 |
| *Mun* | -.016 | -.259 | .796 |
| *Cmpx* | .008 | .149 | .882 |
| *ITEmp* | $-.080^{\dagger}$ | -1.675 | .095 |
| $R^2$ | | 0.03 | |
| *F value* | | $2.358^{*}$ | |

Note: 1. Dependent variable: *ITV*; 2. Standardized coefficients are reported; 3. N=455; 4. $^{**}$ $p < 0.01$; $^{*}$ $p < 0.05$; $^{\dagger}$ $p < 0.1$.

**Table 3.3 Model on the Agent Behavior**

Moreover, the results provide certain evidence about the existence of agency problem and agency cost. Note that in the estimation model (3.4.1), environmental variables are taken as control variables. Table 3.3 shows that the coefficients of 3 environmental variables are not significant. Ideally, if divisional managers' investment incentives are well aligned with that of the organization and no agency problem exists, the delegation of decision rights should allow the organization to be perfectly responsive to the environmental turbulence and the variance of the dependent variable (IT investment volatility) should be associated significantly with the variance of the environmental variables. However, as the results indicate, the variance of IT investment volatility is explained mainly by the variance of IT governance structure, rather than that of the environmental uncertainty. This implies that divisional managers' discretionary investment is the main driver of investment volatility and the potential for the agency problem exists.

Another finding from Table 3.3 is that the coefficient of *ITEmp* is negative and marginally significant ($p$<0.1). This implies that the IT knowledge at the site-level helps reduce the agency cost caused by the local manager's strategic behaviors. One potential interpretation of this result is that sites with high ratio of IT employees to total employees are more IT-focused businesses. Therefore, their IT budgets are more in accordance with their revenues.

### 3.4.3 The Inverted-U-Shaped Relationship

Next, we examine how environmental uncertainty influences decentralization in IT purchasing decisions. We use a series of binary logistic regression models to test the relationship between the environmental uncertainty and the adoption of decentralized IT governance at each business site. The logistic regression models are represented as follows,

$$Prob(ITDec_i{=}1) = \beta_0 + \beta_1 Dyn_i + \beta_2 Mun_i + \beta_3 Cmpx_i + \beta_4 ITEmp_i + \beta_5 StVI_i + \beta_6 StHC_i + \beta_7 StDiv_i + \beta_8 StEmp_i + \beta_9 Unc_i^2 + \varepsilon_i \quad (3.4.2)$$

where *Unc*={*Dyn*, *Mun*, *Cmpx*}. Note that the dependent variable *ITDec* is coded as a binary variable with value 0 (centralization) or 1 (decentralization). The logistic regression model basically captures how different organizational variables (such as *StVI* and *ITEmp*) and environmental variables (i.e., *Dyn*, *Mun*, *Cmpx*) influence the probability of adopting a more decentralized IT purchasing decision at each business site. By including a square term $Unc^2$ in the estimation model (3.4.2), we examine a nonlinear relationship between each environmental variable and the decentralization in IT purchasing decision. The results are presented in Table 3.4.

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Coefficients | p-value | Coefficients | p-value | Coefficients | p-value |
| (Constant) | -11.435 | 6.421 | -2.182 | .433 | 2.143 | .219 |
| *Dyn* | 22.637* | .033 | -.416 | .740 | -1.758† | .071 |
| *Mun* | -2.773** | .001 | 5.626† | .077 | -1.412† | .067 |
| *Cmpx* | .039 | .844 | .035 | .854 | .114 | .639 |
| *ITEmp* | -.107 | .906 | -.148 | .870 | .271 | .764 |
| *StVI* | -1.919† | .087 | -2.371* | .038 | -1.742 | .107 |
| *StHC* | .379 | .444 | .463 | .344 | .446 | .364 |
| *StDiv* | .195 | .352 | .188 | .367 | .226 | .280 |
| *StEmp* | .687** | .001 | .615** | .003 | .724** | .000 |
| $Dyn^2$ | -9.831* | .019 | | | | |
| $Mun^2$ | | | -3.993** | .016 | | |
| $Cmpx^2$ | | | | | -.198* | .041 |
| $R^2$ | 0.129 | | 0.127 | | 0.131 | |

Note: 1. Dependent Variable: $Prob(ITDec_i=1)$; 2. N = 455; 3. ** $p < 0.01$; * $p < 0.05$; † $p < 0.1$.

**Table 3.4: Logistic Model Results**

As Table 3.4 indicates, for model 1, the coefficient of *Dyn* is positive and significant, and the coefficient of $Dyn^2$ is negative and significant. This suggests that the increase of dynamism first increases and then decreases the probability of adopting decentralized IT purchase decision, i.e., an inverted-U-shaped relationship. Also, for model 2, the coefficient of *Mun* is positive and significant, and the coefficient of $Mun^2$ is negative and significant. This suggests that the increase of munificence first increases and then decreases the probability of adopting decentralized IT purchase decision. For model 3, the coefficient of $Cmpx^2$ is negative and significant; the coefficient of *Cmpx*, although insignificant, is still positive. Therefore, the results generally support the implication of our analytical model that the relationship between environmental uncertainty and the likelihood of adopting decentralized IT governance is an inverted-U-shaped relationship.

Table 3.4 also provides other results that validate our empirical models. For example, the coefficients of *StVI* in model 1 and 2 are negative and significant, suggesting that if a site's business is more vertically related to that of the headquarter, the company is less likely to adopt a decentralized IT governance at this site. This implies that companies seek more control over those sites with related business by centralizing the decision making. This result is consistent with the view of economics of scope, i.e., if a firm diversifies into related businesses, it is likely that the firm will centralize IT governance (Boynton et al. 1992; Brown and Magill 1994). Furthermore, the coefficients of *StEmp* in all the 3 models are positive and significant, suggesting that a company is more likely to adopt decentralized IT governance at a large site. This finding is in line with the prediction in the existing literature (e.g., Ein-Dor and Segev 1982) that decentralized IT governance is more likely to be adopted in larger organizations.

Figure 3.3 indicates an inverted-U-shaped relationship between the probability of decentralized IT purchasing decision and dynamism (with other independent variables at their mean values). When the absolute value of dynamism is small (i.e., $Dyn<1.16$), the probability of adopting decentralized IT purchase decision at a certain business site increases if dynamism increases. However, when the absolute value of dynamism is large (i.e., $Dyn>1.16$), the probability of adopting decentralized IT purchasing decision decreases in dynamism. Figure 3.4 shows a similar relationship between the probability of decentralized IT purchasing decision and munificence. The shapes of curves in Figure 3.3 and 3.4 are identical in nature to that in Figure 3.1. Therefore, the empirical study provides a general support for the implications of the theoretical model.

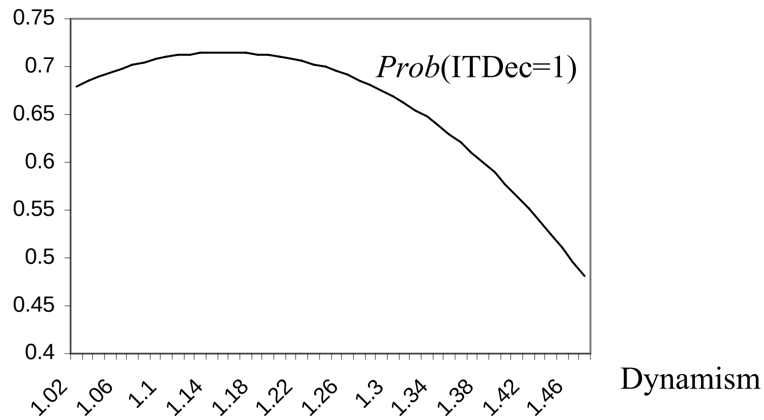


**Figure 3.3: The Inverted-U-Shaped Relationship between *Dynamism* and the probability of high decentralization (*ITDec*=1)**

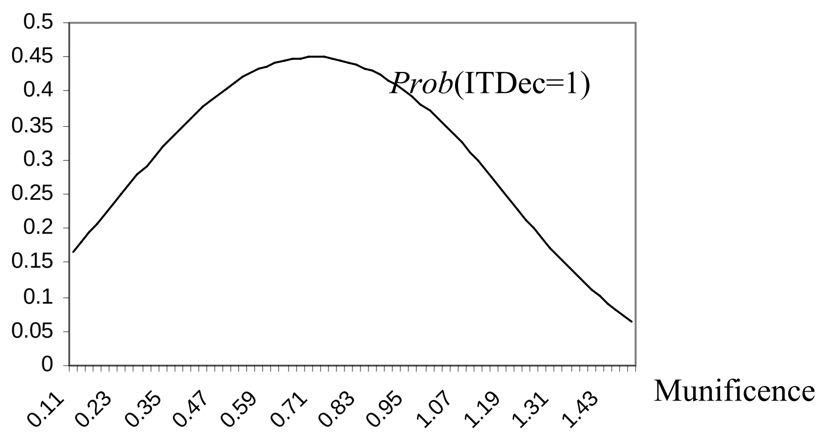


**Figure 3.4: The Inverted-U-Shaped Relationship between *Munificence* and the probability of high decentralization (*ITDec*=1)**

### 3.5 Discussion and Conclusion

The impact of environmental uncertainty on IT governance is quite complex since environmental factors may influence different organizational contingencies and generate conflicting forces on IT governance arrangement. Although previous studies consider the impact of external environment on the organization's choice of IT governance, they largely focused on the singular relationship between the environment and IT governance. This research, in contrast, argues that the relationship between the environment and the company's IT governance structure manifests itself as a more complex and nonlinear relationship.

Based on principal-agent theory, this study builds an analytical model to explain how environmental uncertainty influences the organization's IT governance. The key insight of this model is that environmental uncertainty impacts IT governance through two countervailing forces. On one hand, organizations in highly uncertain environments tend to adopt decentralized IT governance to leverage local managers' information advantage. On the other hand, highly unstable environments can induce managers to behave more strategically (the moral hazard problem) and exaggerate the agency cost. Therefore, the model suggests that decentralized IT governance may not be desirable in both the highly static environments and the highly uncertain environments. In highly static environments, the benefit of decentralization (i.e., the local managers' information advantage) is not significant enough, and firms do not have strong need for responsiveness. Highly unstable environments, on the other hand, may induce more strategic behaviors by the agents. In this case, the agency cost can be very high and offset the benefit of decentralization. Moreover, the analysis suggests that as environmental uncertainty increases, the benefit of decentralization first increases and then decreases, exhibiting an inverted-U shape.

Using a dataset of business sites, the empirical study in this paper confirms the key implication of the theoretical analysis. We examine three environmental factors in the empirical study, i.e., dynamism, munificence, and complexity. The inverted-U-shaped relationship is found between the decentralization of IT governance and dynamism, and between the decentralization of IT governance and munificence. When dynamism (or munificence) increases, the likelihood of decentralized IT governance adopted at a business site first increases and then decreases. Firms are less likely to adopt decentralized IT governance at their business sites either in highly stable environments or in highly uncertain environments.

This study calls for further consideration of the impact of the moral hazard problem and agency cost on IT governance. Hann and Weber (1996) find in their study that more delegation in decision-making is not associated with higher ex post agency cost. In their study, ex post agency cost refers to the cost of ensuring that the agent acts in accordance with the overall goals of the organization once the decision right is delegated. Therefore, it is reasonable that lower ex post agency cost is associated with more decentralized IT governance. In our study, agency cost is considered as economic loss (or inefficiency) caused by the strategic behaviors of the agent. Although the notion of agency cost in Hann and Weber (1996) is different from that in our study, their finding still provides an indirect support for our argument. In this paper, high agency cost is associated with less decentralized IT governance. Kahai, et. al. (2001) also find in their study on Fortune 1000 companies that the decision authority of IT management is more centralized than the allocation of IT recourses. Their explanation is that organizations seek to centralize their decision-making on hardware and software to save costs and avoid unrestricted proliferation. Excess expenditure and unrestricted proliferation can also be considered as examples of the agency cost.

One limitation of this study is that the IT purchasing decision in this study is mainly about hardware infrastructure. The decision making about other aspects of IT, such as software management and project management, may have different features. For example, the adoption of ERP systems may require centralized governance of software management, even though the hardware purchasing decision can be decentralized. Future studies may focus on different aspects of IT governance and explore whether environmental factors have similar influences on those aspects. The second limitation is that we did not directly measure the extent of agency cost. Instead, we confirm the existence of agency behavior by examining whether IT purchasing under decentralized governance is more volatile than that under centralized governance. One direction for future research is to directly measure the extent of agency cost and explicitly study whether agency cost tends to be higher in uncertain environments.

It is worth remarking that our research also contributes to the research in agency theory. Our theoretical and empirical findings are consistent with the predictions in classical agency theory, i.e., when environmental uncertainty limits the principal's ability to monitor and control the agent's performance, the agent tend to be increasingly constrained by the principal through centralization (Holmstrom and Milgrom 1991). However, other studies (e.g., Foss and Laursen 2005) find that output-based compensation scheme may mitigate the moral hazard problem and allow the organization to delegate more decision rights to agents in uncertain environments. Therefore, another future direction to extend this research is to examine in detail the characteristics of the moral hazard problem in IT governance. For example, future research may examine whether performance-based compensation schemes are used in IT-related management. Other research methodologies, such as in-depth survey, can be used to further measure agency cost under different IT governance structures. Studies can also focus on specific behaviors and decisions of local managers in IT investment to explicitly examine the existence and the nature of different moral hazard problems.

# Chapter 4: Partner Relationship Management and Delegated Relational Contracting in IT Service Management

## 4.1 Introduction

In the contemporary business environment firms are increasingly using alliance partners to achieve their objectives that are beyond their own assets and capabilities. Partners play an important role in identifying unexpected customer demand, developing new products, and customizing and implementing the firm's products. For example, in the high-tech industry, more than 40% of the industries revenue is earned through successful partnering (*CRMToday, 2003*). Major enterprise software vendors like Oracle-Siebel rely on hundreds of consulting partners to handle software implementation and related customer service tasks (Simons and Davila 2002). Similarly, large manufacturers like GM, Chevron, DuPont and P&G use a network of partners for new product development (Huston and Sakkab 2006).

A large number of partners poses a challenge in partner relationship management. It is operationally impossible for the senior management to monitor every partner relationship. Therefore, in order to achieve effective partner relationship management, firms often assign dedicated relationship managers to manage different partner relationships. For example, Oracle-Siebel assigns either a Sponsor or a dedicated Alliance Manager to manage each partner relationship. Similarly, for new product development, P&G has a dedicated business development group that is responsible for managing outside relationships (Huston and Sakkab 2006).

The reliance on middle managers for partner relationship management causes an agency problem. In many cases, senior managers design and negotiate the relational agreements with potential partners and let middle-level managers maintain the relational agreements in the day-to-day interactions. This inevitably creates a gap between relationship building and relationship management since the relationship managers may fail to maintain the on-going partner relationships for the firm. This is likely when the firm's goals in relationship management are in conflict with the relationship managers' own short-term interests, such as the pursuit of short-term firm performance. Therefore, the firm often faces challenges in internal coordination. For instance, how should the firm align the relationship managers' incentives with the firm's long-term interests in partnership management? Also, how should the firm align relationship building with relationship management?

There is a vast literature on strategic alliances (e.g., Hagedoorn and Schakenraad 1994; Dyer 1997; Dyer and Singh 1998; Gulati 1998; Nault and Tyagi 2001; Gulati and Kletter 2005) and social networks (e.g., Burt 1992; Kranton 1996; Uzzi 1997) that examines who firms partner with, how firms govern alliances, and how alliances evolve over time and affect performance. However, these streams of research mainly concentrate on the inter-firm interaction in studying these relationships, and pay little attention to firms' internal coordination in ensuring the success of partner relationships. The objective of this paper is to complement the existing literature by focusing on firms' internal processes in managing external partner relationships.

In this paper, we present an analytical model to examine the design and management of partner relationships. We focus on three issues. First, how should the firm design the relationship manager's compensation scheme to align the manager's incentives in partner relationship management with the firm's? Second, when the manager may be myopic about maintaining long-term partner relationships for the firm, should the firm delegate the right to build partner relationships to the relationship manager (Bamford, et. al. 2002)? The above two issues complement the literature on strategic alliances by examining internal organization where the extant literature has concentrated on the external governance structures (e.g., Gulati and Singh 1998; Sampson 2004). Third, we examine how the delegation of relationship building impacts the design of the relationships and influences the firm's pursuit of efficiency and innovation through partnering. This contributes to the literature on the interplay between organization design and firms strategies (e.g., Chang and Harrington 2000; Rivkin and Siggelkov 2003).

