Integration and Corporate Investment

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Abstract

This thesis consists of three chapters that broadly investigates, theoretically and empirically, the effect of firm boundaries and organizational processes on internal resource allocation and corporate investment.

In the first chapter, I develop an equilibrium model of internal competition for corporate resources and show that managers of integrated firms exaggerate the quality of their projects to get funding. Moreover, I show that the problem gets worse with increased integration and puts an endogenous limit on the amount of value-enhancing redistribution that can be achieved in an integrated firm. I then argue that the control rights that come with asset ownership enable a firm to set "the rules of the game" and mitigate negative managerial behavior through organizational processes such as rigid capital budgets, job rotation, centralization and hierarchies. These results point to a comparative advantage that a firm has over other financial intermediaries in allocating resources.

In the second chapter, I empirically explore the effect of integration on the allocation of resources. Specifically, I find that integrated firms use stale information in their investment decisions. In addition, they have more rigid capital budgets and consequently are less responsive to investment opportunities than non-integrated firms. Using a novel approach to identify related segments, I find that the effects are stronger for diversified integrated firms that are engaged in unrelated lines of business. These empirical findings lend support to the theory developed in Chapter 1.

In the third chapter, I take a case study approach and analyze the investment behavior of nonoil segments of oil companies from 1980 to 1995. I find that oil companies reduced their nonoil investments *prior* to the 1986 oil shock. I also perform a number of robustness checks and find that the reductions immediately after the oil shock, contrary to earlier research, do not pass conventional levels of statistical significance. A comprehensive dataset of U.S. petrochemical plants provides independent evidence confirming these findings. Finally, I find that oil companies reduced their nonoil investments in 1992 despite a positive shock to oil prices following the Gulf War. I suggest several conjectures to explain the unexpected reduction and discuss potential avenues for further research.

Thesis Supervisor: David S. Scharfstein
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Finally my loving parents, Emin and Gül, and my precious sister, Meltem. Only they give meaning to this soul. They are all my reasons.

I dedicate this work to the memory of Mustafa Kemal Atatürk, the great founding father of the modern Republic of Türkiye.

May God bless us all with peace, reason and tolerance.

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Chapter 1

Integration, Organizational Processes and Allocation of Resources

1.1 Introduction

Why do firms combine several projects? What is the effect of such integration on the allocation of resources? Do two firms acting independently allocate resources any differently than two firms integrated as one? These are important questions not only because the allocation of resources is a critical process by which an economy channels its scarce endowments to productive use, but also because integration plays a key role in how an economy organizes its methods of production.

The Coasian literature on integration[1] has explored primarily two issues, namely the problem of hold-up and transaction costs, as the fundamental forces determining the boundaries of the firm. The prevailing model of integration of Grossman, Hart and Moore takes asset ownership as a principal driver of incentives and envisions optimal assignment of assets among owner-managers as a way to understand integration. While the property rights approach has been useful in analyzing the determinants of vertical integration, both theoretically and empirically, it is unclear how one can broaden the model to understand the effect of integration

[1] Most notably, Williamson (1975, 1985), Klein, Crawford, and Alchian (1978), Grossman and Hart (1986), and Hart and Moore (1990).

on firm behavior such as the allocation of resources.[2] It is also unclear how one can extend the paradigm to analyze the effect of integration on the allocation of resources in large multi-division firms which are riddled with high levels of informational asymmetry and are run by managers with little or no ownership.[3] For analyzing the behavior of such firms, the central assumptions that integration simply reallocates bargaining power over profits, that efficiency is always achieved through renegotiation, and that owner-managers have the specific knowledge to implement the efficient outcome, are clearly problematic. First, the very size and complexity of the modern firm by and large make it impossible for any one manager, owner or non-owner, to have the necessary knowledge to implement the efficient outcome. Consequently, delegation is pervasive.[4] Second, corporate resources get allocated on the basis of information provided by specialist managers. Communication, while self-interested to a certain degree, plays a crucial role in that process. Third, specialist managers do not bargain over personal profits. Rather, they compete for the firm's limited resources.

To better understand the effect of integration on the allocation of resources then, one must account for the impact that integration has on the degree of informational asymmetry between corporate headquarters and its specialist managers, and on the nature of internal competition for the firm's limited resources. Such an impact surely has important consequences for the efficiency of internal decision-making and the effectiveness of corporate headquarters in allocating capital. In this chapter, I focus on the communication process between corporate headquarters and specialist managers, and develop a simple model of internal competition for corporate resources. Specifically, I consider a two-period setting where specialist managers compete for corporate resources in each period by communicating the type of their projects. Since managers are assumed to have unique expertise and prefer a larger empire over a smaller empire, they are tempted to make exaggerated statements to increase their chances of getting funding for their projects. In fact, if it were not for the multi-period nature of the model, that is if exaggeration had no future consequence and therefore were costless, exaggeration would be the only outcome

[2] As Mullainathan and Scharfstein (2001) point out, "... while we know something about the forces that determine firm boundaries, we know relatively little about how these boundaries affect actual firm behavior. This is a major limitation in our understanding of the nature of the firm."

[3] Bolton and Scharfstein (1998) make a similar point and emphasize the need to incorporate the Berle and Means perspective on agency into the Coasian view of the firm.

[4] See Aghion and Tirole (1997), Baker, Gibbons and Murphy (1999).

in an integrated firm. Of course in reality, there are career consequences to making exaggerated statements. For example, managers who exaggerate potentially lose credibility ex-post. Or the decision to exaggerate may signal talent. My model has a similar career effect that endogenously makes exaggeration costly and induces managers to be more forthcoming in their statements.[5] Nonetheless, the temptation to exaggerate remains and is stronger for managers for whom the future holds less promise. For example, managers who are less talented exaggerate more than managers who are more talented because less talented managers have less to lose than more talented managers.[6] The effect of such behavior in the model is to reduce allocative efficiency as corporate headquarters has no information but communication from managers to allocate resources.[7] Perhaps more interestingly, the model predicts the quality of communication to get worse with increased integration. For example, managers who are otherwise honest when facing low levels of internal competition start to exaggerate when faced with higher levels of internal competition because the presence of more managers makes it more difficult to get funding while staying honest. Obviously, not all is bad with integration. An integrated firm can create value by pooling resources and shifting funds from bad projects to good projects. I take the possibility of such value-enhancing redistribution to be the principal benefit of integration.

To summarize then, there are two opposing effects of increased integration in my model. On the one hand, increased integration expands the opportunity set. This is good for allocative efficiency. On the other hand, increased integration intensifies the internal competition for corporate resources. This is bad for incentives, makes it harder to elicit useful information and hurts allocative efficiency. As a result, the theory predicts the optimal degree of integration to be the point which balances the marginal cost of integration from worsened quality of communication with the marginal benefit of integration from an expanded opportunity set. This aspect of the model more generally points to a theory of the firm based on the efficient allocation of resources.

[5] See Baker, Gibbons and Murphy (2001a, 2001b) for a repeated-game perspective on integration. In the same spirit, repetition in my model enables the parties to utilize specialized knowledge that they cannot otherwise utilize in a one-shot game.

[6] The model allows other interpretations such as asset quality and line of business, e.g. the temptation to exaggerate is stronger for managers assigned to bad assets.

[7] Obviously the assumption that corporate headquarters is completely uninformed is not intended to be realistic. A richer setting where division managers are relatively more informed about the specifics of their projects than corporate headquarters would generate qualitatively similar results.

The model also allows an alternative interpretation as a bank financing a portfolio of projects. Such an interpretation yields a theory of financial intermediation based on the same ideas. Similar to a firm, a bank too may want to expand as long as the marginal benefit of integration (diversification) exceeds the marginal cost. This line of argument captures the often-expressed contention against the counterfactual prediction of Diamond (1984) that there be one big bank financing the entire economy to economize on monitoring costs. The model provides an intuitive reason that shows the impracticality of this idea – it is simply and inherently difficult for numerous areas of lending expertise to coexist efficiently.

To further explore the differences between a firm and a bank, I draw on Holmström's (1999) view of the firm as a subeconomy. I argue that the control rights that come with asset ownership enable a firm to set "the rules of the game" and mitigate negative managerial behavior in ways that a bank cannot. Many organizational processes and structures that we observe in practice indeed come with asset ownership and can be viewed as altering the rules of the game. I show how some of them can improve allocative efficiency and make the firm a better financial intermediary than a bank. The notion that organizational processes and structure can shape managerial behavior is by no means new to this thesis. Many organizational researchers have made similar arguments.[8] Organizational processes and structure, by defining the game, can change and improve behavior. For example, I show that a firm can improve communication and allocative efficiency by making some portion of its capital budget non-contingent. Of course, a natural question to ask is why a bank cannot offer a similarly rigid financing scheme. The answer lies in asset ownership. Not so surprisingly, it is very difficult to get a manager to stay in a rigid scheme once he finds out that he is good. By making certain that good managers are not able to defect with the physical assets that potentially make them more valuable, I argue that a firm can gain leverage over human capital that a bank without asset ownership cannot.

Another organizational remedy I consider is job rotation. I show that the chance of being assigned to a possibly more profitable set of assets gives hope to managers, who find themselves currently assigned to bad assets, and makes them more forthcoming. Needless to say, a bank cannot take a manager from one of its projects and assign him to another. As a matter of

[8] Bower (1970), Chandler (1962), Crozier (1967), Simon (1945) to name a few. Milgrom and Robert (1988) is the closest in spirit with its emphasis on "influence activities".

fact, job rotation is just one example of what a firm can do with careers more generally. To the extent that such control over careers is important for manipulating managerial behavior, a firm may be better at intermediating finance than a bank. In the same spirit, I show how centralization can improve behavior by getting managers to engage in team production that is successful only if communication is accurate. When a manager in a centralized firm thinks about making an exaggerated statement, he takes into account not only the reputational consequences that are part of the basic model but also the disruptive effect that his misleading statements may have on team production. Finally, I show how delegation and hierarchies can arise endogenously as a commitment device to constrain internal competition and improve the quality of communication.

There is ample clinical evidence in the management literature suggesting the prevalence of the kinds of informational asymmetry that drive my model. In what is now widely recognized as a classic on capital budgeting and resource allocation, Bower (1970) provides insights about the degree of informational asymmetry between corporate headquarters and division managers. Conceding that the expertise and information necessary to make project proposals reside in managers who are much closer to markets, he writes:

> In fact, once a project emerges from the initial stages of definition it is not only hard to change it, but in some cases hard to reject it. Too much time has been invested, too many organizational stakes get committed, and at very high levels of management too little substantive expertise exists to justify second guessing the proposers. (p. 54)

Bower also provides evidence of the agency problem that leads to exaggeration in my model.[9] As much as the gap in technical expertise, an additional problem appears to be the parochial attitude of managers who tend to regard their lines of business as having some special importance. The following quotes from interviews conducted by Bower show how this parochialism can be particularly taxing when managers propose project ideas that compete for the firm's limited resources:

[9] See Jensen (2001) for evidence of widespread misrepresentation in the context of the budgeting process.