We adopt the relational contract (Gibbons 2005; Levin 2003; Baker, et. al. 2002, 1994) framework to model the relationship between the firm and the partner.[10] The firm develops the relational contract with the partner and assigns a dedicated manager to maintain the relationship (i.e., execute the relational contract) with the partner. However, the firm can also decentralize and delegate the relational contracting to the manager, i.e., the manager rather than the firm designs and develops the relational contract with the partner. Once the relational contract is developed, the partner exerts efforts according to the relational agreement. The partner's contribution may only be observable to the

[10] Relational contracts refer to informal agreements or implicit contracts which are not enforceable by a third party (such as a court) but are sustained by the future value of the on-going relationship between the involved parties. Terms in relational contracts cannot be put in formal contracts either because they are hard to verify (e.g. quality) or they are uncertain *ex ante* (e.g. demand fluctuation). Relational contracts are

manager. The manager manages the relationship by compensating the partner for its contribution. The manager has private information about his inclination to maintain the long-term partner relationship for the firm. Here, a myopic manager may have the incentive to renege on the relational contract (i.e., refuse to compensate the partner for non-contractible tasks) and increase short-term profits. Therefore, we also examine how the firm can implement a compensation mechanism to regulate the manager and elicit his private information.[11] By eliciting the manager's private information the firm is able to ensure that the relational contract with the partner is not reneged on in relationship management.

We find that the firm can benefit by adopting a policy of contingent delegation, i.e., the firm delegates the relational contracting to the manager conditional on the manager self-selecting the compensation contract developed for the farsighted manager. We show that this approach benefits the firm in two ways. First, contingent delegation helps the firm in screening the myopic manager from the farsighted manager. Specifically, contingent delegation decreases the incentive for the myopic manager to mimic the farsighted manager and renege on the relational contract that is supposed to be managed by the farsighted manager. In this way contingent delegation reduces the cost for the firm to elicit the manager's private information. Second, when the manager can also exert his own effort in contributing to firm's performance, we find that contingent delegation may help the firm in increasing the effort incentive for the farsighted manager.

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common in practice. For example, in business-to-business commerce, about two-thirds of all US companies have either implicit contracts for prices or implicit understandings with their customers (Gibbons 2005).

[11] Such treatment of compensation as a revelation mechanism has its roots in the contract theory literature (e.g., Laffont and Martimort 2002).

In this sense, delegation can also be justified from the perspective of incentive management.

We also examine the impact of delegation on the design of the relational contract. We find that the farsighted manager, who is delegated the right of relational contracting, tends to discourage the partner from making non-contractible contributions. In other words, in developing the relational agreement, the farsighted manager encourages the partner to focus more on completing tasks that can be specified in formal contracts (e.g., software implementation). The partner is discouraged from pursuing flexible tasks that are difficult to anticipate and specify in formal contracts (e.g., discovering unexpected customer needs and developing customized solutions). In this sense, delegation of relational contracting promotes efficiency rather than innovation, since the partner is motivated to follow formally established procedures. In contrast, if the firm were to follow centralized contracting where the firm itself designs the relational contract with the partner, the partner is encouraged to perform more non-contractible tasks which lead to more innovation.

The findings in this paper call for further examination of the relationship between the organizational structure and the pursuit of efficiency and innovation (e.g., March 1991; Ghemawat and Ricart i Costa 1993; Rivkin and Siggelkov 2003). Prior literature (e.g., Jensen and Meckling 1992; Ghemawat and Ricart i Costa 1993; Anand and Mendelson 1997; Carley and Lin 1997; Nault 1998; Chang and Harrington 2000; Rivkin and Siggelkov 2003) suggests that in dynamic environments decentralization of decision making facilitates innovation. The explanation is that delegating decision rights to managers who are often better informed about the local environment can make the firm more adaptive. In contrast, in our setup decentralization is used to alleviate the agency problem arising from managers' unobserved myopia. In this case, decentralization may lead the partnership to focus more on efficiency-oriented tasks as the farsighted manager would like to ease the partner's concern over the uncertainty associated with the non-contractible innovation activities.

In terms of analytical techniques, the model in this paper is related to the literature in economics that examines the issue of delegated contracting (e.g., Melumad, et. al. 1995; 1997; Laffont and Martimort 1998). However, our work differs from this literature by examining the delegation of relational contracting rather than the delegation of formal contracting. Also, we focus on the mechanism with contingent delegation while the existing literature mainly focuses on complete delegation (where the delegation is not dependent on the agent's type).

The rest of the paper is organized as follows. In section 4.2 we present our model, and in section 4.3 we present the benchmark case where the firm adopts centralized contracting. In section 4.4, we examine decentralization where the firm adopts contingent delegation in relational contracting. Section 4.5 examines the case where both the manager and the partner can exert effort to improve firm performance. Section 4.6 discusses the implications of the results and section 4.7 concludes the paper.

### 4.2 The Model

We consider a three-stage model in which a firm hires a manager to manage the relationship between the firm and a partner.[12] However, the manager may be myopic about maintaining a long-term relationship between the firm and the partner. A myopic manager is likely to sacrifice the firm's long-term partner relationship to pursue short-term benefits. The manager's myopia is defined later in this section. Also, the manager has private information about his own myopia. This is an issue about information asymmetry. The three stages are as follows.

●In Stage 1, the firm contracts with the manager on his compensation. When there is asymmetric information, the firm can elicit the manager's private information (about his myopia) by designing the manager's compensation contract as a revelation mechanism;

●In Stage 2, the firm develops a relational contract with the partner. The relational contract specifies the relationship-based interaction between the firm and the partner over an infinite number of periods in stage 3;

●In Stage 3, the firm and the partner engage in repeated interaction. In each period, the partner performs tasks for the firm and the firm promises to make payments to the partner based on the realized task outcomes. The manager, rather than the firm, observes the realized task outcomes and decides on the payments to the partner.

This three-stage model captures the key phases of partnering, i.e. *Find phase*, *Design phase* and *Manage phase* (Praise and Sasson 2002). In the Find phase, the firm not only looks for potential partners, but also acquires knowledge about the management skills and characteristics of its managers, to choose the best personnel for relationship management. In the model, Stage 1 captures this knowledge acquisition in the Find

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[12] Here the term "the firm" refers to the top executives (e.g. CEO or VPs) of the firm. In contrast, the term "the manager" refers to the middle level managers who are responsible for managing partnership activities

phase. Stage 2 captures the Design phase in which the firm designs the activities and responsibilities in the partnership and forms an agreement with the partner. Stage 3 captures the Manage phase in which the relationship manager monitors the status of the relationship and organizes an effective working environment for the partner.

**Relational Contracting and Relationship Management (Stage 2 and 3).** The partner relationship in stage 3 is defined as follows. The firm and the partner engage in repeated interaction over $N$ periods, $N = \infty$. In each period, the partner performs two types of tasks: fixed tasks and flexible tasks. Fixed tasks generate a base value $y_L > 0$ to the firm and are pre-specified in the formal contract between the firm and partner. For example, Siebel's consulting partners' fixed tasks include software implementation, which can be pre-specified in formal business contracts. We normalize the partner's cost to perform the fixed tasks to zero. Also, the partner is paid a constant base payment $p$ in each period of stage 3 for delivering the fixed tasks. It is assumed that $p$ is exogenously given in the formal contract between the firm and partner.

Next, in addition to the fixed tasks, the partner can also perform flexible tasks that cannot be pre-specified in formal contracts. For example, consulting partners can conduct customized software development based on unexpected customer needs. We assume that the flexible tasks generate value depending on the partner's efforts. Specifically, if the partner exerts an effort $e_p$, the task generates an add-on value $e_p$ for the firm. This effort can be considered as innovation, i.e., discovering unexpected opportunities (e.g., unique user requirements) to generate value for the firm. We assume that the effort cost for the

but may not necessarily be involved in establishing the partnership.

partner is $C\left(e_p\right)=\frac{\theta_p e_p^2}{2}$.[13] To compensate the partner for the flexible tasks, the firm promises that the partner will be paid an additional payment $b_p e_p$ in each period of stage 3 if an add-on value $e_p$ is generated from the partner's non-contractible flexible tasks. Here $b_p$ can be considered as a *relational bonus rate*. For example, if the consulting partner develops customized software products to increase the customer's satisfaction, the firm can reward the partner based on the level of customer satisfaction. In this sense, $b_p$ drives the relationship-based interaction between the firm and the partner. If $b_p$ is large, the partner is encouraged to exert more effort on non-contractible flexible tasks. $b_p$ is not specified in the formal contract but is determined in the relational contract between the firm and the partner (as described below).

The distinction between fixed tasks and flexible tasks captures whether the firm realizes efficiency or innovation through partnering. If the partner performs more non-contractible flexible tasks, it suggests that the partner is motivated to go beyond the certainty associated with the formal contract to discover new opportunities to generate value. In this sense the firm realizes innovation through partnering. Otherwise, if the partner mainly focuses on the fixed tasks specified in the formal contract, the firm just realizes efficiency through partnering.

In the stage 2, the firm develops a relational contract with the partner to determine the relational bonus rate $b_p$. Following the relational contracting literature (e.g. Baker, et. al. 2002), we assume that $b_p$ and the outcome $e_p$ are not formally contractible. In other

[13] The quadratic form of the cost function is used for expository convenience. The insights derived from the model are also applicable to other convex cost functions.

words, $b_p$ and $e_p$ are observable but not verifiable. For example, in the enterprise software industry, the customer's special needs and therefore the partner's particular service activities may not be anticipated *ex ante*. Although the partner's effort and outcomes (e.g., the customer's satisfaction with the software package customization) can be observed and can be used for relationship-based compensation, it is hard for a third party (e.g., a court) to verify and enforce them. Therefore, the *ex post* outcome-based payment $b_p e_p$ is merely an implicit promise between the firm and the partner, and the firm can renege by refusing to pay $b_p e_p$. If such reneging takes place, following the relational contracting literature (e.g., Baker, et. al. 2002), we assume that the partner will punish the firm by refusing to exert any effort on flexible tasks in the subsequent periods. In other words, the relational contract is enforced by the future relational benefits.

It is assumed that in stage 3, the manager, rather than the firm, observes the base value $y_L$ and the added-on value $e_p$, and makes the payment to the partner based on the observed outcome. The manager may have an incentive to renege on the relational contract by refusing to pay the partner $b_p e_p$ for the non-contractible tasks performed by the partner. The manager's incentive to renege is discussed later.

Considering the partner relationship, the firm's expected per-period gross profit from partnering is given as

$$\Pi = y_L + e_p - b_p e_p - p \qquad (4.2.1)$$

If the manager never reneges on the relational contract in relationship management, the firm's problem in relational contracting with the partner can be represented as

$$P1 : \max_{b_p} \Pi = y_L + e_p - b_p e_p - p$$

$$s.t. \quad e_p \in \arg\max b_p e_p - \frac{\theta_p e_p^2}{2} + p \tag{4.2.2}$$

(4.2.2) is the partner's *incentive-compatibility* constraint, i.e. the partner chooses an effort to maximize its expected payoff. Therefore, the first-order condition yields the optimal partner effort $e_p = \frac{b_p}{\theta_p}$ . Substituting the optimal partner effort into (4.2.1), the firm's per-period gross profit from partnering, as function of $b_p$, can be represented as

$$\Pi(b_p) = y_L + \frac{b_p}{\theta_p} - \frac{b_p^2}{\theta_p} - p \tag{4.2.3}$$

**The Manager's Compensation Scheme (Stage 1).** In stage 1, the firm determines the compensation for the manager in each period of stage 3. It is assumed that the manager's compensation scheme is characterized by $\{m, b_m, r\}$, where $m$ denotes a base wage, $b_m$ denotes the manager's bonus rate as a percentage of the firm's per-period gross profit from partnering $\Pi$, and $r$ is defined as a parameter that determines a delayed bonus payment which depends on the partner's satisfaction with the relationship. In each period, if the firm's gross profit is $\Pi$, the firm pays the manager a total wage of $m + b_m(\Pi - b_p r)$ in the current period and holds a bonus of $b_m b_p r$. The bonus amount $b_m b_p r$ is paid in the next period if no reneging takes place and the relationship continues (in other words, the partner is still satisfied with the relationship).

The use of bonus rate $b_m$ in the manager's compensation is to motivate the manager's effort in contributing to the firm's performance.[14] The use of delayed bonus payment is common. For example, Oracle-Siebel often holds part of its alliance

[14] In section 4.5 we model how the bonus rate $b_m$ motivates the manager's efforts.

managers' bonus until long-term projects are completed (Simons & Davila 2002). Note that the amount of delayed bonus is also dependent on $b_p$. This means that if the manager is assigned to manage a more complex relationship and encourages more non-contractible flexible tasks from the partner, the more of the manager's bonus will be held for delay. Therefore, if no reneging takes place and the relationship continues, the manager's expected per-period income in stage 3 is

$$I = m + b_m\left[\Pi\left(b_p\right) - b_p r\right] + \frac{b_m b_p r}{1+\delta} \tag{4.2.4}$$

where $0 < \delta < 1$ denotes the manager's discount factor. The discount factor captures the manager's myopia. A myopic manager values the future income less than a farsighted manager, and has a higher discount factor. We assume that the firm's discount factor and the partner's discount factor are equal to zero to capture the manager's relative myopia. Note that $b_p$ is determined in relational contracting in stage 2, rather than in stage 1. However, once the firm learns the manager's discount factor in stage 1, both the firm and the manager can rationally anticipate the value of $b_p$, i.e., what type of relational contract the firm will build with the partner in stage 2.[15] Also, it is assumed that, in each period, the total payment for the manager should not be less than the manager's reservation income, $M_0$.

[15] Note that since $b_p$ is non-contractible and can only be determined in stage 2, the manager's compensation contract in stage 1 is an incomplete contract. The exact amount of delayed bonus $b_m b_p r$ is not specified in the compensation contract in stage 1. Rather, it is determined in stage 2 once $b_p$ is chosen. Then, one issue is whether the firm will deviate by delaying more or less bonus. In our case, the firm should have no incentive to deviate. This is because the firm's deviation will only increase the likelihood that the manager reneges on the relational contract and causes the relationship to end. Since the firm's discount factor is one, the loss of the relationship is infinitely costly for the firm. Therefore, the firm has no incentive to deviate.

In the following analysis, we first take $b_m$ as a constant. Generally, the manager's bonus rate is used by the firm to motivate the manager's effort and is determined by the multitude of the manager's responsibilities. Therefore, taking $b_m$ as a constant lets us separate the issue of partner relationship management from the issue of motivating the manager's own effort. This simplifies the analysis and helps to illustrate how the manager's bonus payment may create an incentive for a myopic manager to renege on the relational contract in pursuit of short-term firm performance. Later, we will consider the case with endogenous $b_m$ and incorporate the manager's own effort into the model. When $b_m$ is constant, the firm's problem in manager's compensation design is to decide on the base wage $m$ and the delayed bonus parameter $r$. Note that the delayed bonus causes a deflation in the manager's income. Therefore, to compensate for this deflation, the firm has to increase the manager's base wage in each period. This increases the compensation expense for the firm.

Next, we model the manager's incentive to renege. In doing so, we consider the manager's state-dependent psychological motivation to seek additional income in the short-term (e.g., Chen, et. al. 2005). Specifically, with a probability $\beta$ the manager's utility over income $I$ is $kI$, and with a probability $1-\beta$ the manager's utility over income $I$ is $I$, where $k>1$. Therefore, $k$ captures the manager's psychological motivation to seek extra income in the short-term. In the model, reneging is a way for the manager to seek extra income in the short-term. By reneging on the relational contract and refusing to pay the partner $b_p e_p$ for the non-contractible tasks, the manager increases the firm's current period gross profit by an amount of $b_p e_p$ and gains an extra income of

$b_m b_p e_p$ in the current period. We focus on the most interesting case when $k$ is sufficiently large such that the manager only reneges in a $k$-state period when his utility over income is high.[16] Table 4.1 summarizes the notations in the model. Figure 1 presents a timeline of the stage game when the firm contracts with both the manager and the partner (i.e., centralized contracting) and no reneging takes place in relationship management.

| | | | |
|---|---|---|---|
| $e_p$ | The partner's effort | $M_0$ | The manager's per-period reservation income |
| $e_m$ | The manager's effort | $b_p$ | The relational bonus rate |
| $p$ | The base payment to the partner | $\delta$ | The manager's discount factor |
| $\Pi(b_p)$ | The firm's expected per-period gross profit from partnering | $\beta$ | The probability that the manager has a high utility over income |
| $m$ | The manager's base wage | $k$ | The manager's high utility scale over income |
| $b_m$ | The manager's bonus rate | $b_m b_p r$ | The manager's delayed bonus |

**Table 4.1: Model Notations.**

**Benchmark: Centralized Contracting When the Manager's Discount Factor is Known**

We first consider a benchmark case in which the firm knows the manager's discount factor. In this case, there is no need to delegate the relational contracting to the manager

[16] The manager never has the incentive to renege when he is in a non-*k*-state. This is because in this model setup, once the manager reneges in a non-*k*-state, his gain in income utility in the current period can never exceed his loss in future expected income utility. If $k$ is too small, e.g. $k$=1, the manager's incentive to seek extra income in the current period is sufficiently small such that he is unlikely to renege on any relational contract.