> There will always be a segment of business you'll still want to be in, regardless of financial criteria... I told my group that they should not worry about the approval of their projects. (p. 9)
>
> We're making 5% on all those 35% projects. (p. 13)
>
> And any manager worth having can produce numbers that will make a project look good. (p. 15)

There is a related and growing literature that investigates the nature and efficiency of internal capital markets. Building on the incomplete contracts approach pioneered by Grossman and Hart (1986), and Hart and Moore (1990), Gertner, Scharfstein and Stein (1994) explore some of the differences between internal and external finance by emphasizing the extent to which the two modes of financing differ with regard to the allocation of control rights. As GSS point out, control rights reside with corporate headquarters (the investor) in an internal capital market, whereas they reside with the manager (and not the investor) in a bank-lending arrangement. Comparing the two modes of financing, GSS show that internal finance leads to higher investor monitoring but lower managerial effort than external finance. Their framework, however, does not address the potential communication problems as well as the question of how capital gets allocated across divisions that compete for the firm's limited resources.

Stein (1997), extending the control ideas of GSS, shows that corporate headquarters can create value by combining several projects under one roof and actively shifting funds from one project to another, a winner-picking role that a non-owner intermediary such as a bank cannot perform. In comparison, the model presented in this chapter takes an opposite stance on the competence of corporate headquarters and on the role of division managers in the allocation of capital. Division managers are assumed to have the relevant expertise, giving them an active role in the allocation of capital. And, any winner-picking strategy on the part of corporate headquarters, to the extent possible, relies on information contained in self-interested communication from division managers.

Scharfstein and Stein (2000) demonstrate how influence costs can lead to inefficiencies in capital allocation in a two-tier agency setting.[10] In their model, division managers extract

[10]The two-tier agency approach is also somewhat reminiscent of March (1962) which portrays the firm as a

greater overall compensation by engaging in rent-seeking activities and, in some cases, the increased compensation takes the form of preferential capital allocations that are inefficient.[11] Although the model presented in this chapter too predicts capital allocations that are inefficient relative to the first-best allocation, the underlying mechanisms are quite different. For example, their model requires an agency problem at the level of the CEO whereas my model shows that this is not necessary. Moreover, the framework allows me to make further predictions regarding the effect of increased internal competition and to explore organizational remedies to deal with some of the problems.

Brusco and Panunzi (2000) argue that ex-post redistribution from one manager to another can be bad for ex-ante effort incentives and that it can be optimal to limit such redistribution.[12] However, their model focuses on the effort aspect of the agency problem which has received the bulk of the attention in previous work whereas my model focuses on the communication of specialized knowledge which, the clinical evidence suggests, is an important part of what goes on in internal capital markets.

Maksimovic and Phillips (2001) develop a profit-maximizing model of a conglomerate where optimal growth in different industries is driven by differences in profitability and firm-specific managerial talent. Their approach abstracts away from the asymmetric information considerations of this chapter and takes the number of industries as given. Matsusaka (2001) views integration as a search process by which firms experiment and find a good fit for their organizational capabilities. Berkovitch, Israel and Tolkowsky (2000) explore the decision to integrate as a trade-off between the need to manage agency problems and the need to obtain information from the market.

The chapter proceeds as follows. Section 2 develops the basic model. I show that managers of integrated firms exaggerate their projects to get funding and that the problem gets worse with increased integration. In Section 3, I discuss the implications of self-interested communication for allocative efficiency. Section 4 considers organizational remedies that can indirectly improve managerial behavior and hence allocative efficiency. In Section 5, I discuss testable implications

political coalition and stresses the importance of taking a systems view to understanding decision-making within firms.

[11] Rajan, Servaes and Zingales (2000) predict similar inefficiencies due to internal power struggles.

[12] An earlier work by Rotemberg and Saloner (1994) makes the same point for narrow business strategies.

of the ideas developed in Sections 2, 3 and 4. I provide concluding remarks in Section 6.

1.2 The Model

Suppose there are two types of managers, who may be either g (good) or b (bad), with probabilities β and $1-\beta$, respectively. Further suppose that there are two types of projects, which may again be either good or bad, with returns R_H (high) and R_L (low), respectively. Projects of bad managers always turn out to be bad. Projects of good managers, on the other hand, can be good with probability μ and bad with probability $1-\mu$.[13,14]

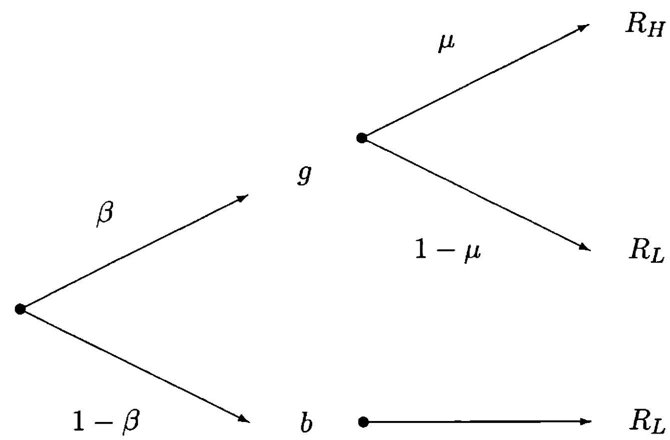

Figure 1-1: Managerial Talent and Project Outcomes

Managers know whether they are good or bad.[15] Moreover, managers are assumed to be empire-builders and hence derive private benefits from managing as big a capital budget as possible. Furthermore, managers are assumed to prefer a more profitable empire over a less profitable empire. Formally, their utility function is given by:

$$U(K_i, R_i) = K_i R_i \tag{1.1}$$

[13]This is the sense in which a good manager is better than a bad manager.

[14]The results are robust to the generalization that a bad manager gets a good project with a probability less than $1-\mu$. All that is required is that the future hold less promise for some managers than others.

[15]An alternative formulation would be to assume that managers do not know whether they are good or bad but update their priors as they get good or bad project ideas.

Competition for corporate resources K takes place over two periods. In period 1, each manager comes up with a project idea. If the manager is bad, he always comes up with a bad project. If the manager is good, he can come up with either a good project or a bad project. After coming up with a project idea, each manager then makes a statement about the type of his project, h (high) or l (low).[16] Based on statements made, the firm's capital budget K then gets allocated to the seemingly best projects. In period 2, each manager gets a new project idea as in period 1. Since managerial talent remains the same in period 2, one can also think about managerial talent as the line of business the manager is involved in. Managers discount their period-2 payoffs at a rate $\delta < 1$.

The cross-product of manager and project types in period 1 constitutes the relevant type within the game. There are three types of managers: A, B and C. A type-A manager is a good manager and has a good project in period 1. A type-B manager is a good manager but has a bad project in period 1. A type-C manager is a bad manager and always has a bad project.

Based on statements made and project results observed in period 1, including the results of projects that were not undertaken,[17] corporate headquarters forms a posterior about the type of its managers, and determines which among them are eligible to compete for the firm's resources in period 2.[18]

I assume that a manager would be patient enough to wait for a potentially better project idea in the future if he did not have a good project idea today but thought that the future held some promise. In the context of the model, this implies

$$R_L < \delta R_E \tag{1.2}$$

[16]The idea that at very high levels of management too little substantive expertise exists to evaluate and compare projects, and that a manager with significant specialized knowledge, if he so chooses, can make either statement regardless of his true project type is central to the model. This is also a significant technological deviation from Holmström (1982).

[17]Observability of results for projects that were not undertaken is without loss of generality and, in fact, reduces a manager's temptation to exaggerate. Nonobservability would only make the communication problem worse.

[18]Perhaps this is the best place to dispense with an argument one might have against the modeling approach taken here: why not use the standard tools of mechanism design? I have various reasons and chief among them is the communication focus of this chapter. The mechanism design approach generously assumes that incentive schemes can be based on the communication of specialized knowledge which, for all practical purposes, can be neither contracted nor understood by the superior. See Harris and Raviv (1996) for a mechanism design approach in which corporate headquarters is assumed to have the ability to find out the truth.

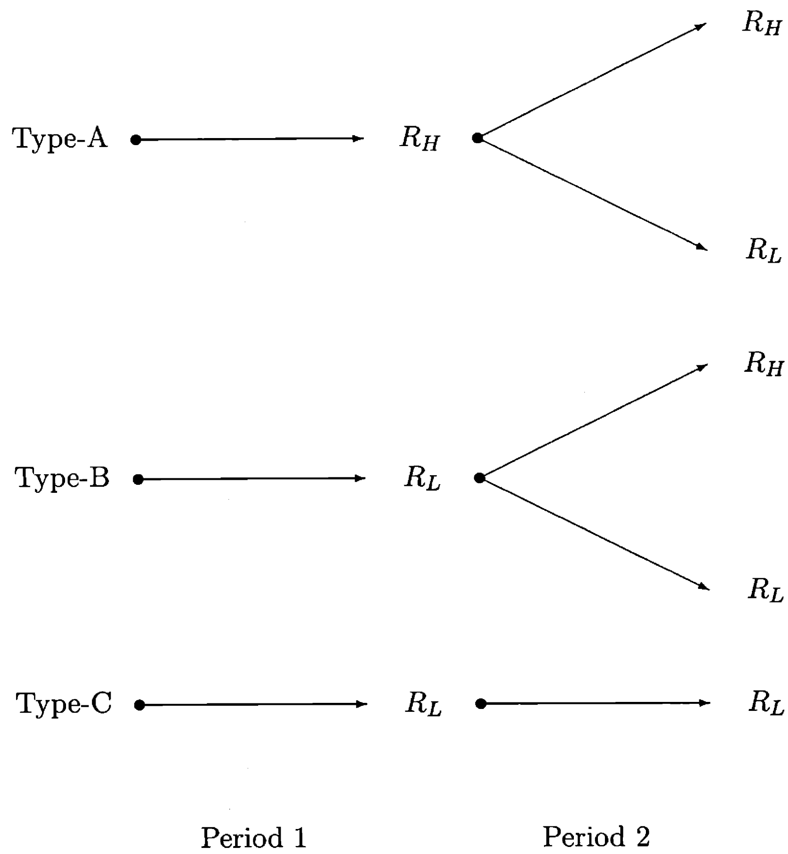

Figure 1-2: Manager Types

where $R_E \equiv [\mu R_H + (1 - \mu) R_L]$. Both gross returns R_H and R_L are assumed to be greater than 1. This assumption can be relaxed if one is willing to impose an additional layer of agency problem between investors and corporate headquarters. As a solution concept, I use the standard Bayesian Perfect Nash Equilibrium (BPNE). Out of equilibrium beliefs, when and if necessary, are fixed so as to satisfy the Cho-Kreps intuitive criterion.