[17] and the firm contracts with both the manager and the partner. From (5.2.3), by solving the first-order condition $\partial\Pi(b_p)/\partial b_p = 0$, the optimal relational bonus rate chosen by the firm in stage 2 is given as,

$$b_p = \tfrac{1}{2} \tag{5.2.5}$$

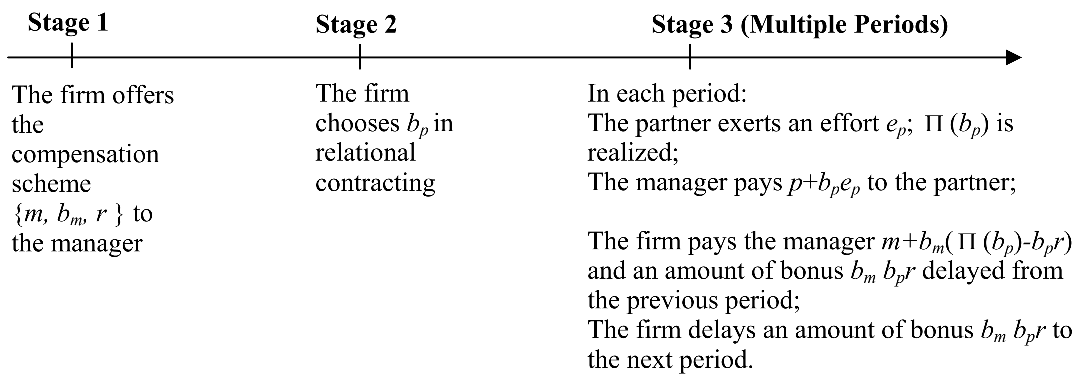


**Figure 4.1: Timing of Contracting and Relationship Management**
(When the Firm Contracts with both the Manager and the Partner)

Since the relational contract cannot be enforced by a third-party, in stage 3 the manager may have an incentive to renege on the relational bonus $b_p e_p$ to the partner once $e_p$ is realized. By reneging, the manager can increase the firm's current period gross profit $\Pi$ by an amount of $b_p e_p$, so as to gain an extra income of $b_m b_p e_p$ in the current period. Therefore, the manager's gain from reneging is,

$$kb_m b_p e_p = kb_m \frac{b_p^2}{\theta_p} \tag{4.2.6}$$

as the partner's effort is $e_p = \frac{b_p}{\theta_p}$. However, as a result of the reneging, the partner will no longer exert any effort. The reneging causes the manager a total aggregate loss from the

[17] There is no need to delegate the relational contracting since in a complete information case the firm can

subsequent periods that is equal to, [18]

$$\frac{1}{\delta}\left(1-\beta+\beta k\right)b_m\left(\frac{b_p}{\theta_p}-\frac{b_p^2}{\theta_p}+\frac{b_p r}{1+\delta}\right) \tag{4.2.7}$$

Therefore, the manager has no incentive to renege as long as

$$kb_m\frac{b_p^2}{\theta_p}\le\frac{1}{\delta}\left(1-\beta+\beta k\right)b_m\left(\frac{b_p}{\theta_p}-\frac{b_p^2}{\theta_p}+b_p r\right) \tag{4.2.8}$$

$$\Rightarrow b_p\le\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right) \tag{4.2.9}$$

(4.2.8) is also known in the relational contract literature (e.g. Levin, 2003) as the *dynamic enforcement* (DE) constraint. (4.2.9) indicates that the upper bound for the partner's relational bonus rate $b_p$ is constrained by the manager's discount factor.

***Proposition 4.1*** *When* $\delta<\frac{1-\beta+\beta k}{k}$ *, (a) the firm chooses* $r=0$ *in compensating the manager, i.e., the firm does not delay any bonus to the manager; (b) In stage 2 (relational contracting), the firm chooses a relational bonus rate* $b_p=\frac{1}{2}$ *. (Proof is in the Appendix B1)* [19]

The intuition behind Proposition 4.1 is straightforward. The objective of delaying the manager's bonus is to reduce the manager's incentive to renege on the relational contract and ensure the partner's satisfaction. When $\delta<\frac{1-\beta+\beta k}{k}$ , the manager cares enough about the future income so that even if $r=0$, he has no incentive to renege on the

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do no worse than the manager in relational contracting.

[18] The term $\left(1-\beta+\beta k\right)$ is the manager's expected utility index over the income, $b_m\left(b_p-b_p^2\right)/\theta_p$ is the manager's bonus amount in any period attributed to the partner's effort, and $\frac{b_m b_p r}{1+\delta}$ is the manager's income from the delayed bonus in any period.

[19] The proofs of all the propositions are in the supplemental document.

relational contract with a relational bonus rate of $b_p = \frac{1}{2}$ as in (4.2.5). A positive $r$ does not impact the manager's behavior but simply raises the compensation expense for the firm since the manager deflates the value of delayed bonus payment. Therefore, the firm chooses $r = 0$ and does not delay any bonus payment to the manager.

We now consider the case when $\delta > \frac{1-\beta+\beta k}{k}$ so that the firm may use delayed bonus payment (i.e., $r > 0$) to regulate the manager. The firm's problem in compensating the manager can be characterized as

$$P2 \ : \ \max_{\{m,r\}} \Pi(b_p)(1-b_m) - m - b_m b_p r$$

$$s.t. \ \ b_p \le \frac{1-\beta+\beta k}{\delta k + 1 - \beta + \beta k}(1+\theta_p r) \qquad (4.2.10)$$

$$m + b_m[\Pi(b_p) - b_p r] + \frac{b_m b_p r}{1+\delta} \ge M_0 \qquad (4.2.11)$$

(4.2.10) ensures that the manager does not renege on the relationship (see 4.2.9). (4.2.11) is the manager's *participation constraint* i.e., the manager's per-period payment should not be lower than $M_0$. Proposition 4.2 characterizes the optimal compensation contract for the manager and the optimal relational contract for the partner.

***Proposition 4.2*** *When* $\delta > \frac{1-\beta+\beta k}{k}$ *,*

*(a) The firm delays a proportion of the manager's bonus (i.e.,* $r > 0$*) when* $b_m$ *is not too large. The firm chooses the base wage m to make the manager earn an aggregate discounted income of* $M_0$ *in each period of stage 3; (the optimal r and m are characterized in the Appendix B2).*

*(b) In stage 2 (relational contracting), the firm chooses a relational bonus rate*

$$b_p = \frac{1-\beta+\beta k}{\delta k + 1 - \beta + \beta k}\left(1+\theta_p r\right) \quad (4.2.12)$$

*to ensure that the manager does not renege on the relationship.*

Proposition 4.2 indicates that when the manager is myopic, the firm may delay part of the manager's bonus to prevent him from reneging on the relational contract. The delay in the bonus allows the firm to choose a larger relational bonus rate $b_p$ (4.2.12 indicates that $b_p$ is increasing in $r$). When $b_m$ is too large, if the firm delays part of the bonus, it has to compensate the manager with a large base wage for the delay. In this case, the delay in bonus is very costly for the firm and the firm does not delay. In the subsequent analysis, we focus on the more interesting case where the firm delays part of the manager's bonus when $\delta > \frac{1-\beta+\beta k}{k}$.

### 4.3 Centralized Contracting where Managers have Private Information

Now we consider the case where the firm is not informed about the manager's discount factor. Suppose that there are two types of managers: the *s*-type (*shortsighted*) manager and the *f*-type (*farsighted*) manager. The shortsighted (farsighted) manager has a discount factors $\delta_s$ ($\delta_f$), where $\delta_s > \delta_f$. In the rest of the paper, for expository clarity, we use the subscripts *s* and *f* in all notations to represent the case for the *s*-type manager and the *f*-type manager, respectively. It is assumed that the probability that the manager is a *s*-type (*f*-type) manager is $\rho_s$ ($\rho_f = 1-\rho_s$). Also it is assumed that $\delta_s$ and $\delta_f$ satisfy $\delta_f < \frac{1-\beta+\beta k}{k} < \delta_s$. According to Proposition 1, this assumption implies that in a complete information case the firm delays part of the $s$-type manager's bonus (i.e., $r_s > 0$), but does not delay the *f*-type manager's bonus (i.e., $r_f = 0$). Also, if the firm knows that the manager is a *s*-type manager, the firm will promise a relational bonus rate $b_{ps} = \frac{1-\beta+\beta k}{\delta_s k+1-\beta+\beta k}(1+\theta_p r_s)$ to the partner in relational contracting. This is because according to (4.2.9), the *s*-type manager will not renege when the relational bonus rate is $b_{ps} = \frac{1-\beta+\beta k}{\delta_s k+1-\beta+\beta k}(1+\theta_p r_s)$. If the firm knows that the manager is a *f*-type manager, the firm will promise a relational bonus rate $b_{pf} = \frac{1}{2}$, since $b_{pf} = \frac{1}{2}$ is the optimal relational bonus rate as indicated in (4.2.5) and the *f*-type manager never reneges.

If the firm does not know the manager's type, the firm can design a compensation mechanism to elicit the manager's private information. Once the firm is informed about the manager's type, it is able to develop a relational contract with the partner which the manager will not renege on.

Suppose that in stage 1 the firm offers a menu of compensation contracts $\{m_i, b_m, r_i\}$ (again, $b_m$ is exogenously given) for type $i$, where $i = \{s, f\}$, and the manager chooses a particular compensation scheme from the menu, based on his private information. Therefore, to elicit the manager's private information, the firm should ensure that the manager honestly chooses the compensation scheme for his type. To achieve that, it is without loss of generality to focus on a direct revelation mechanism for this problem (e.g., Laffont and Martimort 2002, pg. 48). In such a mechanism, the manager first announces his type $i$, and the firm designs a compensation scheme $\{m_i, b_m, r_i\}$ based on the manager's announced type. By the Revelation Principle, the manager should be provided with proper incentives to reveal his type truthfully. In this section, since $b_m$ is exogenous, we drop it and denote the compensation scheme as $\{m_i, r_i\}$. Also we introduce the following notations. Let $\pi_i(m_i, r_i)$ denote the $i$-type manager's expected lifetime income utility when he chooses the compensation scheme $\{m_i, r_i\}$. Let $\pi_i^{mimic}(m_j, r_j, b_{pj})$ denote the $i$-type manager's expected lifetime income utility when he mimics the $j$-type manager by choosing the compensation scheme $\{m_j, r_j\}$ and leads the firm to choose a relational bonus rate $b_{pj}$ in relational contracting ($i, j \in \{s, f\}, i \neq j$). Let $b_{pf}^*$ be the optimal relational bonus rate chosen by the firm when the manager is a $f$-type manager. The firm's problem is represented as

$$P3 : \max_{\{m_i, r_i\}_{i\in\{s,f\}}} \sum_{i\in\{s,f\}} \rho_i \left[\Pi(b_{pi})(1-b_m) - m_i - b_m b_{pi} r_i\right]$$

$$s.t. \quad b_{ps} = \frac{1-\beta+\beta k}{\delta_s k + 1 - \beta + \beta k}(1+\theta_p r_s); b_{pf} = b_{pf}^*$$

$$\pi_i(m_i, r_i) \geq \pi_i^{mimic}(m_j, r_j, b_{pj}), \quad i, j \in \{s, f\}, i \neq j \tag{4.3.1}$$

$$\pi_i(m_i, r_i) \geq \left(\frac{1+\delta_i}{\delta_i}\right) M_0 (1-\beta+\beta k), \quad i \in \{s, f\} \tag{4.3.2}$$

The *incentive-compatibility* constraint (4.3.1) implies that a $i$-type manager finds it optimal to truthfully reveal his type. The *participation constraint* (4.3.2) implies that a $i$-type manager finds it worthwhile to accept the compensation contract.

From the standard solution of the screening contract (e.g., Laffont and Martimort, 2002) we can conclude that the $f$-type manager has no incentive to mimic the $s$-type manager. This is because with a $s$-type manager, the firm will chooses a lower relational bonus rate (i.e. $b_{ps} < b_{pf}$). Therefore, mimicking causes the $f$-type manager to manage a partner relationship which entails lower partner effort and value from flexible tasks. Thus, we only need to consider the $s$-type manager's incentive to mimic the $f$-type manager. In doing so, we examine the *s*-type manager's expected utility $\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right)$ from mimicking.

***Lemma 4.1*** *The s-type manager's expected life-time income utility by mimicking a f-type manager is*

$$\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right) =$$
$$\left(\frac{1+\delta_s}{\delta_s}\right) M_0\left(1-\beta+\beta k\right) + \underbrace{\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right) b_m\left[\frac{b_{pf}^2}{\theta_p}k - \frac{1}{\delta_s}\left(\frac{b_{pf}}{\theta_p} - \frac{b_{pf}^2}{\theta_p} + b_{pf}r_f\right)\left(1-\beta+\beta k\right)\right]}_{s\text{-type manager's information rent}} \quad (4.3.3)$$

The objective for the *s*-type manager to mimic the *f*-type manager is to get assigned to manage a partner relationship that is supposed to be managed by a *f*-type manager. The partner relationship managed by the *f*-type manager encourages more effort from the partner. The *s*-type manager can then benefit by reneging on this relationship and increasing short-term firm performance. Note that if reneging takes place, it takes place only once, and after that the partner never exerts effort. The probability that there is no reneging for $t-1$ periods and reneging takes place at period $t$ is $\left(1-\beta\right)^{t-1}\beta$. When the reneging takes place at period $t$, from (4.2.6), the present value of the gain from reneging is $\frac{1}{\left(1+\delta_s\right)^{t-1}}\left(b_{mf}b_{pf}e_{pf}k\right) = \frac{1}{\left(1+\delta_s\right)^{t-1}} b_{mf}\left(\frac{b_{pf}^2}{\theta_p}k\right)$. Similarly, the present value of the loss from reneging, according to (4.2.7), is $\frac{1}{\left(1+\delta_s\right)^{t-1}}\left[\frac{1}{\delta_s} b_{mf}\left(\frac{b_{pf}}{\theta_p} - \frac{b_{pf}^2}{\theta_p} + \frac{b_{pf}r_f}{1+\delta}\right)\left(1-\beta+\beta k\right)\right]$. Therefore, in (4.3.3), the second term captures the *s*-type manager's information rent, i.e., the extra income utility (over the utility from the reservation income) that the *s*-type manager earns so that he has no incentive to mimic the *f*-type manager. Table 4.2 summarizes how different parameters affect the *s*-type manager's incentive to mimic.

| | $r_f$ | $m_s$ | $b_{pf}$ | $b_m$ |
|---|---|---|---|---|
| The *s*-type manager's incentive to mimic | — <br><br> Mimicking causes more bonus to be delayed | — <br><br> Mimicking causes the loss of a large base wage | + <br><br> $b_{pf}$ leads to more partner effort. The *s*-type benefits more by reneging on this relationship | + <br><br> The *s*-type manager earns more bonus from reneging and increasing short-term firm performance |

**Table 4.2: Forces driving the *s*-type Manager's Incentive to Mimic**

The firm's expected per-period net profit, $F$, defined as the expected per-period gross profit from partnering less the manager's expected compensation, can be represented as,

$$F = (1-\rho_s)\left[\Pi(b_{pf})(1-b_m) - M_0 - \left(\frac{\delta_f}{1+\delta_f}\right) b_m b_{pf} r_f\right] + \rho_s\left[\Pi(b_{ps})(1-b_m) - \left(\frac{\delta_s}{1+\delta_s}\right) b_m b_{ps} r_s - M_0\right] - \rho_s\left[\left(\frac{\delta_s}{1+\delta_s}\right)\frac{\pi_s^{mimic}(m_f, r_f, b_{pf})}{(1-\beta+\beta k)} - M_0\right] \quad (4.3.4)$$

The firm term in (4.3.4) is the firm's per-period net profit when it has a *f*-type manager. The third term in (4.3.4) is the information rent that the firm has to leave to the *s*-type manager. The sum of the second and third term in (4.3.4) is the firm's per-period net profit when it has a *s*-type manager. Denote $\{(m_s^*, r_s^*), (m_f^*, r_f^*)\}$ as the optimal compensation mechanism in the centralized case. Proposition 4.3 characterizes the optimal compensation. (The details of $\{(m_s^*, r_s^*), (m_f^*, r_f^*)\}$ are provided in the Appendix B3.)

***Proposition 4.3*** *There exists a cutoff value* $\rho_1$ *such that*

*(a) If* $\rho_s \geq \rho_1$ *, the firm delays part of the bonus for both types of managers (i.e.,* $r_f^* > 0$ *,* $r_s^* > 0$ *). The optimal compensation mechanism makes both types of managers earn an income of* $M_0$ *in each period of stage 3;*

*(b) If* $\rho_s < \rho_1$ *, the firm delays part of the bonus only for the s-type managers (i.e.,* $r_f^* = 0$ *,* $r_s^* > 0$ *). The optimal compensation mechanism makes the f-type manager earn an income of* $M_0$ *in each period of stage 3, and the s-type manager earn an income greater than* $M_0$ *in each period of stage 3.*

Proposition 4.3 shows that even if the *f*-type manager's discount factor is $\delta_f < \frac{1-\beta+\beta k}{k}$ , the firm still delays the bonus payment for the *f*-type manager when $\rho_s$ is relatively large (i.e., $\rho_s > \rho_1$ ). In this case, the role of the delayed bonus payment for the *f*-type manager is not to prevent the *f*-type manager from reneging on the relational contract, but to prevent the $s$ -type manager from mimicking the *f*-type manager. This finding explains the prevalence of delayed bonus payments, even when farsighted managers are not likely to renege.

When $\rho_s < \rho_1$, as the manager is more likely to be a *f*-type manger, the firm does not delay the bonus for the *f*-type manager. Otherwise, it has to compensate the *f*-type manager for the delay. Instead, the firm raises the base wage for the *s*-type manager to decrease the *s*-type manager's incentive to mimic the *f*-type manager. However, this leads to an increase in the firm's compensation cost. This is the agency cost due to the information asymmetry about the manager's myopia.

### 4.4 Decentralization: Contingent Delegation of Relational Contracting

In centralized contracting, once the firm knows that the manager is a *f*-type manager, it will choose a relational bonus rate $b_{pf} = b_{pf}^{*}$ in relational contracting. Therefore, the firm can only decrease the $s$-type manager's information rent by increasing $r_f$, i.e., increasing the amount of delayed bonus to the *f*-type manager. However, the firm has to compensate for this delay by raising the *f*-type manager's base wage, which increases the firm's compensation cost. (4.3.3) suggests that another way that the firm can decrease the *s*-type manager's information rent is to decrease the relational bonus rate $b_{pf}$. If, in stage 1, the firm can find a way to credibly commit to a smaller $b_{pf}$, then the firm does not have to delay a large proportion of the bonus for the *f*-type manager and the firm's compensation cost can be reduced. However, since the relational bonus rate $b_{pf}$ is only observable but not contractible, it is also hard for the firm to credibly commit $b_{pf}$ to any value other than $b_{pf}^{*}$ in advance. This lack of commitment reflects the well known "ratchet effect" (Laffont and Tirole 1987; 1988).[20]

An alternative way of credibly committing to a $b_{pf} < b_{pf}^{*}$ is to delegate the relational contracting to the *f*-type manager and let him choose $b_{pf}$. In this section, we consider the following mechanism where relational contracting is delegated to the $f$-type

[20] The *ratchet effect* reflects the agent's concern that once the principal is informed about the agent's private information, the principal will exploit the information in the future interaction. Therefore, if the principal cannot commit to its future behaviors, the agent becomes more strategic in hiding his private information in the early stages. In this case, when the firm cannot commit to a lower $b_{pf}$, the *s*-type manager has a larger incentive to mimic the *f*-type manager since mimicking gets the *s*-type manager assigned to manage a relationship with higher partner efforts and value from flexible tasks.

manager. The firm provides a menu of compensation schemes $\{(m_s, r_s), (m_f, r_f)\}$ for the manager to choose from. If the manager chooses $(m_f, r_f)$, then the firm allows the manager to engage in relational contracting with the partner and lets the manager to choose the relational bonus rate $b_{pf}$. Otherwise, if the manager chooses $(m_s, r_s)$, the firm itself contracts with the partner and decides on the relational bonus rate $b_{ps}$. In this case the firm does not delegate the relational contracting to the *s*-type manager. This is because delegation will provide the *s*-type manager with more opportunities to mimic the *f*-type manager. Therefore, the firm is not better off by delegating to the *s*-type manager. Figure 4.2 shows the timing of the game with contingent delegation.

The relational contracting between the *f*-type manager and the partner, in stage 2, is a signaling game. That is, the *f*-type manager may credibly inform the partner about his type by choosing the relational bonus rate $b_{pf}$. The equilibrium concept we employ is the perfect Bayesian equilibrium (PBE). There are two types of PBEs in this game of relational contracting: the *separating equilibriu*m and the *pooling equilibrium*. In the separating equilibrium, the *f*-type manager chooses a $b_{pf}$ such that the *s*-type manager finds it optimal to take the compensation contract $(m_s, r_s)$ and does not get the opportunity to engage in relational contracting. Therefore, in the separating equilibrium, the partner is informed about the manager's type.

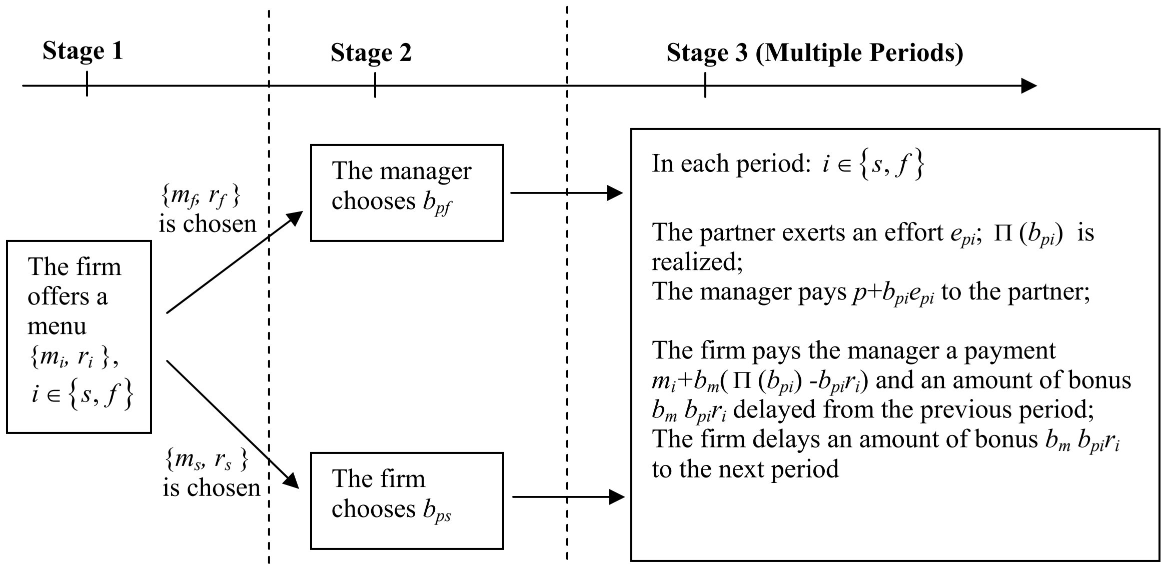



**Figure 4.2: Timing with Contingent Delegation in Relational Contracting**

In the pooling equilibrium, the *f*-type manager chooses a $b_{pf}$ such that the *s*-type manager finds it optimal to take the same compensation contract $(m_f, r_f)$ as the *f*-type manager and gets the opportunity of relational contracting. In the relational contracting the *s*-type manager chooses the same $b_{pf}$ as the *f*-type manager. Therefore, in the pooling equilibrium, the partner cannot distinguish between the two types of managers. The concept of PBE requires that the manager's and the partner's strategies be optimal given the partner's posterior beliefs and that the partner's posterior beliefs be consistent with the manager's strategies. As is well known in the signaling game literature, if the partner holds arbitrary beliefs on the managers' off-equilibrium strategies, a plethora of equilibria arise. Therefore, following other work on signaling games, we impose the intuitive criterion (Cho and Kreps 1987) to restrict the number of equilibria.[21]

***Proposition 4.4*** *Given compensation schemes* $\{(m_s, r_s), (m_f, r_f)\}$ *, denote* $\hat{b}_{pf}$ *as the larger root of*

$$\pi_s^{mimic}(m_f, r_f, b_{pf}) = \pi_s(m_s, r_s) \tag{4.4.1}$$

*Then: (a) if* $\hat{b}_{pf} \geq \frac{(1-\rho_s)+\rho_s(1-\beta)}{2} - \frac{\delta_f r_f}{2(1+\delta_f)}$*, the only PBE that survives the intuitive criterion is a separating equilibrium. In this equilibrium, the f-type manager takes* $(m_f, r_f)$ *and chooses a relational bonus rate* $b_{pf} = \min\left(\hat{b}_{pf}, \frac{1}{2} - \frac{\delta_f r_f}{2(1+\delta_f)}\right)$ *in relational contracting with the partner. The s-type manager chooses* $(m_s, r_s)$ *and is not delegated the authority of relational contracting; (b) if* $\hat{b}_{pf} < \frac{(1-\rho_s)+\rho_s(1-\beta)}{2} - \frac{\delta_f r_f}{2(1+\delta_f)}$ *, the only PBE that survives the intuitive criterion is a pooling equilibrium in which both types of managers take* $(m_f, r_f)$ *and have the authority of relational contracting. In relational contracting, both types of managers choose a relational bonus rate* $b_{pf} = \frac{1}{2} - \frac{\delta_f r_f}{2(1+\delta_f)[\rho_f + \rho_s(1-\beta)]}$ .

Proposition 4.4 first illustrates the potential incentive for the *f*-type manager to separate himself from the *s*-type manager. The *f*-type manager's objective in signaling his type is to increase the partner's effort. Specifically, in the separating equilibrium, the partner knows that only the *f*-type manager engages in relational contracting. Therefore, if the manager chooses a relational bonus rate $b_{pf}$, the partner will exert an effort

[21] Such equilibrium refinement approach in signaling games has been employed in a wide range of research in marketing (e.g., Lariviere and Padmanabhan 1997), supply chain (e.g., Cachon and Lairiviere 2001), and information systems (e.g., Lin, et. al. 2005). The intuitive criterion implies that if a partner sees an out-of-equilibrium strategy (here the strategy is the value of the relational bonus rate) that is dominated

$e_{pf} = \frac{b_{pf}}{\theta_p}$ in stage 3. However, in the pooling equilibrium, the partner knows that the manager engaging in relational contracting is a *f*-type manager with a probability $1-\rho_s$ (the partner's prior belief). Therefore, if the manager chooses a relational bonus rate $b_{pf}$, the partner will only exert an effort $e_{pf} = \frac{\left[\rho_f + \rho_s(1-\beta)\right] b_{pf}}{\theta_p} < \frac{b_{pf}}{\theta_p}$ in stage 3. This is because a *s*-type manager (who is mimicking) will renege on the relational contract at a $k$-state, and this happens with a probability of $\rho_s\beta$. Therefore, with a probability $\rho_s\beta$, the partner will not be paid for his efforts.

Second, Proposition 4.4 implies that the manager's compensation contract has an impact on the manager's signaling behavior. Note that (4.4.1) indicates that $\hat{b}_{pf}$ is the level of relational bonus rate that equalizes the *s*-type manager's expected life-time income utility in mimicking and the *s*-type manager's expected life-time income utility of taking the compensation scheme $(m_s, r_s)$. The value of $\hat{b}_{pf}$ is dependent on the compensation mechanism parameters $(m_s, r_s, m_f, r_f)$. To ensure that the *s*-type manager does not receive a higher income by mimicking the *f*-type manager, the *f*-type manager should choose a $b_{pf} \le \hat{b}_{pf}$. However, if $\hat{b}_{pf}$ is too small such that the partner exerts lower effort for the *f*-type manager in the separating case than in the pooling case, the *f*-type manager may have no incentive to choose a $b_{pf} \le \hat{b}_{pf}$ and separate. From the firm's perspective, however, pooling is not desirable since pooling leads to the possibility of reneging by the *s*-type manager and losing the partner relationship. Therefore, in order to

by the equilibrium strategy of one type of manager and not the other, then the partner should assume that realize a separating equilibrium in stage 2, the firm should choose a compensation mechanism $\{(m_s, r_s), (m_f, r_f)\}$ that makes the *f*-type manager willing to choose a $b_{pf} \le \hat{b}_{pf}$ to realize the separating equilibrium.

Denote $b_{pf}^{**}$ as the optimal relational bonus rate chosen by the *f*-type manager in relational contracting. The firm's problem can be formalized as

$$P4 \ : \ \max_{\{m_i, r_i\}_{i\in\{s,l\}}} \sum_{i\in\{s,l\}} \rho_i \left[\Pi(b_{pi})(1-b_m) - m_i - b_m b_{pi} r_i\right]$$

$$s.t. \ \ b_{ps} = \frac{1-\beta+\beta k}{\delta_s k + 1 - \beta + \beta k}(1+\theta_p r_s); b_{pf} = b_{pf}^{**}$$

$$\pi_i(m_i, r_i) \ge \pi_i^{mimic}(m_j, r_j, b_{pj}), \quad i, j \in \{s, f\}, i \ne j$$

$$\pi_i(m_i, \ r_i) \ge \left(\frac{1+\delta_i}{\delta_i}\right) M_0 (1-\beta+\beta k), \quad i \in \{s, \ l\}$$

Note that the difference between problem P4 and P3 is that the relational bonus rate $b_{pf}^{**}$ is chosen by the *f*-type manager rather than the firm. Denote $\{(m_s^{**}, r_s^{**}), (m_f^{**}, r_f^{**})\}$ as the optimal compensation mechanism with delegation in relational contracting. Proposition 4.5 characterizes the optimal compensation. (The detailed solution of $\{(m_s^{**}, r_s^{**}), (m_f^{**}, r_f^{**})\}$ is provided in Appendix B5.)

***Proposition 4.5*** *There exists a positive* $\rho_1 > 0$*, such that*

*(a) If* $\rho_s \ge \rho_1$ *, the firm delays part of the bonus for both types of managers (i.e.,* $r_f^{**} > 0$, $r_s^{**} > 0$*). The optimal compensation mechanism makes both types of managers earn the reservation income* $M_0$ *in each period of stage 3;*

*(b) If* $\rho_s < \rho_1$ *, the firm delays part of the bonus only for the s-type manager*

the latter implemented the strategy.

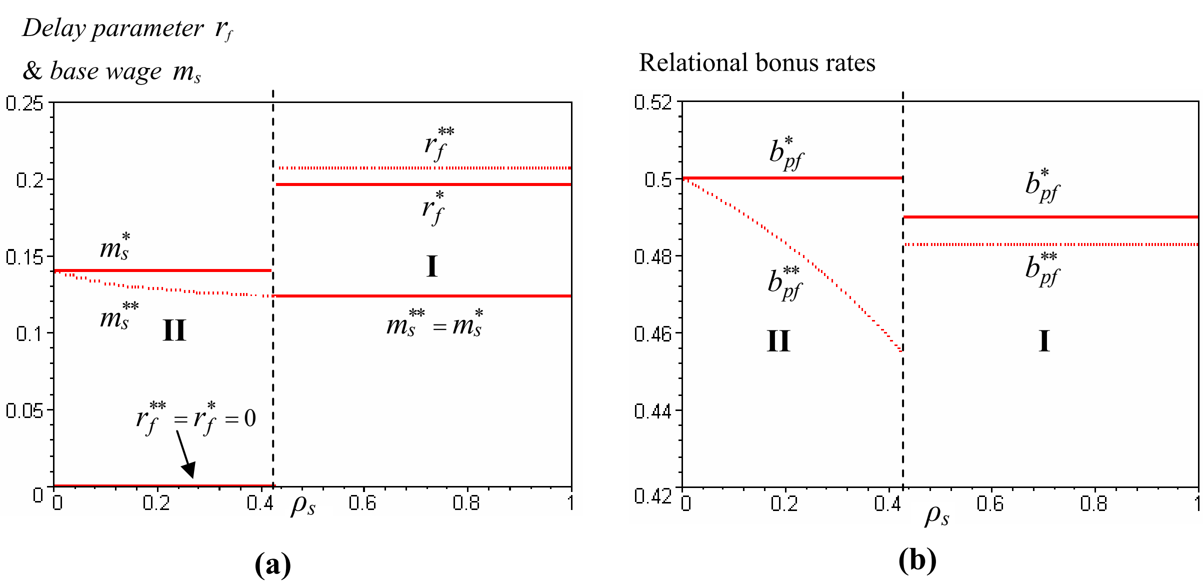
*(i.e., $r_f^{**} = 0$, $r_s^* > 0$). The optimal compensation mechanism makes the f-type manager earn the reservation income $M_0$ in each period of stage 3, and the s-type manager earns an income greater than or equal to $M_0$ in each period of stage 3;*

*(c) In both cases (a) and (b), the f-type manager chooses a $b_{pf}^{**} \le b_{pf}^*$ in the relational contracting.*

***Proposition 4.6*** *If $\rho_s < \rho_1$, it is optimal for the firm to adopt contingent delegation of relational contracting; if $\rho_s \ge \rho_1$, it is optimal for the firm to adopt centralized contracting.*

Proposition 4.5 summarizes how the firm can combine delegation in relational contacting with the manager's compensation contract. Proposition 4.6 indicates when delegated relational contracting can dominate centralized contracting. Figure 4.3 and 4.4 present a numerical example ($k = 3, \beta = 0.2,\ \delta_s = 0.7,\ \delta_f = 0.2,\ \theta_p = 1,\ b_m = 0.3,\ M_0 = 0.5,\ p = 0.05,\ y_L = 1$) to illustrate Proposition 5.5 and 5.6. First, consider region I in Figure 4.3a and 4.3b. In this region, the probability that the manager is a *s*-type is relatively large, i.e. $\rho_s > \rho_1 = 0.43$. To prevent the *s*-type manager from mimicking the *f*-type manager, the firm chooses to delay part of the bonus for the *f*-type manager ($r_f > 0$ for $\rho_s > \rho_1 = 0.43$). In this case, as shown in Figure 4.4, contingent delegation yields lower profits for the firm than centralized contracting. The reason is that if the firm delegates the relational contracting to the *f*-type manager, the *f*-type manager chooses a smaller relational bonus rate $b_{pf}$ so as to decrease the delayed bonus (recall that the delayed bonus for the *f*-type manager is $r_f b_m b_{pf}$). A small $b_{pf}$ discourages the partner from exerting effort on flexible tasks and makes the firm worse off.