1.2.1 Two-Manager Competition

The first point to notice is that competition in period 2 is somewhat redundant. Expecting every manager to announce h if asked to compete in the last period, corporate headquarters might as well allocate the firm's period-2 capital budget K equally among the managers who tie for the highest posterior probability of being a good manager. For what follows, the issue

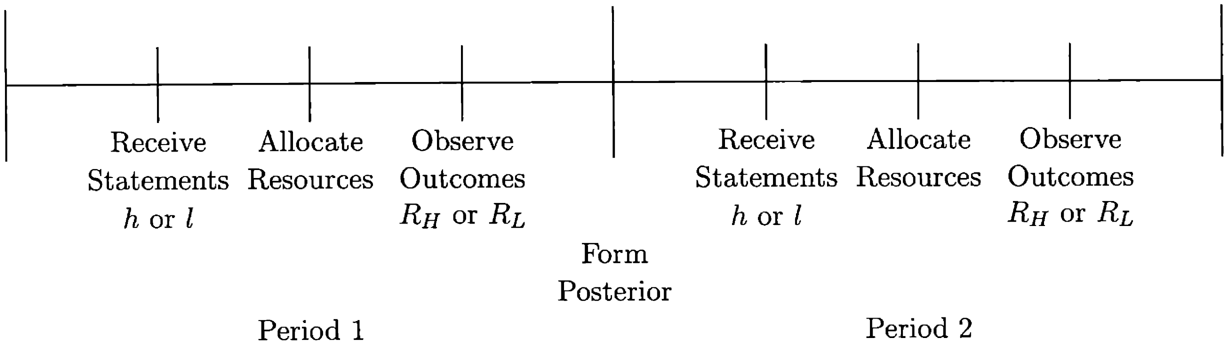

Figure 1-3: Timeline

of whether a formal period-2 competition is held or not does not make a difference.[19]

Lemma 1 *In period* 2, *every manager reports a good project.*

The second point to notice is that a manager isolated from internal competition would have no reason to make a false statement. In fact, when there is only one manager, there really is no need for communication for the purpose of allocating capital.[20] I refer to this as the *stand-alone* case.

When there is competition for limited corporate resources, however, managers may have an incentive to make exaggerated statements to increase their chances of getting funding for their projects. The following proposition shows how such exaggeration may come about even with only two managers competing.

Proposition 2 *The unique equilibrium for two managers is as follows: In period* 1, *bad managers (type-C) exaggerate and state that they have good projects whereas good managers (type-A and type-B) state their true project types.*

Given the conjectured BPNE, only project proposals made by type-C managers in period 1 fail to attain their stated targets and consequently reveal their managers as such. A high project

[19] If managers were not identical ex-ante, it would be optimal to tilt the capital budget against the stronger types as in Lazear and Rosen (1981), and Bulow and Roberts (1989). Since I abstract away from such heterogeneity, it is indeed optimal to divide the capital budget equally among the managers who tie for the highest posterior probability.

[20] Since an isolated manager making a truthful statement is not a unique equilibrium, I am implicitly deferring to reputational concerns. The more relevant point to realize is the inherent difficulty of staying honest when a manager faces internal competition.

outcome in period 1 reveals that the manager is a type-A manager. On the equilibrium path, project proposals made by type-B managers in period 1 attain their stated targets. Therefore, the posterior beliefs after observing the statements and project results in period 1 are

$$P(g \mid h, R_H) = 1 \tag{1.3a}$$

$$P(g \mid h, R_L) = 0 \tag{1.3b}$$

$$P(g \mid l, R_H) = 1 \text{ (out of equilibrium)} \tag{1.3c}$$

$$P(g \mid l, R_L) = 1 \tag{1.3d}$$

Note that although (1.3c) is out of equilibrium, it is not arbitrary. Only projects managed by good managers can produce R_H in period 1. These posterior beliefs determine eligibility for period 2. Lemma 1 summarizes the optimal period-2 strategy. Solving the model backwards, payoff to a type-A manager from announcing h in period 1 is

$$(1-\beta)\underbrace{\left[\frac{1}{2}KR_H + \delta KR_E\right]}_{\text{Facing type-C}} + \beta\left[\mu\underbrace{\left(\frac{1}{2}KR_H + \frac{1}{2}\delta KR_E\right)}_{\text{Facing type-A}} + (1-\mu)\underbrace{\left(KR_H + \frac{1}{2}\delta KR_E\right)}_{\text{Facing type-B}}\right] \tag{1.4}$$

It is perhaps worth explaining the first payoff structure in some detail. When facing a type-C manager, a type-A manager gets half of the capital budget and all of the capital budget in period 1 and period 2, respectively. He gets only half of the capital budget in period 1 because the other manager, who is type-C, states h despite having a bad project. After failing to attain his stated target, however, a type-C manager is identified as a bad manager and consequently gets no capital in period 2. When the other manager too is a type-A manager, the capital budget is divided equally in both periods. Finally, when facing a type-B manager, a type-A manager gets all of the capital budget and half of the capital budget in period 1 and period 2, respectively. He gets all of the capital budget in period 1 because the other manager, who is type-B, states l. After this truthful statement, a type-B manager is identified as a good manager and consequently gets half of the capital budget in period 2.

Payoff to a type-A manager from announcing l in period 1 is

$$(1-\beta)\underbrace{[0+\delta KR_E]}_{\text{Facing type-C}}+\beta\left[\underbrace{\mu\left(0+\frac{1}{2}\delta KR_E\right)}_{\text{Facing type-A}}+\underbrace{(1-\mu)\left(\frac{1}{2}KR_H+\frac{1}{2}\delta KR_E\right)}_{\text{Facing type-B}}\right] \tag{1.5}$$

A type-A manager clearly has nothing to benefit from announcing l.[21] He gives up half of the capital budget in period 1 regardless of the type of the other manager and gains nothing in return. He has a good project and announcing h is the best response.

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\beta)[0+\delta KR_E]+\beta\left[\mu\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E\right)\right] \tag{1.6}$$

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E\right]+\beta\left[\mu\left(\frac{1}{2}KR_L+0\right)+(1-\mu)(KR_L+0)\right] \tag{1.7}$$

The difference is

$$(1-\beta)\left[\frac{1}{2}K(\delta R_E-R_L)\right]+\beta\left[\mu\left(\frac{1}{2}K(\delta R_E-R_L)\right)+(1-\mu)\left(\frac{1}{2}K(\delta R_E-R_L)\right)\right] \tag{1.8}$$

Note that the difference is $\frac{1}{2}K(\delta R_E-R_L)$ regardless of the type of the other manager. Therefore, the expected difference is

$$\frac{1}{2}K(\delta R_E-R_L) \tag{1.9}$$

The expected difference is positive by the assumption stated in (1.2) and announcing l dominates announcing h for a type-B manager. So what keeps a type-B manager honest when he can announce h and potentially get more funding in period 1? The answer is his concern for period 2. A type-B manager could indeed exaggerate by announcing h and receive more funding in period 1 ($\frac{1}{2}K$ in every state compared to announcing l), but failing to attain his

[21]This is also true for any equilibrium and generalizes to the case of n managers.

stated target would label him as a bad manager and lead to less funding in period 2 ($\frac{1}{2}K$ in every state). If instead he announces l, he receives less funding in period 1 ($\frac{1}{2}K$ in every state compared to announcing h), and in return for being patient and demonstrating that he is a good manager, he receives more funding in period 2 ($\frac{1}{2}K$ in every state) when he expects to have a better project idea. That is, the gain that he can obtain by deviating in period 1 is not worth the consequent loss in period 2.

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L + \frac{1}{2}\delta KR_L\right] + \beta\left[\mu\left(\frac{1}{2}KR_L + 0\right) + (1-\mu)\left(KR_L + 0\right)\right] \tag{1.10}$$

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[0 + \delta KR_L\right] + \beta\left[\mu\left(0 + \frac{1}{2}\delta KR_L\right) + (1-\mu)\left(\frac{1}{2}KR_L + \frac{1}{2}\delta KR_L\right)\right] \tag{1.11}$$

The difference is

$$(1-\beta)\left[\frac{1}{2}KR_L(1-\delta)\right] + \beta\left[\mu\left(\frac{1}{2}KR_L(1-\delta)\right) + (1-\mu)\left(\frac{1}{2}KR_L(1-\delta)\right)\right] \tag{1.12}$$

Note again that the difference is constant across all possible states of nature. The expected difference is

$$\frac{1}{2}KR_L(1-\delta) \tag{1.13}$$

Given any amount of time discounting $\delta < 1$, the difference is positive and announcing h dominates announcing l for a type-C manager. The trade-off faced by a type-C manager is similar to that faced by a type-B manager. A type-C manager could indeed pretend to be a type-B manager by announcing l, receive less funding in period 1 compared to announcing h ($\frac{1}{2}K$ in every state), and in return, receive more funding in period 2 ($\frac{1}{2}K$ in every state). But since a type-C manager knows that the future does not hold much promise for him and that he will not have a better project idea in period 2, he prefers getting more funding sooner in period 1. Therefore the conjectured BPNE is indeed an equilibrium. The proof of uniqueness as well as the rest of the proofs are provided in the appendix.

1.2.2 Three-Manager and n-Manager Competition

For higher levels of internal competition, even type-B managers may lose their patience and choose to exaggerate in period 1. In the appendix, I provide a full characterization of the three-manager case and show that type-B managers may choose to exaggerate first with a mixing probability and then in pure strategy as β, the probability of facing a good manager, increases.[22] I outline below the intuition for why type-B managers may lose patience and choose to exaggerate in period 1 as the number of competing managers increases from two to three.