Second, consider region II. In this case, the probability that the manager is a $s$-type is small, i.e., $\rho_s < \rho_1 = 0.43$. Therefore, the firm does not delay the bonus payment for the *f*-type manager, i.e., $r_f^{**} = 0$ (in region II in Figure 4.3a). Rather, the firm raises the base wage for the $s$-type manager (i.e., $m_s$) to eliminate the *s*-type manager's incentive to mimic the *f*-type manager. In Figure 4.3a, the level of $m_s$ in region II is higher than the level of $m_s$ in region I. Delegation can benefit the firm in this case. With delegation, the *f*-type manager chooses a smaller relational bonus rate to prevent mimicking by the *s*-type manager. Expecting this, the firm does not have to increase the base wage $m_s$ too much to prevent mimicking. Therefore, delegation benefits the firm by reducing the compensation costs.




Region I: Delegation is dominated; Delayed bonus for *f*-type
Region II: Delegation dominates; No delayed bonus for *f*-type

**Figure 4.3 (a): Compensation Contract Parameters With Delegated Relational Contracting**
**Figure 4.3 (b): Relational Contract Parameters With Delegated Relational Contracting**

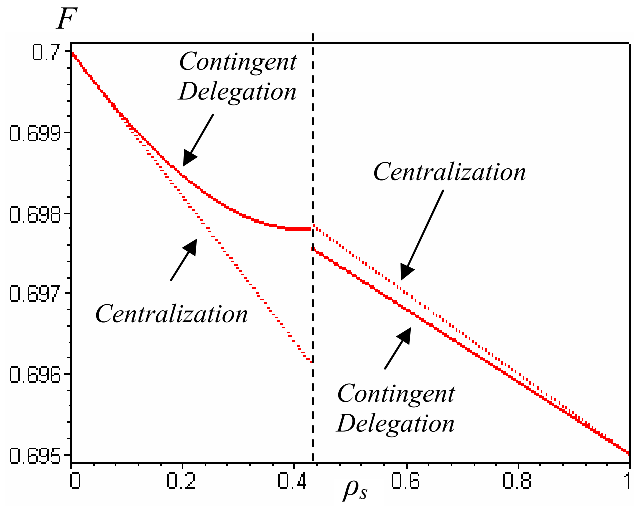



**Figure 4.4: The Firm's Expected Profit, *F***

Third, Proposition 4.5 also indicates that in contingent delegation, the *f*-type manager chooses a smaller relational bonus rate than what the firm does in centralized contracting, i.e., $b_{pf}^{**} \leq b_{pf}^{*}$ (as shown in Figure 4.3b). This is because, by decreasing $b_{pf}$, the *f*-type manager reduces the *s*-type manager's gain from mimicking the *f*-type manager. Note that a higher relational bonus rate $b_{pf}$ induces a larger effort from the partner, which leads to larger firm profit from non-contractible flexible tasks. Thus, a *s*-type manager gains more by choosing the higher relational bonus rate $b_{pf}$ and then reneging on the relationship. In this sense, a high relational bonus rate $b_{pf}$ increases the *s*-type manager's incentive to mimic the *f*-type manager. Therefore, in order to separate, the *f*-type manager decreases the relational bonus rate $b_{pf}$ he offers in relational contracting. This finding implies that when relational contracting is delegated to the *f*-type manager, the *f*-type manager may choose fewer non-contractible tasks in designing the relational contract with the partner.

In summary, Proposition 4.5 and Proposition 4.6 indicate that delegation of relational contracting benefits the firm by reducing the compensation cost in screening the *s*-type manager from the *f*-type manager. However, the *f*-type manager chooses a smaller relational bonus rate than what the firm does in centralized contracting, i.e., $b_{pf}^{**} \le b_{pf}^{*}$.

### 4.5 Extension: Manager's Bonus Rate is Endogenous

We extend the model to examine the case where the firm can also adjust the manager's bonus rate. In doing so, we assume that each type of manager can also exert effort in improving the firm's profits. Specifically, we assume that the firm's expected per-period gross profit (exclusive of the compensation cost) is

$$\Pi = \alpha e_{mi} + \left(y_L + e_p\right) - b_{pi} e_p - p \tag{4.5.1}$$

where $e_{mi}$ denotes the $i$-type manager's effort, $i \in \{s, f\}$, and the coefficient $\alpha$ captures the contribution of the manager's effort.[22] Also, it is assumed that the manager's effort cost function is $\frac{\theta_m e_{mi}^2}{2}$, where $\theta_m > 0$. Correspondingly, the firm compensates the $i$-type manager with a bonus rate $b_{mi}$. The bonus rate motivates the manager's efforts, i.e., the bonus rate $b_{mi}$ captures the *incentive power* of the manager's compensation scheme. In the case when both types of managers never renege on the relational contract, the firm will choose bonus rates $b_{mf} = b_{ms} = 1$ to make the manager a complete *residual claimant*. However, when the firm has incomplete information about the manager's type $\delta_i$, the

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[22] To simplify the exposition we do not consider the case where the *f*-type manager and the *s*-type manager may differ in their effort contribution, i.e., different $\alpha$ values for different types of managers.

firm can design a richer compensation mechanism $\{(m_s, b_{ms}, r_s), (m_f, b_{mf}, r_f)\}$ to elicit the manager's private information. Denote $\{(m_s^{***}, b_{ms}^{***}, r_s^{***}), (m_f^{***}, b_{mf}^{***}, r_f^{***})\}$ as the optimal compensation mechanism with endogenous $b_{ms}$ and $b_{mf}$, and that the firm contracts with both the manager and the partner (i.e., centralized contracting).

***Proposition 4.7*** *In the compensation mechanism* $\{(m_s^{***}, b_{ms}^{***}, r_s^{***}), (m_f^{***}, b_{mf}^{***}, r_f^{***})\}$*, the bonus rates for both types of managers satisfy that* $b_{ms}^{***} < 1$ *and* $b_{mf}^{***} < 1$.

Proposition 4.7 illustrates that in order to regulate the managers in relationship management, the firm is willing to decrease the incentive power of the managers' compensation scheme, i.e., both types of managers are no longer the complete residual claimants, i.e. $b_{ms}^{***} < 1$ and $b_{mf}^{***} < 1$. However, the reason that the firm lowers the incentive power for the *s*-type manager is different from why it lowers the incentive power for the *f*-type manager. For the *s*-type manager, a large bonus rate $b_{ms}$ leads to a higher gain from reneging on the relational contract. To decrease the *s*-type manager's incentive to renege, the firm decreases the *s*-type manager's effort incentive by decreasing the bonus rate $b_{ms}$.

For the *f*-type manager, however, the purpose of reducing the incentive power is to decrease the *s*-type manager's gain from mimicking the *f*-type manager. With a smaller $b_{mf}$, the *s*-type manager will earn lower bonus from mimicking the *f*-type manager and then reneging. Therefore, the firm sacrifices a certain incentive for the *f*-type manager in order to discourage the *s*-type manager from mimicking.

Proposition 4.8 indicates the value of delegated contracting when the managers' bonus rates are endogenous. Denote $\left\{\left(m_s^{****}, b_{ms}^{****}, r_s^{****}\right), \left(m_f^{****}, b_{mf}^{****}, r_f^{****}\right)\right\}$ as the optimal compensation mechanism with endogenous $b_{ms}$ and $b_{mf}$ and contingent delegation in relational contracting.

***Proposition 4.8*** *(a) If $\rho_s < \rho_1$, it is optimal for the firm to adopt contingent delegation of relational contracting; if $\rho_s \geq \rho_1$, it is optimal for the firm to adopt centralized contracting; (b) if $\rho_s < (\geq) \rho_1$, $b_{mf}^{****} > (=) b_{mf}^{***}$, i.e., the f-type manager's bonus rate is higher in the case of contingent delegation than in the case of centralized contracting.*

Proposition 4.8(a) illustrates that in the case with endogenous bonus rates for the managers, delegation in relational contracting can still benefit the firm, as it does in the case with exogenous bonus rates. The underlying intuition is similar. With centralized contracting, the firm always chooses a relational bonus rate $b_{pf}^{***}$, once the firm learns that the manager is a *f*-type manager. However, if the firm can credibly commit to a smaller relational bonus rate $b_{pf}$ with a *f*-type manager, the *s*-type manager's incentive to mimic can be reduced. The delegation of relational contracting to the *f*-type manager is one way of committing to a smaller value of $b_{pf}$, since the *f*-type manager will choose a relational bonus rate $b_{pf}^{****} < b_{pf}^{***}$ to separate himself from the *s*-type manager. Therefore, the firm can use delegation to decrease the *s*-type manager's incentive to mimic. This decreases the firm's compensation cost.

Proposition 4.8(b) reveals an indirect effect of delegation in relational contracting - delegation restores the incentive power of the *f*-type manager's compensation scheme. Since delegation helps to decrease the *s*-type manager's incentive to mimic, the firm does not have to sacrifice a large incentive power for the *f*-type manager (i.e., decrease $b_{mf}$ ) to discourage the *s*-type manager from mimicking. Therefore, with delegation, the firm can use a larger bonus rate $b_{mf}$ to motivate the *f*-type manager to

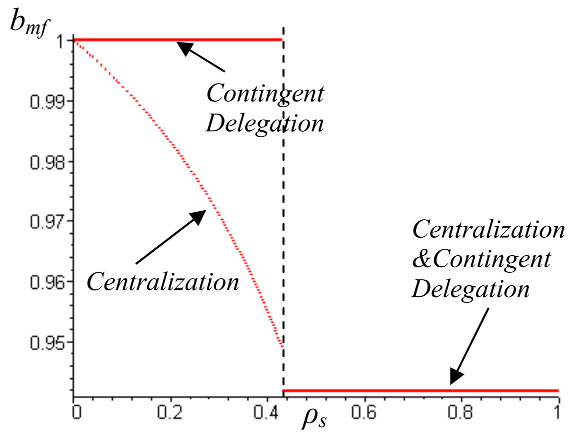


**Figure 4.5: The *f*-type Manager's Compensation Incentive Power, $b_{mf}$**

exert more effort. Figure 4.5 depicts how delegation increases the $b_{mf}$ the firm offers to the *f*-type manager when $\rho_s$ is small. This finding highlights the importance of designing incentive systems with many tools other than incentive contracts. As Gibbons (2005) summarizes: "…organizational design, and decisions that allocate control rights may be as important as contracts in structuring incentives…and multiple instruments need to be chosen as a system rather than in isolation".

### 4.6 Discussion

In this section, we discuss the implications of the model for firms' pursuit of efficiency and innovation. Existing literature suggests that by delegating decision rights to more informed agents (managers), decentralization promotes innovation strategies and behaviors that search for new opportunities. Centralization, on the other hand, promotes efficiency of existing operations, since the firm maintains better control over its operations. These contingencies are summarized in Figure 4.6 as un-shaded ellipses.

In our model, we consider two types of delegation: the delegation in partner relationship management and delegation in relational contracting. The delegation in partner relationship management is driven by the informational advantage of the manager. That is, since the manager has the day-to-day interactions with the partner, it is better for the firm to let the manager manage the partner relationship. Therefore, delegation in partner relationship management facilitates the firm's pursuit of innovation since it extends the firm's capacity in maintaining a large network of partners. This perspective is in line with the existing literature.

On the other hand, our model suggests that delegation in relational contracting does not promote innovation. In the model, with delegation in relational contracting, the farsighted manager tends to choose a smaller relational bonus rate. As a result, the partner will focus more on pre-specified fixed tasks and less on non-contractible flexible tasks. In this sense, delegation in relational contracting leads the partnership to become more efficiency-oriented (i.e., more focused on well defined tasks), and the partner is less motivated to search for new and undefined opportunities to improve the firm's performance. This corresponds to the shaded ellipse in Figure 4.6. This raises the question: what makes delegation in relational contracting distinct from the delegation in relationship management, in affecting the firm's innovation strategies through partnering?

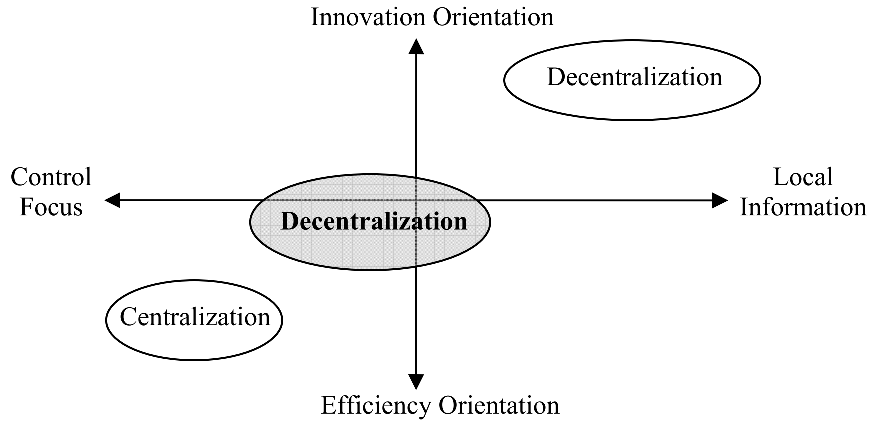


**Figure 4.6: Centralization/Decentralization and Strategic Orientation**

The essential difference is that in this model the firm delegates relational contracting to achieve superior control over the managers (i.e., agents), rather than to leverage managers' local information. Note that in the model, the manager may be myopic and have the incentive to renege on the firm's partner relationship. The myopic manager has an incentive to mimic a farsighted manager in order to get assigned to manage a partnership with a large relational benefit. The relational benefit is characterized by the relational bonus rate. A large relational bonus rate motivates more partner effort in innovation. Therefore, if the relational contract managed by the farsighted manager involves a large relational bonus rate, the myopic manager benefits more from reneging on such relational contract and thus has a large incentive to mimic. A large incentive to mimic makes it more costly for the firm to screen the myopic manager from the farsighted manager. To decrease the screening cost, the firm would like to reduce the partner's innovation effort in the relationship managed by the farsighted manager. The firm can do this by letting the farsighted manager design the relational contract. The farsighted manager induces less partner effort in non-contractible innovation activities, which decreases the myopic manager's gain from mimicking.

Note that unlike delegation in relationship management, delegation in relational contracting does not help the firm gain from the manager's informational advantage. In the centralized case, the firm also screens the myopic manager from the farsighted manager, but with a higher cost than in the case with delegation (since either the firm has to delay a large portion of the bonus for the farsighted manager or the firm has to pay a higher base wage to the myopic manager). In this sense, delegation in relational contracting alleviates the agency problem and helps the firm achieve better internal control over its managers (this control-focused role of decentralization is indicated in Figure 4.6).

The model also suggests that delegation in relational contracting can help increase the incentive power of the farsighted manager's compensation scheme. Therefore, delegation in relational contracting can help the firm maintain the farsighted manager's effort incentive. In this way, the delegation in relational contracting also has important implications for incentive management within the firm (as against incentives for external partners). Gibbons (2005) discusses more issues related to the interplay between the management within and between firms.

## 4.7 Conclusion

This paper investigates the internal coordination in managing external partner relationships. We examine the situation where a firm hires a manager to manage a partner relationship, and study whether the firm should delegate the development of the relational contract to the manager. The model suggests that when the manager may be myopic about maintaining the long-term partner relationship for the firm, the firm can use delegation in relational contracting together with the manager's compensation scheme to screen the myopic manager from the farsighted manager. The delegation in relational contracting can reduce the firm's screening cost and increase the effort incentive for the farsighted manager. Therefore, delegation in relational contracting can improve the firm's control over relationship managers. However, delegation in relational contracting undermines the partner-led innovation since the manager tends to motivate the partner to focus less on the non-contractible tasks. The model in this paper was developed in the context of the relationship between enterprise software vendors and their consulting partners. However, the insights from the model are generalizable to many different contexts, such as the relationships between firms and their IT or business process outsourcing partners, marketing channel partners, and their R&D alliance partners.

The analytical model presented in this paper has implications for empirical analysis. First, it is important to empirically explore the relationship between the delegation in relational contracting and the nature of the partner activities. For example, delegation in relational contracting is unlikely to be observed for partnerships which involve numerous complex and uncertain activities. However, for relationships that entail simpler and more specifiable activities, delegation in relational contracting is more likely to be observed. Second, our analysis suggests that the delegation in relational contracting can be profitably used when the proportion of myopic manager is sufficiently small. Thus, it would be interesting to empirically examine whether delegation is more common where managers have longer tenure. Third, empirical studies can be conducted to explore the link between the delegation in relational contracting and the relationship managers' compensation schemes. For example, it would be interesting to examine if relationship managers with long tenure and more authority in relational contracting have relatively less delay in their compensation.

# Appendix A: Appendix for Chapter 3

### A1. Proof of Proposition 1

With trivial calculus, we can show that $E\left[U_P^C\right] \geq E\left[U_P^D\right]$ if and only if

$$v^2a^2 + \left(u^2a^2 - d + 2da\right)v + du^2a^2 \geq 0 \tag{A1}$$

Denote $A = a^2$, $B = u^2a^2 - d + 2da$, and $C = du^2a^2$. Therefore,

(1) If $B \geq 0$, then the left-hand side (LHS) of (A1) is always positive and therefore $E\left[U_P^C\right] \geq E\left[U_P^D\right]$;

(2) If $B^2 - 4AC \leq 0$, the LHS of (A1) is always positive and therefore $E\left[U_P^C\right] \geq E\left[U_P^D\right]$.

Consider $B = u^2a^2 - d + 2da$. It is straightforward to see that when $a \geq 1/2$, $B \geq 0$. When $a < 1/2$, if $d > (\leq) \frac{u^2a^2}{1-2a}$, then $B < (\geq) 0$. Therefore:

When $a \geq 1/2$, we have $B \geq 0$ and $E\left[U_P^C\right] \geq E\left[U_P^D\right]$, which means that the principal chooses centralized IT governance (i.e., part a of Proposition 3.1 is proved);

When $a < 1/2$ and $d \leq \frac{u^2a^2}{1-2a}$, we have $B \geq 0$ and $E\left[U_P^C\right] \geq E\left[U_P^D\right]$.

With trivial calculus, we can also show that $B^2 - 4AC = \left(d - 4da + 4da^2 - u^2a^2\right)\left(d - u^2a^2\right)$. When $a < 1/2$, we have $\frac{u^2a^2}{1-4a(1-a)} > u^2a^2$. Therefore, $B^2 - 4AC > 0$ if $d < u^2a^2$ or $d > \frac{u^2a^2}{1-4a(1-a)}$.

Note that when $a < 1/2$, $\frac{u^2a^2}{1-4a(1-a)} > \frac{u^2a^2}{1-2a} > u^2a^2$. Therefore,

When $a < 1/2$ and $\frac{u^2a^2}{1-4a(1-a)} \geq d > \frac{u^2a^2}{1-2a}$, we have $B < 0$ but also $B^2 - 4AC \leq 0$. Because $B^2 - 4AC \leq 0$, (A1) holds and $E\left[U_P^C\right] \geq E\left[U_P^D\right]$. When $a < 1/2$ and $d \leq \frac{u^2a^2}{1-2a}$, we have $B \geq 0$

and $E\left[U_P^C\right] \geq E\left[U_P^D\right]$. Therefore, when $a < 1/2$ and $d \leq \frac{u^2 a^2}{1-4a(1-a)}$, we have $E\left[U_P^C\right] \geq E\left[U_P^D\right]$, which means that the principal chooses centralized IT governance (i.e., the first part of b of Proposition I is proved);

When $a < 1/2$ and $d > \frac{u^2 a^2}{1-4a(1-a)}$, we have $B < 0$ and $B^2 - 4AC > 0$. In this case, whether (A1) holds depends on the value of $v$. Note that (A1) can be represented as

$$\left(v - \frac{-B + \sqrt{B^2 - 4AC}}{2a}\right)\left(v - \frac{-B - \sqrt{B^2 - 4AC}}{2a}\right) \geq 0$$

Let $v^1 = \frac{-B - \sqrt{B^2 - 4AC}}{2a}$ and $v^2 = \frac{-B + \sqrt{B^2 - 4AC}}{2a}$, therefore,

(1) if $v \leq v^1$, (A1) holds and the principal chooses centralized IT governance (i.e., part 2.1 is proved);

(2) if $v^1 < v < v^2$, the principal chooses decentralized IT governance (i.e., part 2.2 is proved);

(3) if $v^2 \leq v$, the principal chooses centralized IT governance (i.e., part 2.3 is proved). Q.E.D.

**Proof of Proposition 2**

With trivial calculus, we can show that

$$\Delta = E\left[U_P^D\right] - E\left[U_P^C\right] = -\frac{d}{2(v+d)^2} + \frac{vd}{2(v+d)^3}$$

Therefore $\frac{\partial \Delta}{\partial v} = -\frac{2dva^2 - d^2 + 2ad^2 + a^2 v^2}{4(v+d)^2 (a-1)^2}$. When $v > (<) \frac{d(1-2a)}{a}$, we have $\frac{\partial \Delta}{\partial v} < (>) 0$, which means that $\Delta$ first increases and then decreases in *v*. Q.E.D.

**A2. Measures of Vertical and Horizontal Relatedness**

We employ the measure used in Fan & Lang (2000) to assess the *vertical relatedness* (*StVR*) between the firm's headquarter site and a divisional site. This measure uses the Input-Output (IO) Use table from Bureau of Economic Analysis to capture the input-output interdependencies between two business segments. Based on the IO Use table, the vertical relatedness between a divisional site in industry *j* and a headquarter site in industry *i*, denoted as $V_{ij}$, is calculated as

$$V_{ij} = 1/2\left(a_{ij}/T_j + a_{ji}/T_i\right)$$

where $a_{ij}$ denotes the dollar value of industry *i*'s output required to produce industry *j*'s total output, and $T_j$ denotes the industry *j*'s total output. Similarly for $a_{ji}$. If the two sites have strong make-buy relationship according to the material flow data in the Input-Output table, they will have a high value of vertical relatedness.

We employ the measure used in Fan & Lang (2000) to assess the *horizontal complementarity* (*StHC*) between the firm's headquarter site and a divisional site. First, from the IO Use table, for each industry *i*, we compute the percentage of its output supplied to each intermediate industry *k*, denoted as $b_{ik}$. Then, for each pair of industries *i* and *j*, we calculate the correlation coefficient between $b_{ik}$ and $b_{jk}$ across all *k* except for *i* and *j*. Second, for each industry we calculate the percentage of its input from each intermediate industry *k*, denoted as $d_{ik}$. For each pair of industries *i* and *j*, we then calculate the correlation coefficient between $d_{ik}$ and $d_{jk}$ across all *k* except for *i* and *j*. The horizontal complementarity between a headquarter site in industry *i* and a divisional site in industry *j*, denoted by $C_{ij}$, is calculated as the average of the two correlation coefficients, i.e.,

$$C_{ij} = 1/2\left(corr\left(b_{ik}, b_{jk}\right) + corr\left(d_{ik}, d_{jk}\right)\right)$$

We also use the NAICS code to assess the business distance (*StDist*) between the firm's headquarter site and a divisional site. If a divisional site has the same 4-digit NAICS code as the firm's headquarter site (i.e., this divisional site is in the same 4-digit industry as the headquarter site), the *StDist* for this divisional site is 0; If a divisional site has a different 4-digit NAICS code but the same 2-digit NAICS code as the firm's headquarter site (the divisional site and the headquarter site are in different 4-digit industries but the same 2-digit industry group), the *StDist* for this divisional site is 1; If a divisional site has a 2-digit NAICS code that is different from that of the firm's headquarter site (the divisional site and the headquarter site are in different 2-digit industry groups), the *StDist* for this divisional site is 2.

# Appendix B: Appendix for Chapter 4

## B1: Proof of Proposition 1

If the manager never reneges on the relational contract, the firm will choose a relational bonus rate $b_p = \frac{1}{2}$. When $\delta < \frac{1-\beta+\beta k}{k}$, the manager will never renege on a relational contract with $b_p = \frac{1}{2}$ as (4.2.9) is always satisfied even when $r = 0$. Therefore, when $\delta < \frac{1-\beta+\beta k}{k}$, the firm does not need to delay the bonus payment to prevent the manager from reneging on the relational contract. QED.

## B2: Proof of Proposition 2

When $\delta > \frac{1-\beta+\beta k}{k}$, it implies that $\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k} < \frac{1}{2}$.

Note that the firm can always make the manager's participation constraint binding by choosing

$$m = M_0 - b_m\left[\Pi(b_p) - b_p r\right] - \frac{b_m b_p r}{1+\delta}$$

(B2.1)

Therefore, the firm's per-period net profit can be represented as

$$F = \Pi(b_p) - \frac{b_m b_p \delta r}{1+\delta} - M_0$$

(B2.2)

When $r = 0$, the firm will choose $b_p = \frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}(1+\theta_p r) = \frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k} < \frac{1}{2}$ in relational contracting to prevent reneging from taking place. In this case, however, $\Pi(b_p) = y_L + \frac{b_p}{\theta_p} - \frac{b_p^2}{\theta_p} - p$

$$\frac{dF}{dr}\Big|_{r=0} = \frac{\partial F}{\partial r} + \frac{\partial F}{\partial b_p}\frac{\partial b_p}{\partial r}\Big|_{r=0} = \left(\frac{1}{\theta_p} - \frac{2b_p}{\theta_p}\right)\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\theta_p - \frac{b_m b_p \delta}{1+\delta}$$

$$=\left[\left(1-2\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\right)-\frac{b_m\delta}{1+\delta}\right]\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}$$

Therefore, when $b_m<\left(1-2\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\right)\frac{1+\delta}{\delta}$, $dF/dr>0$ and the firm will choose a $r>0$.

When $r>0$, the firm has no incentive to choose a $r$ to make $b_p=\frac{1}{2}-\frac{b_m\theta_p\delta r}{1+\delta}<\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right)$. This is because $b_p=\frac{1}{2}-\frac{b_m\theta_p\delta r}{1+\delta}$ is the solution of the first-order condition $dF/db_p=0$. If $\frac{1}{2}-\frac{b_m\theta_p\delta r}{1+\delta}<\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right)$, the firm will always choose $b_p=\frac{1}{2}-\frac{b_m\theta_p\delta r}{1+\delta}$ to satisfy $dF/db_p=0$. In this case, by the Envelop Theorem

$$\frac{dF}{dr}=\frac{\partial F}{\partial r}+\frac{\partial F}{\partial b_p}\frac{\partial b_p}{\partial r}=-\frac{b_m b_p\delta}{1+\delta}<0$$

Therefore, the optimal $r$ satisfies $r=\min\left[r',r''\right]$, where $r'$ solves $\frac{1}{2}-\frac{b_m\theta_p\delta r}{1+\delta}=\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right)$ and $r''$ solves the first-order condition

$$\frac{dF}{dr}=\frac{\partial F}{\partial r}+\frac{\partial F}{\partial b_p}\frac{\partial b_p}{\partial r}=\left(\frac{1}{\theta_p}-\frac{2b_p}{\theta_p}-\frac{b_m r\delta}{1+\delta}\right)\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\theta_p-\frac{b_m b_p\delta}{1+\delta}=0$$

where $b_p=\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right)$.

And by (B2.1), the optimal base wage $m$ is given by

$$m=M_0-b_m\left[\Pi\left(b_p\right)-b_p r\right]-\frac{b_m b_p r}{1+\delta},\ b_p=\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right).\qquad \text{QED.}$$

**B3: Proof of Proposition 3**

Note that in problem P3, only the $s$-type manager has the incentive to mimic the $f$-type manager. Therefore, from the standard solution of the screening contract (see e.g. Laffont and Martimort, 2002, pg. 156), we know that the *participation constraint* for the $f$-type manager must be binding as the firm does not need to leave any information rent to the *f*-type manager, i.e. the *f*-type manager earns an income of $M_0$, which is his reservation income. This means that the firm chooses the *f*-type manager's base wage as

$$m_f^* = M_0 - b_m\left(\left(\frac{1}{2\theta_{pf}} - p\right) - \frac{r_f^*}{2}\right) + \frac{b_m r_f^*}{2\left(1+\delta_f\right)}$$

Also, the *incentive constraint* for the $s$-type manager must be binding, i.e. the s-type manager is indifferent between mimicking the *f*-type manager and truthfully revealing his type. Therefore, the firm's expected per-period net profit, denoted as $F$, can be represented as

$$\begin{aligned} F &= \rho_s\left[\Pi\left(b_{ps}\right) - \left(\tfrac{\delta_s}{1+\delta_s}\right)\tfrac{\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right)}{(1-\beta+\beta k)} - \left(\tfrac{\delta_s}{1+\delta_s}\right)b_m b_p r_s\right] + \left(1-\rho_s\right)\left[\Pi\left(b_{pf}\right) - M_0 - \left(\tfrac{\delta_f}{1+\delta_f}\right)b_m b_{pf} r_f\right] \\ &= \rho_s\left[\Pi\left(b_{ps}\right) - \left(\tfrac{\delta_s}{1+\delta_s}\right)b_m b_p r_s - M_0\right] + \left(1-\rho_s\right)\left[\Pi\left(b_{pf}\right) - M_0 - \left(\tfrac{\delta_f}{1+\delta_f}\right)b_m b_{pf} r_f\right] \\ &\quad - \left(\tfrac{\delta_s}{1+\delta_s}\right)\beta\left(\tfrac{1+\delta_s}{\beta+\delta_s}\right)b_m\left[b_{pf}\left(\tfrac{k}{1-\beta+\beta k}\right) - \tfrac{1}{\delta_s}\left(\tfrac{b_{pf}}{\theta_p} - \tfrac{b_{pf}^2}{\theta_p} + b_{pf} r_f\right)\right]\rho_s \end{aligned}$$

(B3.1)

The first (second) term is the firm's per-period net profit when it has a *s*-type (*f*-type) manager and the firm knows the manager's type. The third term in (B3.1) represents the $s$-type manager's average per-period information rent. Therefore, $\frac{\partial F}{\partial r_f}\Big|_{b_{pf}=1/2} = -\left(1-\rho_s\right)\left(\frac{\delta_f}{1+\delta_f}\right)\left(\frac{b_m}{2}\right) + \rho_s\left(\frac{1}{1+\delta_s}\right)\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right)b_m\left(\frac{1}{2}\right)$. When

$$\rho_s < \rho_1 = \left(\frac{\delta_f}{1+\delta_f}\right) \Big/ \left[\left(\frac{\delta_f}{1+\delta_f}\right) + \left(\frac{\beta}{\beta+\delta_s}\right)\right]$$

we have $\frac{\partial F}{\partial r_f}\Big|_{b_{pf}=1/2} < 0$. Therefore, the firm must choose $r_f^* = 0$ in equilibrium, i.e., the firm does not delay the bonus for the *f*-type manager. Otherwise, when $\rho_s \geq \rho_1$, we must have $r_f^* > 0$ in the equilibrium.

When $r_f^* = 0$, $m_s^*$ is chosen such that the $s$-type manager's per-period income is $\left(\frac{\delta_s}{1+\delta_s}\right)\frac{\pi_s^{mimic}\left(m_f^*, r_f^*, b_{pf}^*\right)}{(1-\beta+\beta k)}$, which is greater than his reservation income $M_0$ since the *s*-type manager also receives information rent. Note that the total payment that the *s*-type manager earns in each period is $m_s^* + b_m\left[\Pi\left(b_{ps}^*\right) - b_{ps}^* r_s^*\right] - \frac{b_m b_{ps}^* r_s^*}{1+\delta_s}$ (see 4.2.4). Therefore,

$$m_s^* = \left(\tfrac{\delta_s}{1+\delta_s}\right)\frac{\pi_s^{mimic}\left(m_f^*, r_f^*, b_{pf}^*\right)}{\left(1-\beta+\beta k\right)} - b_m\left[\Pi\left(b_{ps}^*\right) - b_{ps}^* r_s^*\right] + \frac{b_m b_{ps}^* r_s^*}{1+\delta_s}$$

When $r_f^* > 0$, $r_f^*$ is chosen such that the information rent (see 4.3.3) for the $s$-type manager is zero. Therefore, $r_f^*$ is the solution of $\pi_s^{mimic}\left(m_f^*, r_f, b_{pf}^*\right) = \left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$, where $b_{pf}^* = \frac{1}{2} - \frac{b_m \theta_p \delta_f r_f}{1+\delta_f}$ is the solution of the first-order condition $dF_f / db_{pf} = 0$, and $F_f$ is given by

$$F_f = \Pi\left(b_{pf}\right) - \frac{b_m b_{pf} \delta_f r_f}{1+\delta_f} - M_0 .$$

$m_s^*$ is chosen such that the $s$-type manager's per-period income is equal to his reservation income, $M_0$, by (4.2.4),

$$m_s^* = M_0 - b_m\left[\Pi\left(b_{ps}^*\right) - b_{ps}^* r_s\right] + \frac{b_m b_{ps}^* r_s^*}{1+\delta_s} . \qquad \text{QED.}$$

**B4: Proof of Proposition 4**

For expository purpose, we define the following notations. When there exists a pooling equilibrium when both types of managers accept $\left(m_f, r_f\right)$ and choose a $b_{pf}^{'}$ in relational contracting, we denote $\pi_{f-pool}\left(m_f, r_f, b_{pf}^{'}\right)$ and $\pi_{s-pool}\left(m_f, r_f, b_{pf}^{'}\right)$ as the total life-time income utility of the *f*-type manager and *s*-type manager, respectively, in the pooling equilibrium. Also, when there exists a separating equilibrium in which the *f*-type manager choose a $b_{pf}^{''} \neq b_{pf}^{'}$, we denote $\pi_{f-sep}\left(m_f, r_f, b_{pf}^{''}\right)$ and $\pi_{s-sep}\left(m_s, r_s, b_s\right)$ as the total life-time income utility of the *f*-type manager and *s*-type manager, respectively, in the separating equilibrium.