When there are three managers, it turns out that a manager can increase the expected amount of funding he receives over two periods by exaggerating in period 1. This is not to say that he faces no reputational costs in period 2. A manager who increases period-1 funding by exaggerating is sure to lose some period-2 funding as a consequence. But even after taking this cost into account, it turns out that a manager may still come out ahead by exaggerating in period 1. This was certainly not possible when there were two managers. In fact, the only possible equilibrium trade-off was between an equal amount of period-1 funding and period-2 funding. And any one manager's gain from exaggeration had to be the other manager's loss. This one-on-one constraint gets relaxed, however, when there are three or more managers. In a sense the extra manager breaks the one-on-one budget and allows richer trade-offs to arise in equilibrium.

Nevertheless, it is still not clear that a type-B manager would choose to exaggerate in period 1 to increase the expected amount of funding he receives over two periods. He clearly prefers having more funding over less funding. But he also prefers funding in period 2 (when he might have a better project idea) over funding in period 1 (when he has a bad project idea). For a type-B manager to lose patience then, a tighter condition must be met. Specifically, the potential value-weighted increase in period-1 funding must be greater than the consequent value-weighted decrease in period-2 funding.

Three factors help this tighter condition to be met (i) high β, (ii) low μ and (iii) large n. To see why, assume for a moment that type-B managers remain truthful and state l in period 1. Since both type-A managers and type-C managers state h, a type-B manager gets funding

[22] Meanwhile type-C managers continue to exaggerate as before.

in period 1 only if all other managers state l. That is, a type-B manager gets funding in period 1 only if all other managers turn out to be type-B. When this happens, however, it is very tempting for a single type-B manager to state h and get funding away from all other type-B managers. Of course, a type-B manager does not know for sure if all other managers are type-B. They can be type-A or even type-C. But a high β and a low μ make it less likely that they are type-A ($\beta\mu$) or type-C ($1-\beta$), and more likely that they are type-B ($\beta(1-\mu)$). Moreover, a low μ reduces the reputational cost in period 2 by making it less likely that one of the other managers is type-A ($\beta\mu$). Furthermore, the temptation for a single type-B manager to deviate increases intensely as n gets large. In the appendix, I study the mixing equilibrium for the general case of n managers and show that the mixing probability increases with n. In addition, I show that the parameter space $\beta-\mu$ in which type-B managers lose patience and start to exaggerate expands with n.

In a nutshell then, the main message to take away from this section is that increased integration and the intrinsic internal competition for resources can be bad for incentives and potentially can make it more difficult to elicit useful information from specialist managers.[23,24] Needless to say, not all is bad with integration. An integrated firm can create value by pooling resources and shifting funds from bad projects to good projects. But to the extent that such value creation has to rely on self-interested communication from managers, the analysis suggests that there can be an endogenous limit on integration. This is the issue I turn to next.

1.3 Integration and Allocative Efficiency

An integrated firm can improve allocative efficiency by pooling resources and shifting funds from bad projects to good projects. The analysis in the previous section, however, indicates that extracting the much needed information to do this may not be easy and, in fact, may

[23] One can think of this as "diseconomies of management" that Coase (1937) had to assume exogenously so that his benefit-oriented theory of integration did not generate the counterfactual prediction that the entire economy should be owned by one big firm to root out any potential hold-up problem. It is comforting to see that the casual but intuitive diseconomy argument can arise endogenously in a simple equilibrium model of communication.

[24] The model also has a valuable insight to contribute to the age-old central planning debate. As Hayek have argued so eloquently in a number of his writings on the topic, any form of centralized economic management is bound to fail because central planners will not and cannot have knowledge of "particular circumstances of time and place". Perhaps the internal competition perspective has something to add to the debate in conjunction with the well-accepted bounded rationality arguments of Simon (1955).

get more difficult with increased integration. So a natural question to ask is whether the two opposing effects could provide an endogenous limit on integration.

I start by comparing the allocative efficiency of two independent stand-alone firms with that of their integrated counterpart. To make comparison with first-best and second-best easier, I consider two independent stand-alone firms with a capital budget of $\frac{K}{2}$ each.

$$A_{2S} = K(1+\delta)\left[R_L + \beta\mu(R_H - R_L)\right] \tag{1.14}$$

This expression simply represents the expected return that two stand-alone firms can generate over two periods. Full expressions regarding allocative efficiency are provided in the appendix.

1.3.1 First-Best

With full information, an integrated firm can achieve higher allocative efficiency and exceed the allocative performance of two independent stand-alone firms by simply moving funds to the best opportunity available. This is the pure winner-picking role also pointed out by Stein (1997). The improvement in allocative efficiency relative to a stand-alone firm is positive.

$$A_{2I}^{FB} - A_{2S} = (1+\delta)\left[\beta(1-\beta)\mu + \beta^2\mu(1-\mu)\right] K(R_H - R_L) > 0 \tag{1.15}$$

An integrated firm creates value in both periods whenever it has a bad project and a good project. Specifically, an integrated firm creates value when it has (i) both a good manager (β) and a bad manager $(1-\beta)$, and the good manager has a good project (μ), (ii) two good managers $(\beta \times \beta)$, one with a good project (μ) and the other with a bad project $(1-\mu)$. By shifting resources to the better project, an integrated firm achieves higher allocative efficiency than two independent stand-alone firms.

1.3.2 Second-Best

When an integrated firm has to rely on self-interested communication from managers, its allocative efficiency suffers, at least compared to first-best. Compared to first-best, the difference is negative.

$$A_{2I}^{SB} - A_{2I}^{FB} = -\left[\beta\left(1-\beta\right)\mu + \delta\beta^{2}\mu\left(1-\mu\right)\right] K\left(R_H - R_L\right) < 0 \tag{1.16}$$

The reduction in allocative efficiency relative to first-best is due to (i) a bad manager $(1-\beta)$ with a bad project claiming to have a good project and getting funding when there is a good manager (β) who could use that funding in a good project (μ) in period 1, (ii) a good manager (β) with a bad project $(1-\mu)$ claiming to have a good project and getting funding when there is a good manager (β) who could use that funding in a good project (μ) in period 2 (δ). Moreover, the reduction is substantial when the cost of undertaking a bad project instead of a good project $(R_H - R_L)$ is high.

There are some other noteworthy differences compared to first-best. For example, there are instances in which a type-C manager claims to have a good project and gets funding at the expense of a type-B manager in period 1. Although in my model a type-B manager too has a bad project in period 1, he holds more promise than a type-C manager for period 2. In a more general model, one could imagine such diversion from type-B managers to type-C managers to be also costly, e.g. multiplicative investment technology, learning by doing, etc.

Compared to a stand-alone firm, the difference in allocative efficiency is positive.

$$A_{2I}^{SB} - A_{2S} = \left[\beta^{2}\mu\left(1-\mu\right) + \delta\beta\left(1-\beta\right)\mu\right] K\left(R_H - R_L\right) > 0 \tag{1.17}$$

Although less than the first-best improvement, the difference is still positive. An integrated firm improves allocative efficiency relative to two stand-alone firms by shifting funds from (i) a good manager (β) with a bad project $(1-\mu)$ to a good manager (β) with a good project (μ) in period 1, and (ii) a bad manager $(1-\beta)$ with a bad project to a good manager (β) with a good project (μ) in period 2 (δ).

The fact that A_{2I}^{SB} is always greater than A_{2S} should come as no surprise. Given the way the model is set up, integrating two managers will always dominate two independent managers. The intuition for this is quite simple. Suppose that every manager exaggerated and that, as a consequence, no funds could be shifted from one manager to the other. Since the same is true by default for two independent managers, it is clear that integrating two managers can do no worse. This suggests that the model developed so far is missing an important ingredient. Perhaps it is the fact that I have not attributed any explicit cost to exaggeration. Clearly, one can imagine reasons for why exaggeration can in itself be costly over and above what has been modeled in terms of financial returns. That is, aside from diverting resources away from better opportunities, one can imagine reasons for why exaggeration may in itself be destructive and lead to lower project outcomes. Then a stand-alone firm might achieve a higher allocative efficiency than an integrated firm. Compared to a stand-alone firm, there are many instances in which an integrated firm undertakes a project communicated as being good when in fact it is bad.

I do not pursue this point further for two reasons. First, I am somewhat reluctant to make such an exogenous assumption. Without a more first-principles understanding of the phenomena, it would be only speculation to draw conclusions. Second, the model already has rich enough dynamics to demonstrate that increased integration may not always improve allocative efficiency. Hence there is no need to make an exogenous assumption to close the model.

As an example, I look at the allocative efficiency of three managers. For expositional reasons, I assume parameter values are such that the equilibrium at least falls into the region where type-B managers exaggerate with a mixing probability α.[25] Note that if I do not make this assumption, increased integration would continue to create value by expanding the opportunity set. To simplify the analysis, I set $\delta = 0.5$. Moreover, I assume that the inequality stated in (1.2) is satisfied marginally. With these parameters pinned down, β must be greater than 0.5 so that type-B managers lose patience and exaggerate with a mixing probability in period 1.

The analytic expression for $A_{3I}^{SB} - A_{2I}^{SB}$ is not particularly intuitive so instead I plot it numerically in Figure 1-4. One would expect allocative efficiency to suffer as type-B managers choose to exaggerate with a higher mixing probability, that is when β is high and μ is low. Figure 1-4 shows that this is indeed the case. As β increases and μ decreases, the allocative efficiency of a three-manager firm declines and eventually falls below that of a two-manager firm.

It is worth emphasizing the main result so far. The model suggests that there are two

[25]Details of this case are left to the appendix.

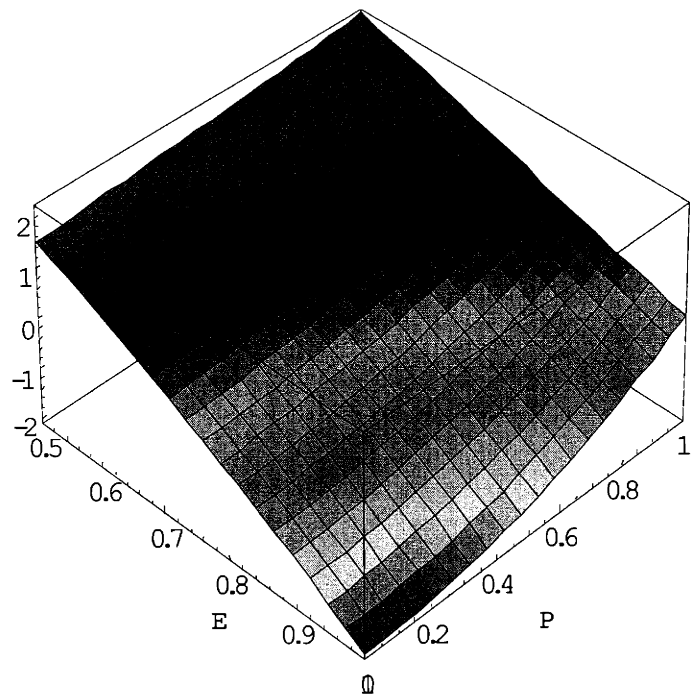

Figure 1-4: Difference in allocative efficiency

opposing effects at work. On the one hand, increased integration helps expand the opportunity set. This allows more value-enhancing redistribution from bad projects to good projects to take place. On the other hand, increased integration intensifies the internal competition for resources. This is bad for incentives and makes it harder to elicit useful information. The optimal point to stop further integration then is when the marginal cost of integration from worsened quality of communication exceeds the marginal benefit of integration from having a more expanded opportunity set. This aspect of the model more generally points to a theory of the firm based on the efficient allocation of resources.