In a pooling equilibrium, the partner believes that the manager is a *s*-type manager with a probability $\rho_s$ (i.e. the prior belief). Therefore, the partner chooses an optimal effort

$$e_p \in \arg\max\left[\rho_f + \rho_s\left(1-\beta\right)\right]b_p e_p - \frac{\theta_p e_p^2}{2} + p$$

which yields $e_{pf} = \frac{\left[\rho_f + \rho_s(1-\beta)\right]b'_{pf}}{\theta_p}$. This is because a $s$-type manager at a $k$-state will renege on the relational contract, which happens with a probability $\rho_s\beta$ and the partner will not be paid for his effort. Therefore, the payoffs of the two types of managers' in the pooling equilibrium can be represented as

$$\pi_{f-pool}\left(m_f,\ r_f,\ b'_{pf}\right) = b_m\left[y_L + \frac{\left[\rho_f+\rho_s(1-\beta)\right]b'_{pf}}{\theta_p} - \frac{\left[\rho_f+\rho_s(1-\beta)\right]b'^2_{pf}}{\theta_p} - p\right] + \left[\frac{b_m b'_{pf} r_f}{1+\delta_f} - b_m b'_{pf} r_f\right] + m_f$$

(B4.1)

The first terms in (B4.1) is the *f*-type manager's total bonus, the second terms in (B4.1) is the *f*-type manager's income from delayed bonus, the third terms in (B4.1) is the base wage. If the $f$-type manager has no incentive to deviate, then $b'_{pf}$ must satisfy the first-order condition $b_m\left[\frac{\left[\rho_f+\rho_s(1-\beta)\right]}{\theta_p} - \frac{2\left[\rho_f+\rho_s(1-\beta)\right]b'_{pf}}{\theta_p} - r_f\right] + \frac{b_m r_f}{1+\delta_f} = 0$. Therefore, in a pooling equilibrium

$$b'_{pf} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)\ \left[\rho_f + \rho_s\left(1-\beta\right)\right]}$$

Next, in the separating equilibrium, the partner is informed about the manager's *f*-type when it observes $b''_{pf}$. Therefore,

$$\pi_{f\text{-}sep}\left(m_f, r_f, b''_{pf}\right) = b_m\left[\Pi\left(b''_{pf}\right) - b''_{pf} r_f\right] + \frac{b_m b''_{pf} r_f}{1+\delta_f} + m_f$$

$$\pi_{s\text{-}sep}(m_s, r_s, b_s) = b_m[\Pi(b_{ps}) - b_{ps} r_s] + \frac{b_m b_{ps} r_s}{1+\delta_s} + m_s = \pi_s(m_s, r_s)$$

Note in order to discourage the $s$-type manager from mimicking, $b''_{pf}$ should satisfy that $\pi_s^{mimic}\left(m_f, r_f, b''_{pf}\right) \le \pi_s\left(m_s, r_s\right)$. Let $\tilde{b}_{pf}$ denote the larger root of $\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right) = \pi_s\left(m_s, r_s\right)$. Therefore, $b''_{pf} \le \tilde{b}_{pf}$. Also, $b''_{pf}$ should satisfy the first-order condition $\frac{\partial \pi_{f-sep}\left(m_f, r_f, b''_{pf}\right)}{\partial b''_{pf}} \ge 0$, i.e. $b''_{pf} \le \frac{1}{2} - \frac{\delta_f r_f}{2\left(1+\delta_f\right)}$ (otherwise, the *f*-type manager can get better off by decreasing $b''_{pf}$ ). Therefore, in the separating equilibrium the *f*-type manager must choose

$$b''_{pf} = \min\left(\tilde{b}_{pf},\ \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}\right)$$

(B4.2)

If $b''_{pf} < \left[\rho_f + \rho_s\left(1-\beta\right)\right] b'_{pf}$, which can be transformed as $b''_{pf} < \frac{\left(1-\rho_s\right)+\rho_s\left(1-\beta\right)}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ , then $\pi_{f-sep}\left(m_f, r_f, b''_{pf}\right) < \pi_{f-pool}\left(m_f, r_f, b'_{pf}\right)$, which means the *f*-type manager's payoff in the separating equilibrium is less than its payoff in the pooling equilibrium. In this case, the *f*-type manager has no incentive to deviate from the pooling equilibrium and separate himself from the *s*-type manager. Therefore, the only equilibrium is a pooling equilibrium.

If $b''_{pf} \ge \left[\rho_f + \rho_s\left(1-\beta\right)\right] b'_{pf}$ (i.e., $b''_{pf} \ge \frac{\left(1-\rho_s\right)+\rho_s\left(1-\beta\right)}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ ), then $\pi_{f-sep}\left(m_f, r_f, b''_{pf}\right) \ge \pi_{f-pool}\left(m_f, r_f, b'_{pf}\right)$. The $f$-type manager can be weakly better off by deviating from $b'_{pf}$ to $b''_{pf}$ to separate himself from the *s*-type manager. Since the *s*-type manager does not find it profitable to mimic the *f*-type manager by accepting $\left(m_f, r_f\right)$ and choosing $b''_{pf}$ , when the partner observes a relational bonus rate $b_{pf}^{''}$, the partner rationally concludes that the manager is of *f*-type. For any other value of $b_{pf}$, it concludes that the manager is of *s*-type. This separating equilibrium is the only equilibrium. QED.

**B5: Proof of Proposition 5**

First, the firm's objective in delaying the *s*-type manager's bonus (i.e., $r_s^{**} > 0$) is to prevent the *s*-type manager from reneging on the relational contract. Therefore, following the proof of Proposition 4.2, the optimal $r_s^{**}$ satisfies $r_s^{**} = \min\left[r', r''\right]$, where $r'$ solves $\frac{1}{2} - \frac{b_m \theta_p \delta_s r}{1+\delta_s} = \frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r\right)$ and $r''$ solves the first-order condition

$$\left(\frac{1}{\theta_p} - \frac{2b_{ps}}{\theta_p}\right)\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\theta_p - \frac{b_m b_{ps}\delta_s}{1+\delta_s} = 0$$

where $b_{ps} = \frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\left(1+\theta_p r_s\right)$.

Next, since the firm does not need to leave any information rent to the *f*-type manager, the *f*-type manager earns an income of $M_0$ in each period, which is his reservation income. This implies that the firm chooses the *f*-type manager's base wage

$$m_f^{**} = M_0 - b_m\left[\Pi\left(b_{pf}^{**}\right) - \frac{r_f^{**}}{2}\right] + \frac{b_m b_{pf}^{**} r_f^{**}}{1+\delta} \qquad \text{(B5.1)}$$

Before we derive $r_f^{**}$ and $m_s^{**}$, we first establish two claims, i.e. Claim 1 and Claim 2.

***Claim 1.*** *If* $\rho_s \geq \rho_1 = \left(\frac{\delta_f}{1+\delta_f}\right)/\left(\frac{\delta_f}{1+\delta_f} + \frac{\beta}{\beta+\delta_s}\right)$ *, then we must have* $r_f^{**} \geq 0$ *(i.e., the firm may or may not delays bonus for the f-type manager) and*

$$\pi_s\left(m_s^{**},r_s^{**}\right)=\pi_s^{mimic}\left(m_f^{**},r_f^{**},b_{pf}^{**}\right)=\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$$

*(i.e., the s-type manager earns an income of $M_0$ in each period, which is his reservation income. In other words, the s-type manager's information rent is zero).*

*Otherwise, if $\rho_s<\rho_1=\left(\tfrac{\delta_f}{1+\delta_f}\right)/\left(\tfrac{\delta_f}{1+\delta_f}+\tfrac{\beta}{\beta+\delta_s}\right)$, we must have $r_f^{**}=0$ and $\pi_s\left(m_s^{**},r_s^{**}\right)=\pi_s^{mimic}\left(m_f^{**},r_f^{**},b_{pf}^{**}\right)>\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$ (i.e., the s-type manager has a positive information rent).*

**Proof:** Consider the case when $\rho_s\geq\rho_1=\left(\tfrac{\delta_f}{1+\delta_f}\right)/\left(\tfrac{\delta_f}{1+\delta_f}+\tfrac{\beta}{\beta+\delta_s}\right)$. If $\pi_s\left(m_s^{**},r_s^{**}\right)>\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$, then the firm can be made better off by choosing a $r_f^{'}>r_f^{**}$ and a $m_s^{'}<m_s^{**}$ such that the relational bonus rate $b_{pf}$ is unchanged, i.e., $b_{pf}\left(r_f^{**},m_s^{**}\right)=b_{pf}\left(r_f^{'},m_s^{'}\right)$, and the *s*-type manager's per-period income decreases to $M_0$ , i.e., the *s*-type manager's expected life-time income utility decreases to $\pi_s\left(m_s^{'},r_s^{**}\right)=\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$.

To see that, note that if we fix the value of $b_{pf}$ , then the first derivative of the firm's expected per-period net profit $F$ w.r.t. $r_f$ is

$$\frac{\partial F}{\partial r_f}=\left[-\left(1-\rho_s\right)\left(\frac{\delta_f}{1+\delta_f}\right)+\left(\frac{\beta}{\beta+\delta_s}\right)\rho_s\right]b_m b_{pf}>0$$

which implies that the firm can be made better off by increasing $r_f$ and decreasing $m_s$ until $\pi_s\left(m_s,r_s\right)=\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$. Therefore, we must have $r_f^{**}\geq 0$ and $\pi_s\left(m_s^{**},r_s^{**}\right)=\left(\tfrac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$ .

If $\rho_s < \rho_1 = \left(\frac{\delta_f}{1+\delta_f}\right) / \left(\frac{\delta_f}{1+\delta_f} + \frac{\beta}{\beta+\delta_s}\right)$, then fixing $b_{pf}$, we have $\frac{\partial F}{\partial r_f} = \left[-\left(1-\rho_s\right)\left(\frac{\delta_f}{1+\delta_f}\right) + \left(\frac{\beta}{\beta+\delta_s}\right)\rho_s\right] b_m b_{pf} < 0$, i.e., the firm's expected profit is decreasing in $r_f$. Therefore, we must have $r_f^{**} = 0$ in equilibrium. Suppose we have $r_f^{**} > 0$ and $\pi_s\left(m_s^{**}, r_s^{**}\right) = \left(\frac{1+\delta_s}{\delta_s}\right) M_0\left(1-\beta+\beta k\right)$. Then the firm can be made better off by choosing a $r_f^{'} = 0$ and a $m_s^{'} > m_s^{**}$ such that the relational bonus rate $b_{pf}$ is unchanged, i.e., $b_{pf}\left(r_f^{**}, m_s^{**}\right) = b_{pf}\left(r_f^{'}, m_s^{'}\right)$ and $\pi_s\left(m_s^{'}, r_s^{**}\right) > \left(\frac{1+\delta_s}{\delta_s}\right) M_0\left(1-\beta+\beta k\right)$. Therefore, $\pi_s\left(m_s^{**}, r_s^{**}\right) > \left(\frac{1+\delta_s}{\delta_s}\right) M_0\left(1-\beta+\beta k\right)$ in equilibrium.

QED.

***Claim 2.*** *In the separating equilibrium with* $r_f^{**} > 0$, *the firm always choose a* $r_f^{**}$ *such that* $b_{pf}^{**} = \hat{b}_{pf} \le \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$, *where* $\hat{b}_{pf}$ *is defined in Proposition 4 as the larger root of* $\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right) = \pi_s\left(m_s, r_s\right)$.

**Proof:** Note that in delegation of relational contracting, $\hat{b}_{pf}$ is the level of relational bonus rate that makes the *s*-type manager indifferent between mimicking and not mimicking. In the separating equilibrium, the *f*-type manager must choose $b_{pf}^{**} \le \hat{b}_{pf}$ in order to separate. If $\hat{b}_{pf} > \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ the *f*-type manager chooses $b_{pf} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ in relational contracting. Then

$$\frac{\partial F}{\partial r_f} = -\left(1-\rho_s\right)\left(\frac{\delta_f}{1+\delta_f}\right) b_m b_{pf} < 0$$

Therefore, the firm has an incentive to decrease $r_f$ until $\hat{b}_{pf} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$. QED.

Next, we characterize the solution of $r_f^{**}$ and $m_s^{**}$. First, consider the case when $\rho_s > \rho_1$. In this case, according to *Claim 1*, $\pi_s\left(m_s,\ r_s\right) = \left(\frac{1+\delta_s}{\delta_s}\right) M_0\left(1-\beta+\beta k\right)$, i.e. the s-type manager should receive a per-period income of $M_0$. Therefore, $m_s^* = M_0 - b_m\left[\Pi\left(b_{ps}^{**}\right) - b_{ps}^{**} r_s^{**}\right] - \dfrac{b_m b_{ps}^{**} r_s^{**}}{1+\delta_s}$.

Also, the equation $\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right) = \pi_s\left(m_s, r_s\right)$ reduces to

$$\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right) b_m\left[\frac{b_{pf}^2}{\theta_p}k - \frac{1}{\delta_s}\left(\frac{b_{pf}}{\theta_p} - \frac{b_{pf}^2}{\theta_p} + b_{pf} r_f\right)\left(1-\beta+\beta k\right)\right] = 0$$

Therefore $\hat{b}_{pf}$ is determined by $\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right) b_m\left[\frac{b_{pf}}{\theta_p}k - \frac{1}{\delta_s}\left(\frac{1}{\theta_p} - \frac{b_{pf}}{\theta_p} + r_f\right)\left(1-\beta+\beta k\right)\right] = 0$ and given $r_f$, we have

$$\hat{b}_{pf} = \frac{\left(1+\theta_p r_f\right)\left(1-\beta+\beta k\right)}{k\delta_s + \left(1-\beta+\beta k\right)} \qquad \text{(B5.2)}$$

and

$$\frac{\partial \hat{b}_{pf}}{\partial r_f} = \frac{\theta_p\left(1-\beta+\beta k\right)}{k\delta_s + \left(1-\beta+\beta k\right)} > 0$$

Denote $\hat{r}_f$ as the solution of $\hat{b}_{pf} = \frac{\left(1+\theta_p r_f\right)\left(1-\beta+\beta k\right)}{k\delta_s+\left(1-\beta+\beta k\right)} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$, i.e. $\hat{r}_f = \frac{\left[k\delta_s+\left(1-\beta+\beta k\right)\right]\left(1+\delta_f\right) - 2\left(1-\beta+\beta k\right)\left(1+\delta_f\right)}{2\theta_p\left(1-\beta+\beta k\right)\left(1+\delta_f\right) + \theta_p\left[k\delta_s+\left(1-\beta+\beta k\right)\right]\delta_f r_f}$. Note that if $r_f > \hat{r}_f$, then $\hat{b}_{pf} > \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ and the *f*-type manager will choose $b_{pf} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}$ in relational contracting (the Proposition 4.4 establishes that the *f*-type manager will choose $b_{pf} = \min\left(\hat{b}_{pf},\ \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2\left(1+\delta_f\right)}\right)$ in the separating equilibrium); if

$r_f \le \hat{r}_f$, then $\hat{b}_{pf} \le \frac{1}{2} - \frac{\theta_p \delta_f r_f}{2(1+\delta_f)}$ and the *f*-type manager will choose $b_{pf} = \hat{b}_{pf}$ in relational contracting. If the firm chooses a $r_f > \hat{r}_f$, then the firm delays more of the *f*-type manager's bonus than necessary. The firm can be made better off by decreasing $r_f$ to $r_f = \hat{r}_f$, which increases $b_{pf}$ from $\frac{1}{2} - \frac{\theta_p \delta_f r_f}{2(1+\delta_f)}$ to $\hat{b}_{pf}$ (The intuition is that the decrease in $r_f$ lets the firm delay less bonus for the *f*-type manager, and the increase in $b_{pf}$ induces more partner effort.). Therefore, we must have $b_{pf}^{**} = \hat{b}_{pf}$ in the separating equilibrium.

The first derivative of the firm's expected per-period profit net $F$ w.r.t. $r_f$ is

$$\begin{aligned}\frac{\partial F}{\partial r_f} &= \left[-(1-\rho_s)\left(\frac{\delta_f}{1+\delta_f}\right)+\left(\frac{\beta}{\beta+\delta_s}\right)\rho_s\right]b_m b_{pf} + (1-\rho_s)\left[\left(\frac{1}{\theta_p}-\frac{2b_{pf}}{\theta_p}\right)-\left(\frac{\delta_f}{1+\delta_f}\right)b_m r_f\right]\left(\frac{\partial b_{pf}}{\partial r_f}\right)\\ &= \left[-(1-\rho_s)\left(\frac{\delta_f}{1+\delta_f}\right)+\left(\frac{\beta}{\beta+\delta_s}\right)\rho_s\right]b_m b_{pf} + (1-\rho_s)\left(\frac{1}{\theta_p}-b_m\right)\left(\frac{\delta_f}{1+\delta_f}\right)r_f\left(\frac{\theta_p(1-\beta+\beta k)}{k\delta_s+(1-\beta+\beta k)}\right)\end{aligned}$$

Therefore, when $\frac{\partial F}{\partial r_f}|_{r_f=\hat{r}_f} > 0$, $r_f^{**} = \hat{r}_f$ (the firm has no incentive to choose $r_f^{**} > \hat{r}_f$); when $\frac{\partial F}{\partial r_f}|_{r_f=\hat{r}_f} < 0$, $r_f^{**} < \hat{r}_f$ and $r_f^{**}$ satisfies that $\frac{\partial F}{\partial r_f}|_{r_f=r_f^{**}} = 0$.