Interestingly, the model can also be interpreted as a bank financing a portfolio of projects. Similar to a firm, a bank too may want to combine projects as long as the marginal benefit of integration (diversification) exceeds the marginal cost. Perhaps what we have then is a theory of financial intermediation. Although the argument for limited integration and diversification is somewhat inconsistent with Diamond's (1984) model of a bank, it is indeed more realistic. We do not see one big bank financing the entire economy as predicted by Diamond's model. It is well understood that diversification is good but only to a certain degree. What researchers have argued is that issues related to technical expertise start to bind after a point. That is, as a bank diversifies into new areas of lending, efficiency starts to suffer. With a slight reinterpretation, this is what my model predicts, too. When one views a bank as a firm that is in the business of making loans, the analogy becomes clearer. Too much diversification into unrelated lines of lending business can be dysfunctional. Instead, a limited diversification strategy that brings out the best of integration but stops before the dark side kicks in might be preferred.

Finally, the model points to an interesting comparison between internal and external capital markets. Perhaps external capital markets are plagued by what most of us argue is their most fundamental strength, unfettered competition. As the model shows, however, too much competition can be a bad thing when it comes to eliciting specialized knowledge. In such an environment, there is immense value to be created by committing to less competition and, in some ways, one can view firms as serving that purpose. By acting as isolated islands, firms can shelter their managers from intense competition for capital and improve allocative efficiency.

Holmström's (1999) view of the firm as a subeconomy is especially relevant here.[26] Holmström argues that concentrated ownership of assets under a single authority (the island) brings with it a great variety of instruments that can be used to influence and improve managerial behavior "in a manner richer and more varied" than what would be possible under separate ownership.[27] For example, a firm can set work rules; rotate managers between different projects; design jobs; delegate authority; control exactly who knows what and when. In effect, the control rights that come with asset ownership enable a firm to set "the rules of the game". To the extent that such control rights are important for improving managerial behavior, a firm might be a better financial intermediary than a bank.

The idea that asset ownership brings with it value-enhancing control rights has the potential to get us much closer to a theory of the firm based on the efficient allocation of resources. Armed with such control rights in a world riddled with informational asymmetries and significant externalities in contracting, a firm might be able to alter the game to improve efficiency in ways

[26] The Grossman-Hart-Moore paradigm taken literally, Holmström argues, can only explain why individuals own assets, but not why firms own assets. In reality of course, workers rarely own any assets. Instead, ownership of assets are clustered in firms.

[27] Holmström (1999), p.88

that a bank cannot. To complete the theory then, I need to show that such alterations are indeed possible.

1.4 Control Rights and Organizational Design

The view of the firm as a subeconomy naturally brings an inescapable analogy between a government and a corporate headquarters. While this is not the place to argue whether second-best intervention is desirable or not in a market economy, it seems that such ideas have enormous potential inside firms. By internalizing some of the externality that different types of managers impose on each other, a corporate headquarters can influence and improve managerial behavior in a number of ways. Many organizational processes and structures that we observe in practice help firms achieve that exact goal. In this section, I explore how a firm might use some of them to improve allocative efficiency. But more importantly, I argue why a bank may not be able to replicate them without the control rights that come with asset ownership.

In the analysis that follows, I do not consider incentive contracts for a multitude of reasons. First, incentive contracts can be very costly in the presence of significant private benefits, that is when monetary incentives have limited effect on managerial behavior. I provide a formal proof of this argument in the appendix. Specifically, I look at incentive contracts that induce truthful reporting in my model and show that the cost of such incentive contracts can arbitrarily approach K, the firm's capital budget. Second, the problem of informational asymmetry is such that a manager needs to be rewarded for admitting that he has a bad project. Of course, there is nothing inherently wrong with such contracts, except that the idea does not sound familiar. How many firms do we know of that pay their managers for submitting bad project proposals? Third, suppose that even a good manager with a good idea has to spend some effort to achieve a good project outcome. Then incentive contracts that reward a manager for admitting that he has a bad project can be very counterproductive. Especially if personal effort is costly enough, a good manager may never have the incentive to propose a good project and spend the effort to make it a success. Instead, he would take the easy route; submit a bad project and collect the counterproductive reward. Fourth, if preferences are not additively separable in income, compensating differentials will be incomplete.[28] Therefore in general, monetary incentives cannot be expected to solve the problem fully. Finally, I am more interested in exploring what a firm can do differently than a bank. There is no reason to assume that a bank cannot offer a financial contract that essentially replicates the payoff profile of what we call an incentive contract inside a firm.[29]

Before getting into further detail, I should emphasize a general lesson that emerges from the analysis. An effective design instrument does two things to improve managerial behavior. One, it reduces the potential gain from exaggeration. And two, it increases the cost. All of the design instruments considered next do more or less the same.

1.4.1 Rigid Divisional Capital Budgets

A firm can improve managerial behavior by reducing internal competition. One natural way to reduce internal competition and improve managerial behavior is rigid divisional capital budgets. With less at stake, managers might be more forthcoming in their communication. I formalize this idea in Proposition 3.[30]

It is important to note that internal competition is always beneficial in a first-best setting. The idea of having less internal competition, in effect, putting some sand in the wheels to improve allocative efficiency is really a second-best argument.

Proposition 3 *Making a portion of the capital budget non-contingent can eliminate exaggeration by bad managers (type-C) in period* 1*. Specifically, as long as the contingent portion does not exceed* $(1-\beta\mu)\,\delta$ *share of the capital budget, every manager tells his true project type.*

A rigid capital budget improves managerial behavior in essentially two ways. First, a rigid capital budget reduces the potential gain from exaggeration by allocating some of the capital before managers get a chance to make their statements. With less amount of capital open

[28] Milgrom (1988).

[29] It has often been argued that firms are inherently better than markets at constructing performance measures and dealing with moral hazard. Such arguments are very convincing for low-level workers. But one would expect the comparative advantage to be much smaller, if any, for high-level managers who are the main focus here.

[30] Milgrom and Roberts (1988) make a related point. An organization may optimally demand and use less information to avoid costly and wasteful effort by managers to influence decisions. See also Gibbons (1999) for a simple model along the same lines. Caillaud and Tirole (2001) provide a similar argument in the context of political parties.

to competition, a manager has less to gain by exaggerating. Second, a rigid capital budget promises a non-contingent allocation in period 2 for managers who behave in period 1, in effect making it more costly to exaggerate.

The fundamental question now is, why is it that a firm can have a rigid capital budget but a bank cannot? The answer has to do with a combination of adverse selection and control rights. Suppose that there is no asymmetric information at the beginning and that managers find out their types only after integration, say by working with the assets and getting their project ideas. Since there is some ex-ante uncertainty about managerial ability, managers initially would be willing to accept a rigid scheme. The problem, however, is ex-post. Once a manager finds out that he is good, a rigid scheme would have a very hard time keeping him. Not so surprisingly, he would like to defect to a non-rigid scheme in period 2, if not in period 1. The reason he may have to postpone defection until period 2 is that he may need the project result in period 1 to credibly prove that he is a good manager. At the same time, a rigid scheme would be a magnet for bad managers. With not much upside, bad managers would love to stay. Such degree of adverse selection would make it very hard for a bank to implement a rigid loan policy in a profitable way. And in fact, one would expect opportunistic banks to form in period 2 to exploit the situation and aggressively recruit good managers from period 1 as clients.[31]

With asset ownership, things are a bit different as defection is no longer that easy. A good manager who works for a firm cannot take the assets and defect to a bank that offers a non-rigid loan policy in period 2. Of course, he himself can leave if he so chooses. In fact, we call them entrepreneurs.[32] But the point is that he cannot take with him the assets that potentially make him more valuable. Then to the extent that asset ownership helps a firm to gain leverage over its human assets, there would be less defection and a firm would have a comparative advantage over a bank in implementing rigid schemes.[33]

Even if a rigid capital budget can improve managerial behavior, it may still not be optimal since information is used less aggressively. The decision to implement a rigid scheme ultimately depends on the resulting allocative efficiency. The full expression regarding A_{2I}^{RS} is provided in

[31] Interestingly, this points to a useful role banks can play in financing proven projects or managers.

[32] Gromb and Scharfstein (2001) develop an equilibrium labor-market model of entrepreneurship which predicts high ability managers to become entrepreneurs.

[33] Rajan and Zingales (1998) propose a theory of the firm based on controlling employee access to physical assets.

the appendix.

Compared to a stand-alone firm, the difference in allocative efficiency is strictly positive.

$$A_{2I}^{RS} - A_{2S} = \beta\mu\left[\nu\left(1-\beta\mu\right) + \delta\mu\left(1-\beta\right)\right] K\left(R_H - R_L\right) > 0 \tag{1.18}$$

where ν is the contingent portion of the capital budget. With a rigid scheme, an integrated firm is able to shift funds to type-A managers $(\beta\mu)$ in period 1 from not only type-B managers but also type-C managers $(1-\beta\mu)$, albeit at a slower pace ν. As an offset, however, because of the pooling of type-B and type-C managers in period 1, an integrated firm with a rigid scheme is able to shift funds from only type-C managers to type-A managers in period 2.

Compared to non-rigid second-best, the difference is increasing in the contingent share of the capital budget ν as expected.

$$\begin{aligned} A_{2I}^{RS} - A_{2I}^{SB} &= A_{2I}^{R} - A_{2S} - \left(A_{2I}^{SB} - A_{2S}\right) \\ &= K\beta\mu\left[\nu\left(1-\beta\mu\right) - \left(1-\mu\right)\left(\beta + \delta\left(1-\beta\right)\right)\right]\left(R_H - R_L\right) \end{aligned} \tag{1.19}$$

Proposition 4 *There exists δ^* such that for $\delta > \delta^*$ the rigid scheme achieves higher allocative efficiency than the non-rigid scheme.*

Propositions 3 and 4 highlights a natural limit on how aggressive an uninformed corporate headquarters can be in picking winners. Moreover, it provides an alternative explanation for what has typically been argued as socialism in internal capital markets, the seemingly lower sensitivity of integrated (multi-segment) firms to investment opportunities in their industries. Rigidity may simply be the optimal response of a corporate headquarters that is less informed than its managers. In Section 5, I provide a few suggestions that should help to empirically differentiate between the two explanations.[34]

As a final point, the idea that capital budgets of integrated firms cannot be too high-powered has parallels to the multi-tasking results of Holmström and Milgrom (1991). Informational asymmetry is the driving force as in their setting. Obviously the form is different, i.e. hidden

[34] There seems to be an interesting business cycle implication of the model. To the extent that parameters β and μ increase in an economic upturn, integrated firms would have to implement even more rigid capital budgets than non-integrated firms.

information versus hidden action, but the fundamental competition among "unobservables" is the same.

1.4.2 Job Rotation

The overwhelming view of both academics and practitioners seems to be that job rotation among managers, especially at high levels, is good and productive. General Electric is often cited as an example to argue how it can help not only managers gain invaluable experience but also firms spread best business practices. The popular press seems to agree.[35]

> Exposure to many disparate businesses ... give executives more ideas and confidence than most business people ever acquire... Executives raised in such an environment get a couple of advantages. First, they just know more. Managerially, they've seen the world. They've built a greater fund of ideas and practices than managers who've spent a career in one industry. Second, they've seen ideas applied successfully across industries, making them less afraid to try the unconventional. You're very reluctant to turn the world upside down if it's the only world you know.

Job rotation can be very effective in the context of my model as well, but for a somewhat different reason. To see why, suppose that the source of informational asymmetry in the model is not about managerial talent but about asset quality. That is, some of the assets that the firm has are profitable and some of them are not. Neither the firm nor the managers have knowledge of this at the time of integration, but the managers find out more as they work closely with the assets and get project ideas in period 1. Now imagine that a manager learns that the set of assets he is working with are not of high quality. As long as he is assigned to these assets, he knows not only that he will have a bad project in period 1, but also that he will not be able to come up with a good project idea in period 2. With the future not holding a lot of promise, he would choose to exaggerate in period 1. If instead there were some chance that he might be assigned to a possibly more profitable set of assets in period 2, he might be more forthcoming because only doing so would bring about the new assignment in period 2. I interpret this chance

[35] CEO super bowl. Fortune. Aug 2, 1999.

of being assigned to a different set of assets in period 2 as job rotation.[36]

Proposition 5 *Rotating managers to a different set of assets in period* 2 *can eliminate exaggeration by bad managers (type-C) in period* 1. *Specifically, there exists a probability of job rotation* $p \in (0,1)$ *and* δ^{**} *such that for* $\delta > \delta^{**}$, *every manager tells his true project type.*

In some sense, job rotation gives hope to a manager who is currently assigned to a bad set of assets. Of course, job rotation is just one example of what a firm can do with careers more generally. As the subeconomy view of the firm suggests, ownership of assets gives a firm the control rights with which to design the jobs related to them. For example, a firm can decide when and where to promote managers, create career paths, and so on. In effect, ownership of assets more generally allows a firm to run an internal labor market in a potentially value-enhancing way.

Without the control rights that come with asset ownership, a bank does not have the degree of control that a firm has over careers. Needless to say, a bank cannot take a manager from one of its projects and assign it to another. Then to the extent that such control over careers is important for manipulating managerial behavior, a firm might be a better financial intermediary than a bank.

Finally, the idea of job rotation points to an interesting conjecture about why firms that are made up of unrelated businesses do not appear to be faring so well and trade at lower valuation multiples than comparable firms that operate exclusively in a single line of business. Many explanations have been forwarded. But perhaps a more fundamental reason for a diversification strategy to have dysfunctional consequences is that it forces managers to accumulate human capital that ends up being too specific for the present job and of no use elsewhere in the firm, and makes it very hard to rotate them. As the model shows, getting trapped with a bad set of assets can make a manager desperate. There is ample indirect evidence that supports this conjecture. Scharfstein (1998) finds that diversified firms invest more in low-Q and less in high-Q businesses when compared to pure stand-alone firms. Gertner, Powers and Scharfstein (1999) find that spun-off units in high-Q businesses subsequently increase their investments.

[36]There are obviously other reasons for job rotation e.g. better matching of jobs and workers as argued by Alchian and Demsetz (1972), improved measurement of managerial talent to provide better performance contracts as in Aron (1988), etc.

Certainly, it would be interesting to empirically investigate whether these observed patterns are due to a careers effect more directly.

1.4.3 Centralization

The degree of centralization in production is perhaps one of the most important organizational design choices made by a firm. By centralizing certain aspects of production, a firm can achieve economies of scale otherwise unattainable or avoid wasteful duplication otherwise inevitable. These effects have been much discussed and explored in the literature. For this reason I do not pursue them here, although they have direct applications in the model. Instead I provide an unorthodox point of view on what centralization can do to foster more constructive and positive communication from managers.

Suppose that a firm can carve out a fraction θ of the assets from each manager and form a centralized unit with which each has to work. Clearly, a bank cannot do this since it does not have the control rights that come with asset ownership. For concreteness, think of a firm where all the marketing and distribution assets are centralized. Managers have to work with this centralized function to market and distribute their products but otherwise are free from any interference in their day-to-day operations. Further suppose that the centralized function needs some sort of a statement from each manager to coordinate and plan actions to make the team production a success and achieve the project's full potential. The problem, however, is that the centralized function is not allowed to receive private communication to improve coordination and instead has to rely on statements made by managers when they competed for corporate resources. If this is too abstract, it really should not be. Again for concreteness, think of a centralized marketing function that is making plans based on the project proposal that was presented to the corporate headquarters. Private communication is not possible, say because the headquarters staff eats lunch in the same corporate cafeteria and can overhear private conversations.

Portrayed in this way, it should be obvious why centralization would improve managerial behavior. When a manager contemplates making an exaggerated statement to get more resources in such a firm, he will take into account not only the reputational consequences, but also the disruptive effect that his misleading statement may have on the centralized function. In some sense, this line of argument endogenizes the idea that exaggeration itself may be destructive and lead to lower project outcomes. Parenthetically, the argument made here should not be confused with the standard monitoring argument that is often made in corporate finance. The way in which centralization is envisaged to induce positive managerial behavior is not by making corporate headquarters more informed about managers and projects, but by forcing managers to get involved in team production that is successful only if communication is accurate and forthcoming.

To see how the model works with a centralized unit, suppose that a manager states h and that the probability of him having a good project is $\widehat{\beta}$. This probability can be lower or higher than $\beta\mu$ depending on equilibrium strategies of the managers, but never zero since a type-A manager has no reason to state anything other than h. Upon receiving the statement, the centralized unit has two choices. It can plan for either h or l. When plans are made for h, the centralized unit runs the risk of miscoordination with a bad project with probability $1-\widehat{\beta}$. If instead plans are made for l, there still is a risk of miscoordination, but this time with a good project with probability $\widehat{\beta}$. Choosing the best out of two evils, plans would be made for h if

$$\widehat{\beta}\theta R_H > \left(1-\widehat{\beta}\right)\theta R_L \tag{1.20}$$

I assume that R_H is large enough so that plans are made for h when a manager states h. This assumption may seem too strong, but it really does not need to be. To see why, suppose that the coordination outcome is a logarithmic function, instead of the all-or-nothing formulation above. Then the program of the centralized unit would be

$$\max_x \log(x)\,\widehat{\beta}\theta R_H + \log(1-x)\left(1-\widehat{\beta}\right)\theta R_L \tag{1.21}$$

The optimal coordination response x^* would fall in the range $[0,1]$ and increase with R_H.

$$x^* = \frac{\widehat{\beta}R_H}{\widehat{\beta}R_H + \left(1-\widehat{\beta}\right)R_L} \tag{1.22}$$

The point is that, in either formulation, exaggeration would lead to a lower project outcome. To simplify the analysis, I continue with the all-or-nothing formulation. However, this should not affect the main message.

It is worth qualifying the idea before getting into further detail. The idea as presented so far does not ascribe any cost to centralization. As argued by Hayek (1945), efficiency dictates economic production to be undertaken by those who possess the relevant specialized knowledge and expertise. To the extent team production unnecessarily dilutes specialized knowledge and puts certain aspects of production in the hands of less specialized managers, centralization can be inefficient and costly. Moreover, centralization might not even be feasible for a firm made up of unrelated businesses. This insight proves to be useful when I discuss testable implications in Section 5.

Proposition 6 *For $\theta < \theta_l$, bad managers (type-C) exaggerate and state that they have good projects whereas good managers (type-A and type-B) state their true project types. For $\theta > \theta_h$, every manager reports the true type of his project in both periods. There exists δ^{***} such that for $\delta > \delta^{***}$ the two regions are non-overlapping $\theta_l < \theta_h$.*

In summary, centralization can play a significant role in implementing the desired equilibrium by increasing θ. By forcing managers to internalize the disruptive effect that their misleading statements may have on the centralized function, team production induces managers to be more forthcoming and improves the quality of communication.

1.4.4 Hierarchy

Similar to the argument made for rigid divisional capital budgets, hierarchies along divisional lines can be seen as an organizational device to restrain internal competition. Delegation and hierarchy, by reducing the intensity of internal competition, can improve the quality of communication.[37]

To illustrate the basic idea, consider the following simple example where the firm has four managers. These managers can be organized in two ways. First, they can compete simultaneously for the whole capital budget K. This is the familiar flat organization (Figure 1-5).

[37] The notion that delegation and hierarchy can serve as a bonding/commitment device is by no means new to this chapter. In fact, the argument is a common one in organizational economics. But I believe the interpretation provided here about delegation and hierarchy restraining internal competition and thereby improving the quality of communication is new.

Second, the firm can hire two division managers and delegate to each of them half of the capital budget $\frac{K}{2}$. Each division manager then gets two managers that in turn compete simultaneously for the smaller capital budget $\frac{K}{2}$ (Figure 1-6). Which option is better in terms of allocative efficiency?

In general, there are two opposing effects to consider: winner-picking versus communication. It is easy to see that, if corporate headquarters were perfectly informed about the projects presented by specialist managers, the flat structure would dominate. Choosing the best out of four would always lead to higher value, statistically speaking on average, than choosing the best out of two. This is the winner-picking effect pointed out by Stein (1997). On the other hand, the potential for exaggeration would be higher when four instead of two managers compete simultaneously for corporate resources. That is, there might be more exaggeration when internal competition is more intense. Indeed, depending on parameter values, the firm can end up in an equilibrium where not only type-C managers but also type-B managers exaggerate in period 1. Specifically, for high values of β, which lead to the dysfunctional equilibrium for the flat structure, the hierarchical structure may achieve higher allocative efficiency.