To see why $b_{pf}^{**} \le b_{pf}^{*}$ in this case, recall that in centralized case, $b_{pf}^{*} = \frac{1}{2} - \frac{b_m \theta_p \delta_f r_f^{*}}{1+\delta_f}$. In delegation, $b_{pf}^{**} = \hat{b}_{pf} < \frac{1}{2} - \frac{\theta_p \delta_f r_f^{**}}{2(1+\delta_f)} < \frac{1}{2} - \frac{b_m \theta_p \delta_f r_f^{**}}{2(1+\delta_f)}$. If $b_{pf}^{**} > b_{pf}^{*}$, the firm can be better off in centralized case to decrease $r_f^{*}$ until $b_{pf}^{*} = b_{pf}^{**}$. By doing so, the firm increases its expected net profit in centralized case without causing any reneging.

Second, consider the case when $\rho_s < \rho_1$. In this case $r_f^{**} = 0$, and we just need to derive $m_s^{**}$. Again, let $b_{pf}$ be the larger root of $\pi_s^{mimic}\left(m_f, r_f, b_{pf}\right) = \pi_s\left(m_s, r_s\right)$, and we denote the solution of $b_{pf}$ as a function of $m_s$, i.e., $b_{pf}\left(m_s\right)$. In the separating equilibrium, the *f*-type manager will choose $b_{pf}\left(m_s\right)$ to prevent the *s*-type manager from mimicking. Consider the impact of changing $m_s$ on $F$,

$$\frac{\partial F}{\partial m_s} = \left(1-\rho_s\right)\left(\frac{1}{\theta_p} - \frac{2b_{pf}}{\theta_p}\right)\left(\frac{\partial b_{pf}\left(m_s\right)}{\partial m_s}\right) - \rho_s$$

denote $\widetilde{m}_s$ and $\widetilde{b}_{pf}$ as the solution of

$$\pi_s^{mimic}\left(m_f^{**}, r_f^{**} = 0, b_{pf}\right) = \pi_s\left(m_s, r_s^{**}\right);\ \left(1-\rho_s\right)\left(\frac{1}{\theta_p} - \frac{2b_{pf}}{\theta_p}\right)\left(\frac{\partial b_{pf}}{\partial m_s}\right) - \rho_s = 0$$

If $\widetilde{b}_{pf} \geq \frac{(1-\rho_s)+\rho_s(1-\beta)}{2}$, then we have $b_{pf}^{**} = \widetilde{b}_{pf}$ and $m_s = \widetilde{m}_s$. If $\widetilde{b}_{pf} < \frac{(1-\rho_s)+\rho_s(1-\beta)}{2}$, then $\widetilde{m}_s$ cannot be the equilibrium solution. The reason is that if the firm chooses $\widetilde{m}_s$, then in relational contracting, the $f$-type manager finds it optimal to choose $b_{pf}^{**} = \frac{(1-\rho_s)+\rho_s(1-\beta)}{2}$ which leads to a pooling equilibrium, rather than choosing $b_{pf}^{**} = \widetilde{b}_{pf}$ which leads to a separating equilibrium. Therefore, the firm would like to increase $m_s$ until $b_{pf}\left(m_s\right) = \frac{(1-\rho_s)+\rho_s(1-\beta)}{2}$. Therefore, the equilibrium solution entails $b_{pf}^{**} = \frac{(1-\rho_s)+\rho_s(1-\beta)}{2}$ and $m_s^{**}$ such that $\pi_s\left(m_s^{**}, r_s^{**}\right) = \pi_s^{mimic}\left(m_f^{**}, r_f^{**} = 0, b_{pf}^{**}\right)$. Note that since the firm chooses $r_f^{**} = 0$ and raises $m_s$ to prevent the *s*-type manager from mimicking, the *s*-type manager may receives a per-period income higher than $M_0$.

Also, note that when $\rho_s < \rho_1$, we have $b_{pf}^{*} = \frac{1}{2}$. Therefore, $b_{pf}^{**} \leq b_{pf}^{*} = \frac{1}{2}$. QED.

**B6: Proof of Proposition 6**

First, consider the case when $\rho_s < \rho_1$. In this case, $r_f^{**} = 0$ in equilibrium. With delegation of relational contracting, the *f*-type manager choose a $b_{pf}$ given by (B4.3) to separate himself from the *s*-type manager. This $b_{pf}$ is a function of the *s*-type manager's base wage $m_s$. We denote this function as $b_{pf}(m_s)$. Note that in the centralized contracting case, the firm chooses a $b_{pf}^* = \frac{1}{2}$. In the case with delegation of relational contracting, the firm can always choose a $m_s$ which leads to a $b_{pf}(m_s) = b_{pf}^* = \frac{1}{2}$. Therefore, the firm can be at least as well with delegation as with centralized contracting. When it is better for the firm to have a $b_{pf}^{**} \neq b_{pf}^* = \frac{1}{2}$, delegation makes the firm strictly better off.

Second, consider the case when $\rho_s \geq \rho_1$. In this case, since $\pi_s(m_s, r_s) = \pi_s^{mimic}(m_f, r_f, b_{pf})$ $= \left(\frac{1+\delta_s}{\delta_s}\right) M_0 (1-\beta+\beta k)$. We have $b_{pf} = \frac{(1-\beta+\beta k)}{k\delta_s + (1-\beta+\beta k)}(1+\theta_p r_f)$ (see B5.2). In centralized contracting, the optimal $b_{pf}^*$ satisfies that $b_{pf}^* = \frac{1}{2} - \frac{b_m \theta_p \delta_f r_f}{1+\delta_f}$. Therefore, in centralized contracting, $r_f^*$ satisfies that $\frac{1}{2} - \frac{b_m \theta_p \delta_f r_f^*}{1+\delta_f} = \frac{(1-\beta+\beta k)}{k\delta_s + (1-\beta+\beta k)}(1+\theta_p r_f^*)$. In delegation of relational contracting, the $b_{pf}^{**}$ chosen by the *f*-type manager satisfies that $b_{pf}^{**} = \frac{1}{2} - \frac{\theta_p \delta_f r_f}{1+\delta_f}$. Therefore, in the delegation of relational contracting, $r_f^{**}$ satisfies that $\frac{1}{2} - \frac{\theta_p \delta_f r_f^{**}}{1+\delta_f} = \frac{(1-\beta+\beta k)}{k\delta_s + (1-\beta+\beta k)}(1+\theta_p r_f^{**})$.

Since $\pi_s^{mimic}(m_f^*, r_f^*, b_{pf}^*) = \pi_s^{mimic}(m_f^{**}, r_f^{**}, b_{pf}^{**}) = \left(\frac{1+\delta_s}{\delta_s}\right) M_0 (1-\beta+\beta k)$, without delegation, the firm's expected per-period net profit $F$ in the separating equilibrium is

$$F^{*}=\rho_{s}\left[\Pi\left(b_{ps}^{*}\right)-\left(\frac{\delta_{s}}{1+\delta_{s}}\right)b_{m}b_{ps}^{*}r_{s}^{*}-M_{0}\right]+\left(1-\rho_{s}\right)\left[\Pi\left(b_{pf}^{*}\right)-M_{0}-\left(\frac{\delta_{f}}{1+\delta_{f}}\right)b_{m}b_{pf}^{*}r_{f}^{*}\right]$$

In delegation, the firm's expected per-period net profit $F$ in the separating equilibrium is

$$F^{**}=\rho_{s}\left[\Pi\left(b_{ps}^{**}\right)-\left(\frac{\delta_{s}}{1+\delta_{s}}\right)b_{m}b_{ps}^{**}r_{s}^{**}-M_{0}\right]+\left(1-\rho_{s}\right)\left[\Pi\left(b_{pf}^{**}\right)-M_{0}-\left(\frac{\delta_{f}}{1+\delta_{f}}\right)b_{m}b_{pf}^{**}r_{f}^{**}\right]$$

Also note that, in the separating equilibrium, $b_{ps}^{*}=b_{ps}^{**}$, and $r_{s}^{*}=r_{s}^{**}$. Substituting $r_{f}^{*}$, $b_{pf}^{*}=\frac{1}{2}-\frac{\theta_{p}\delta_{f}r_{f}^{**}}{1+\delta_{f}}$, $r_{f}^{**}$ and $b_{pf}^{**}=\frac{1}{2}-\frac{\theta_{p}\delta_{f}r_{f}^{**}}{1+\delta_{f}}$, tedious comparison shows that

$$F^{*}-F^{**}=\frac{\omega\delta_{f}^{2}\left(\varpi-\omega\right)\left(b_{m}-1\right)}{\theta_{p}\left(b_{m}\delta_{f}\varpi+b_{m}\delta_{f}\omega+2\omega+2\omega\delta_{f}\right)^{2}\left(\delta_{f}\varpi+3\delta_{f}\omega+2\omega\right)^{2}}\eta$$

where $\omega=1-\beta+\beta k$, $\varpi=k\delta_{s}$, and

$$\eta=b_{m}\left[b_{m}\delta_{f}\left(2\delta_{f}+1\right)\left(\varpi+\omega\right)^{2}+\left(\delta_{f}+1\right)\omega\left(5\delta_{f}\varpi+3\delta_{f}\omega+\omega+3\varpi\right)\right]-\omega\left(\delta_{f}+1\right)^{2}\left(\varpi+\omega\right)$$

When $b_{m}\to 0$, $\eta<0$. Note that $b_{m}<1$ and $\varpi>\omega$ (since $\delta_{s}>\frac{1-\beta+\beta k}{k}$ by assumption), therefore, $F^{*}>F^{**}$ when $b_{m}$ is small enough. Moreover, trivial algebra indicates that $F^{*}>F^{**}$ when $b_{m}<\left(1-2\frac{1-\beta+\beta k}{\delta_{s}k+1-\beta+\beta k}\right)\frac{1+\delta_{s}}{\delta_{s}}$ (this is the assumption that ensures the firm to delay bonus for the *s*-type manager, see B2).

QED.

**B7: Proof of Proposition 7**

With the mechanism $\left\{\left(m_{s},b_{ms},r_{s}\right),\left(m_{f},b_{mf},r_{f}\right)\right\}$, the firm's per-period net profit can be represented as

$$F=\rho_s\left[\alpha e_{ms}+\left(\frac{b_{ps}}{\theta_p}-\frac{b_{ps}^2}{\theta_p}-p\right)-M_0-\frac{b_{ms}b_{ps}\delta_s r_s}{1+\delta_s}-\frac{\theta_m e_{ms}^2}{2}\right]+$$

$$(1-\rho_s)\left[\alpha e_{mf}+\left(\frac{b_{pf}}{\theta_p}-\frac{b_{pf}^2}{\theta_p}-p\right)-M_0-\frac{b_{mf}b_{pf}\delta_f r_f}{1+\delta_f}-\frac{\theta_m e_{mf}^2}{2}\right]$$

$$-\left(\frac{\delta_s}{1+\delta_s}\right)\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right)b_{mf}\left[\frac{b_{pf}^2}{\theta_p}\left(\frac{k}{1-\beta+\beta k}\right)-\frac{1}{\delta_s}\left(\frac{b_{pf}}{\theta_p}-\frac{b_{pf}^2}{\theta_p}+b_{pf}r_f\right)\right]\rho_s$$

The $i$-type manager will exert an effort $e_{mi}=\frac{\alpha b_{mi}}{\theta_m}$. When the $s$-type manager's information rent is zero, $\frac{\partial b_{pf}}{\partial b_{mf}}=0$, the FOCs are

$$\frac{\partial F}{\partial r_s}=0\Rightarrow\left\{1-2\left[\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}(1+\theta_p r_s)\right]-\frac{b_{ms}\delta_s}{1+\delta_s}(2\theta_p r_s+1)\right\}\left(\frac{1-\beta+\beta k}{\delta k+1-\beta+\beta k}\right)=0$$

$$\frac{\partial F}{\partial b_{ms}}=0\Rightarrow\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{ms}}{\theta_m}-\frac{b_{ps}\delta_s r_s}{1+\delta_s}=0 \tag{B7.1}$$

$$\frac{\partial F}{\partial r_f}\geq 0\Rightarrow(1-\rho_s)\left[\left(\frac{1}{\theta_p}-\frac{2b_{pf}}{\theta_p}\right)\frac{\partial b_{pf}}{\partial r_f}-\frac{b_{mf}b_{pf}\delta_f}{1+\delta_f}-\frac{b_{mf}\delta_f r_f}{1+\delta_f}\frac{\partial b_{pf}}{\partial r_f}\right]\geq 0$$

$$\frac{\partial F}{\partial b_{mf}}=0\Rightarrow(1-\rho_s)\left(\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{mf}}{\theta_m}-\frac{b_{pf}\delta_f r_f}{1+\delta_f}\right)=0 \tag{B7.2}$$

By imposing that $\frac{\alpha^2}{\theta_m}$ is sufficiently large to ensure the concavity of $F$, we can derive the optimal $b_{ms}^{***}, r_s^{***}, b_{mf}^{***}, r_f^{***}$ by jointly solving the FOCs. (B7.1) suggests that $b_{ms}^{***}<1$ and (B7.2) suggests that $b_{mf}^{***}<1$.

When the $s$-type manager's information rent is positive, the first-order condition w.r.t. $b_{mf}$ can be represented as

$$\frac{\partial F}{\partial b_{mf}}=(1-\rho_s)\left(\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{mf}}{\theta_m}-\frac{b_{pf}\delta_f r_f}{1+\delta_f}\right)-\rho_s\Phi_1(b_{pf})=0 \tag{B7.3}$$

where $\Phi_1(b_{pf})=\left(\frac{\delta_s}{1+\delta_s}\right)\beta\left(\frac{1+\delta_s}{\beta+\delta_s}\right)\left[\frac{b_{pf}^2}{\theta_p}\left(\frac{k}{1-\beta+\beta k}\right)-\frac{1}{\delta_s}\left(\frac{b_{pf}}{\theta_p}-\frac{b_{pf}^2}{\theta_p}+b_{pf}r_f\right)\right]$. Note that

$b_{mf}\Phi_1\left(b_{pf}\right)=\pi_s\left(m_s,r_s\right)-\left(\frac{1+\delta_s}{\delta_s}\right)M_0\left(1-\beta+\beta k\right)$ represents the $s$-type manager's information rent. The solution of first-order condition (B7.3) suggests that with delegation $b_{mf}^{***}<1$. QED.

**A8: Proof of Proposition 8**

Part (a) shows when delegation in relational contracting benefits the firm. The proof follows the similar approach as the proof for Proposition 4.6, except that here there is one more dimension of complexity, i.e. the firm can change $b_{mf}$ and $b_{ms}$. The intuition why the firm benefits from delegation in relational contracting is same as that in Proposition 4.6. That is, when $\rho_s<\rho_1$, delegation in relational contracting allows the firm to decrease the *s*-type manager's base wage $m_s$ and save the screening cost. When $\rho_s>\rho_1$, delegation in relational contracting does not benefit the firm since the *f*-type manager chooses lower $b_{pf}$ to reduce the bonus delay for him, which decreases the firm's benefit from partnering.

Consider part (b). Note that with delegation, signaling entails that $b_{pf}^{****}\le b_{pf}^{***}$. We also consider two cases: first, the $s$-type manager has a positive information rent; second, the $s$-type manager has zero information rent.

In the first case, $r_f^{****}=0$. The first derivative of the firm's per-period net profit *F* w.r.t. $b_{mf}$ can be represented as (see B7.3)

$$\frac{\partial F}{\partial b_{mf}}=\left(1-\rho_s\right)\left(\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{mf}}{\theta_m}\right)-\rho_s\Phi_1\left(b_{pf}\right)=0 \qquad \text{(B8.1)}$$

where $b_{mf}\Phi_1\left(b_{pf}\right)$ represents the $s$-type manager's information rent on a per-period basis. When $b_{pf}^{****}<b_{pf}^{***}=\frac{1}{2}$, we also have $\Phi_1\left(b_{pf}^{****}\right)<\Phi_1\left(b_{pf}^{***}\right)$. The intuition is, when $b_{pf}$ is smaller, the $s$-

type manager's incentive to renege is also smaller since less partner effort is motivated. Therefore, by comparing the first-order conditions (A7.3) and (A8.1)

$$\left(1-\rho_s\right)\left(\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{mf}^{****}}{\theta_m}\right)=\rho_s\Phi_1\left(b_{pf}^{****}\right)<\rho_s\Phi_1\left(b_{pf}^{***}\right)=\left(1-\rho_s\right)\left(\frac{\alpha^2}{\theta_m}-\frac{\alpha^2 b_{mf}^{***}}{\theta_m}\right)$$

we must have that $b_{mf}^{****} > b_{mf}^{***}$.

In the second case, $r_f^{****} > 0$. Note that in this case, $s$ -type manager's information rent is always zero. Therefore, by comparing the first-order conditions (B7.3) and (B8.1), we must have that $b_{mf}^{****} = b_{mf}^{***}$. QED.

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