It would be interesting to push this idea further along the lines of the team-theoretic literature on organizational design, most notably Radner (1992, 1993), Sah and Stiglitz (1986), Bolton and Dewatripont (1994), and Garicano (2000). The model presented in this chapter captures many real-world issues pertaining to incentives, moral hazard and asymmetric information that the operations research focus of this literature leaves out. Yet it is simple enough to generate the kinds of sharp predictions characteristic of the team-theoretic literature.

Finally, one can argue that a bank could do the same without the control rights that come with asset ownership. I do not have a terribly convincing counter argument except to note that the idea of organizing projects along divisional lines in the case of a bank sounds more like having separate banks. For a firm, the situation can be different. It could be that, even though the divisions are more or less autonomous, it makes sense to combine them under one corporate umbrella because they share a critical asset.

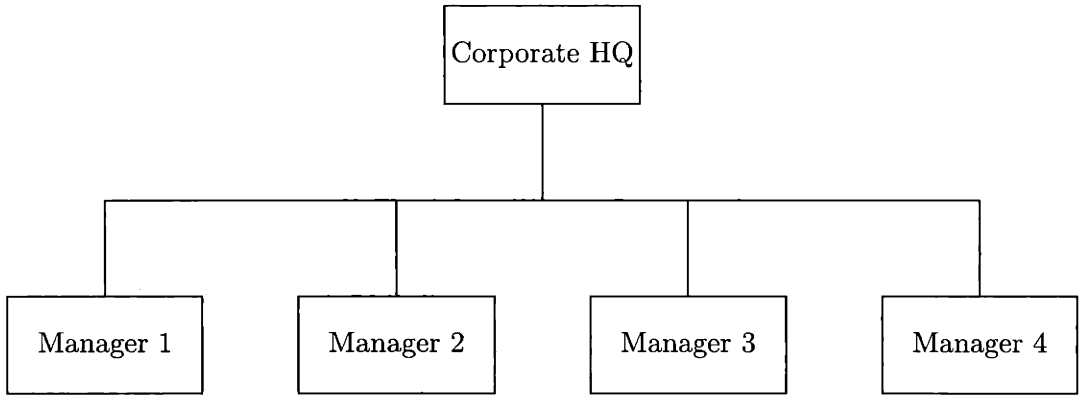

Figure 1-5: Flat Structure

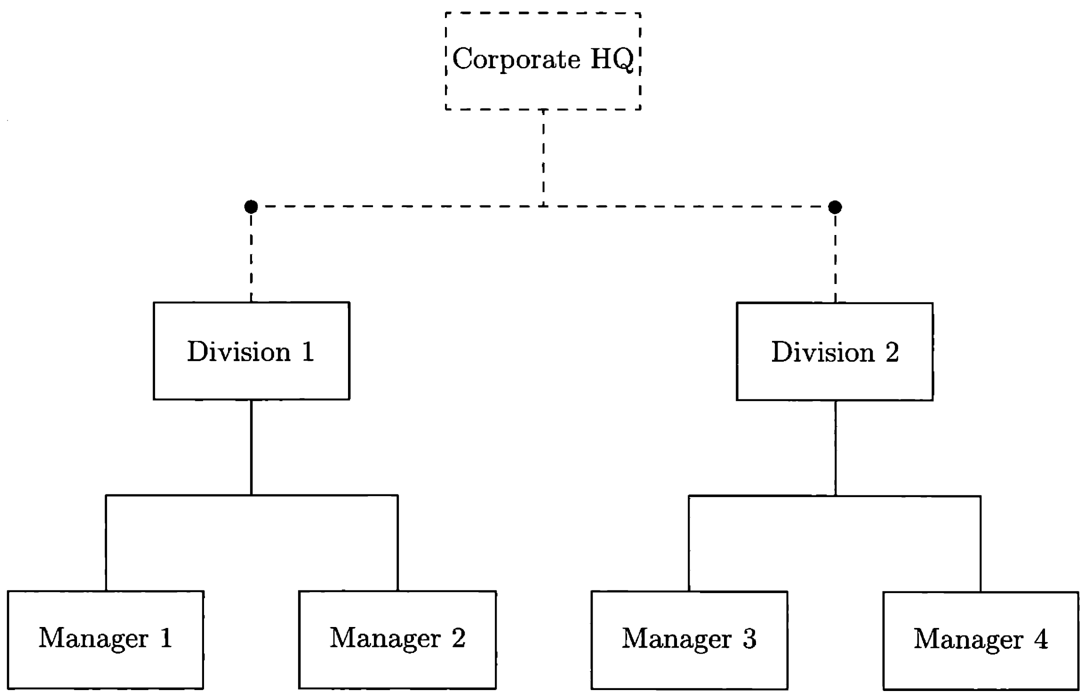

Figure 1-6: Hierarchical Structure

1.5 Testable Implications

In this section, I discuss testable implications of the ideas developed in Propositions 3-6. Most, if not all, can be tested using publicly available data sources such as Compustat firm and segment files which provide basic segment-level accounting data such as sales, assets, operating profits, depreciation and capital spending for every distinct business that constitutes more than 10 percent of total sales. In fact, the segments in these files typically have a senior top manager who translates very nicely into the specialist manager in my model. Also the segment-level data can help determine whether a firm is integrated or not. Of course, one would ideally like to have more extensive data on capital budgeting procedures, organizational structure, personnel policies and so forth but such detailed data are not widely available.

Hypothesis 1 *An integrated firm should have a more rigid capital budget than a non-integrated firm.*

Hypothesis 2 *A diversified integrated firm should have a more rigid capital budget than a focused integrated firm.*

Hypothesis 3 *A smaller segment of an integrated firm should have a more rigid divisional capital budget than a larger segment.*

Hypothesis 1 follows directly from Proposition 4. By restraining internal competition, an integrated firm can improve the quality of communication from managers and achieve higher allocative efficiency. The idea has parallels to the influence cost perspective of Milgrom and Roberts (1988) which suggests that an organization may optimally constrain potential communication channels and use less information to reduce the temptation of managers to engage in costly and wasteful activities to influence decisions. Similarly in my model, an integrated firm may optimally use less information to reduce the temptation of managers to make exaggerated statements.

Hypothesis 2 is based on the observation that organizational remedies such as centralization and job rotation are more difficult to put into practice at a diversified integrated firm that is made up of unrelated businesses than a focused integrated firm that is made up of related businesses. As I have pointed out earlier, this may simply be an issue of feasibility than anything else. It is hard to imagine what can be centralized in a firm made up of unrelated businesses. Also it is hard to imagine that a manager with expertise in one particular business can be rotated easily to a completely unrelated one. Unable to use these organizational remedies effectively, one would expect a diversified integrated firm to use rigidity more than a focused integrated firm. From an empirical perspective, Hypothesis 2 provides a more stringent test of the model by using an observed variation in the composition of integrated firms.

Hypothesis 3 provides an interesting test of the relevance of specialized knowledge. While it is not a formal prediction of the model, the underlying assumption for it is fairly simple. We, human beings, have limited cerebral and sensory capabilities.[38] This imperfection means that our capacity to acquire specialized knowledge is limited. Faced with such a constraint, it would be only optimal to ration that capacity and use it on areas and topics where the returns are the highest. In the case of a corporate headquarters, that area and topic would be the larger segments of the firm to which a significant portion of corporate resources is committed. And as a result, the degree of informational asymmetry would be relatively less for the larger segments than for the smaller segments. Of course, there are other reasons that would make the degree of informational asymmetry higher for the smaller segments. For example, the smaller segments may simply be newer to the firm. Or perhaps they are located further away from corporate headquarters.[39] In either case, the underlying reason for having a rigid divisional capital budget would be the same, namely the lack of specialized knowledge about the smaller segments at higher levels of management.

These hypotheses, however, should not be interpreted negatively for integrated firms. By its very nature, integration brings not only opportunity but also many challenging problems. Any negative interpretation would fail to appreciate the difficulty of providing appropriate incentives in a complex environment.[40]

[38] Simon (1955), Jensen and Meckling (1992).

[39] In fact it would very interesting to test the effect of distance if the data were available. In addition, it would be interesting to investigate how distance as a factor has changed over time. Petersen and Rajan (2000) investigate a similar question and find that the distance between small firms and their lenders have increased with advances in computing and communications.

[40] Holmström (1999), Gibbons (2000).

1.6 Conclusion

This chapter explores the effect of integration on the allocation of resources. I develop an equilibrium model of internal competition for funds in which corporate headquarters relies on communication from specialist managers to allocate resources. Since managers are assumed to have the relevant technical expertise and prefer larger empires, exaggeration arises as a potential problem. The model indicates both a bright side and a dark side to increased integration. On the one hand, increased integration expands the opportunity set and allows more value-enhancing redistribution from bad projects to good projects to take place. On the other hand, increased integration intensifies the internal competition for corporate resources and leads to more exaggeration. As a result, the model predicts an endogenous limit on integration that balances the marginal benefit from having an expanded opportunity set with the marginal cost from the consequent deterioration in the quality of communication. This aspect of the model more generally points to a theory of the firm based on the efficient allocation of resources.

The model also has a natural interpretation as a bank financing a portfolio of projects which helps to think about financial intermediation more broadly and various differences between a firm and a bank more specifically. In this pursuit, I draw on Holmström's (1999) view of the firm as a subeconomy, and argue that the control rights that come with asset ownership enable a firm to set "the rules of the game" and mitigate negative managerial behavior in ways that a bank cannot. Many organizational processes and structures that we observe in practice indeed come with asset ownership and can be viewed as altering the rules of the game. I show how some of these organizational remedies such as rigidity in capital budgeting, rotating managers, centralization and hierarchies can improve allocative efficiency, and make the firm a better financial intermediary than a bank.

At the end, I provide several implications of the model that can be tested on widely available data. The model predicts the capital budgets of integrated firms to be more rigid than the capital budgets of nonintegrated firms. The model also predicts the effects to be more pronounced in diversified integrated firms that operate in unrelated lines of business. The next chapter tests some of these predictions.

Finally, there appears to be ample opportunity for productive cross-fertilization between finance and organizational economics. Needless to say, more extensive data on organizational structure and personnel policies would be very useful in discerning the impact that organizational processes and structure have on the allocation of resources. It is somewhat disappointing that there has not been any significant amount of clinical research on these issues since the seminal work of Bower (1970). Such analyses would contribute tremendously to our understanding of the nature of the firm.

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1.7 Appendix

1.7.1 Proof of Propositions

Proof of Proposition 1 (Uniqueness). To show uniqueness, the redundancy of period-2 competition helps to reduce the search for potential equilibria to period-1 strategies. But with three types and three period-1 strategies (pure h, pure l, and mixing), there are still 27 potential equilibria to check.

Noting that there can be no equilibrium in which type-A managers announce l in period 1 further cuts down the number of potential equilibria to nine. To prove this by contradiction, assume that announcing l in period 1 is a best response. Since announcing l reduces period-1 funding with certainty in any equilibrium, it must have a period-2 benefit. But the posterior for a type-A manager is the same regardless of what he states in period 1 – an R_H outcome in period 1 perfectly reveals him as a type-A manager. With a constant posterior, there can be no period-2 benefit, hence the contradiction. Similarly, there can be no equilibrium in which type-B managers announce h and type-C managers get revealed perfectly by announcing l in mixing or pure strategies. Without a period-2 benefit, announcing l in period 1 can never be a best response.

Using Proposition 1, one can also rule out equilibria where type-C managers announce h and type-B managers announce h in mixing or pure strategies– remember announcing l is a best response for type-B managers. For the same reason, one can also rule out equilibria where type-B managers announce l and type-C managers announce l in mixing or pure strategies – remember announcing h is a best response for type-C managers. With six more equilibria eliminated, there are three equilibria left to check.

Assume that type-B managers mix (announce h with probability α and l with probability $1-\alpha$) in period 1. Can announcing l be a best response for type-C managers?

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L + \frac{1}{2}\delta KR_L\right] + \beta\left[\mu(0+0) + (1-\mu)\left(\alpha[0+0] + (1-\alpha)\left[\frac{1}{2}KR_L + \frac{1}{2}\delta KR_L\right]\right)\right]$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[KR_L+\delta KR_L\right]$$
$$+\beta\left[\mu\left(\frac{1}{2}KR_L+0\right)+(1-\mu)\left(\alpha\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]+(1-\alpha)\left[KR_L+\delta KR_L\right]\right)\right]$$

Announcing h clearly dominates announcing l for a type-C manager. Therefore, the conjecture cannot be an equilibrium.

Finally consider the equilibrium in which both type-B and type-C managers mix with probabilities α and γ, respectively. Depending on parameter values, there are two cases: (i) $P(g \mid h, R_L) > P(g \mid l, R_L)$, and (ii) $P(g \mid h, R_L) < P(g \mid l, R_L)$.

If $P(g \mid h, R_L) > P(g \mid l, R_L)$, payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[\gamma(0+0)+(1-\gamma)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right)\right]$$
$$+\beta\left[\mu(0+0)+(1-\mu)\left(\alpha\left[0+0\right]+(1-\alpha)\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]\right)\right]$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[\gamma\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right)+(1-\gamma)\left(KR_L+\delta KR_L\right)\right]$$
$$+\beta\left[\mu\left(\frac{1}{2}KR_L+0\right)+(1-\mu)\left(\alpha\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]+(1-\alpha)\left[KR_L+\delta KR_L\right]\right)\right]$$

Announcing h clearly dominates announcing l for a type-C manager. Therefore, the conjecture cannot be an equilibrium.

If $P(g \mid h, R_L) < P(g \mid l, R_L)$, payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[\gamma(0+\delta KR_L)+(1-\gamma)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right)\right]$$
$$+\beta\left[\mu(0+0)+(1-\mu)\left(\alpha\left[0+\delta KR_L\right]+(1-\alpha)\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]\right)\right]$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[\gamma\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right)+(1-\gamma)(KR_L+0)\right]$$
$$+\beta\left[\mu\left(\frac{1}{2}KR_L+0\right)+(1-\mu)\left(\alpha\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]+(1-\alpha)\left[KR_L+0\right]\right)\right]$$

Announcing h clearly dominates announcing l for a type-C manager. Therefore, the conjecture cannot be an equilibrium. The only possible equilibrium left is the equilibrium identified in Proposition 1.■

Proof of Proposition 2. Given the conjectured BPNE, every manager attains his stated target in period 1. A high project outcome in period 1 reveals that the manager is type-A. The posterior beliefs after observing the statements and project results in period 1 are

$$\begin{aligned}
P(g \mid h, R_H) &= 1 \\
P(g \mid h, R_L) &= 0 \text{ (out of equilibrium)} \\
P(g \mid l, R_H) &= 1 \text{ (out of equilibrium)} \\
P(g \mid l, R_L) &= \frac{\beta(1-\mu)}{\beta(1-\mu)+(1-\beta)}
\end{aligned}$$

Note that although the posterior $P(g \mid l, R_H)$ is out of equilibrium, it is not arbitrary. Only type-A managers can deliver R_H in period 1. In addition, to make the conjectured equilibrium Cho-Kreps proof, I fix the posterior belief $P(g \mid h, R_L)$ be a bad manager with probability one.[41] These posterior beliefs determine eligibility for period 2. Lemma 1 summarizes the optimal period-2 strategy. Let ν denote the contingent share of the capital budget. A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\nu)\left[\frac{1}{2}K(R_L+(1-\beta\mu)\delta R_E)\right]$$
$$+\nu\left[(1-\beta)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E\right)+\beta\left(\mu[0+0]+(1-\mu)\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E\right]\right)\right]$$

[41] Since a type-B manager can always make a credible speech and claim to be a good manager by promising not to announce h if the posterior was greater than zero.

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\nu)\left[\frac{1}{2}KR_L+0\right]+\nu\left[(1-\beta)(KR_L+0)+\beta\left(\mu\left[\frac{1}{2}KR_L+0\right]+(1-\mu)[KR_L+0]\right)\right]$$

The difference is

$$\frac{1}{2}K[(1-\beta\mu)\delta R_E-\nu R_L]$$

Since the contingent portion of the capital budget ν is less than $(1-\beta\mu)\delta$, the difference is positive and announcing l dominates announcing h for a type-B manager.

Payoff to a type-C manager from announcing l in period 1 is

$$\begin{aligned}&(1-\nu)\left[\frac{1}{2}(1+(1-\beta\mu)\delta)KR_L\right]\\&+\nu\left[(1-\beta)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right)+\beta\left(\mu[0+0]+(1-\mu)\left[\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L\right]\right)\right]\end{aligned}$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\nu)\left[\frac{1}{2}KR_L+0\right]+\nu\left[(1-\beta)(KR_L+0)+\beta\left(\mu\left[\frac{1}{2}KR_L+0\right]+(1-\mu)[KR_L+0]\right)\right]$$

The difference is

$$\frac{1}{2}KR_L[(1-\beta\mu)\delta-\nu]$$

Since the contingent portion of the capital budget ν is less than $(1-\beta\mu)\delta$, the difference is positive and announcing l dominates announcing h for a type-C manager.■

Proof of Proposition 3. Substitute in $(1-\beta\mu)\delta$ for ν, the maximum contingent share possible.

$$K\beta\mu\left[\delta(1-\beta\mu)^2-(1-\mu)(\beta+\delta(1-\beta))\right](R_H-R_L)$$

The difference is positive for

$$\delta\left[(1-\beta\mu)^2-(1-\beta)(1-\mu)\right]>\beta(1-\mu)$$

Simple algebra shows that $(1-\beta\mu)^2-(1-\beta)(1-\mu)>0$. Therefore, the difference is positive for $\delta>\delta^*$

$$\delta>\frac{\beta(1-\mu)}{(1-\beta\mu)^2-(1-\beta)(1-\mu)}$$

Rearranging the expression for δ^*

$$\delta^*=\frac{\beta(1-\mu)}{\beta(1-\mu)+(1-\beta\mu)^2-(1-\mu)}$$

δ^* is less than 1 when $(1-\beta\mu)^2-(1-\mu)>0$. Solving for β yields two roots, $\beta>\frac{1+\sqrt{1-\mu}}{\mu}$ and $\beta<\frac{1-\sqrt{1-\mu}}{\mu}$. The first root is not useful since it provides a lower bound for β that is greater than 1.

Analyzing the second root, it can be shown that the expression $\frac{1-\sqrt{1-\mu}}{\mu}$ is increasing in the range $[0,1]$. As μ approaches 1, the upper bound for β approaches 1. However this bound is not good enough since the overall ratio gets unstable at the same time. As μ approaches 0, the upper bound for β is indeterminate. Using L'Hôpital's rule

$$\begin{aligned}\left[\frac{\frac{d}{d\mu}\left(1-\sqrt{1-\mu}\right)}{\frac{d}{d\mu}(\mu)}\right]_{\mu\to0} &= \left[\frac{1}{2\sqrt{1-\mu}}\right]_{\mu\to0}\\ &= \frac{1}{2}\end{aligned}$$

Therefore, if δ^* is to be less than 1, β and μ cannot be too high at the same time (Figure 1-7).

■

Proof of Proposition 4. Posterior beliefs and eligibility for period 2 are the same as in the case of rigid capital budgets. Let p denote the probability of job rotation in period 2. A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

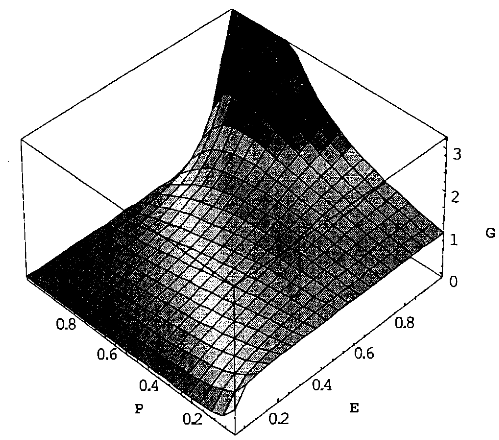


Figure 1-7: Lower bound δ^* in $\beta - \mu$ space

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L + \delta\left(p\left[\frac{1}{2}KR_L\right] + (1-p)\left[\frac{1}{2}KR_E\right]\right)\right]$$
$$+\beta\left[\mu(0+0) + (1-\mu)\left(\frac{1}{2}KR_L + \frac{1}{2}\delta KR_E\right)\right]$$

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)\left[KR_L + 0\right] + \beta\left[\mu\left(\frac{1}{2}KR_L + 0\right) + (1-\mu)(KR_L + 0)\right]$$

The difference is positive for

$$p < \frac{(1-\beta\mu)\,\delta R_E - R_L}{(1-\beta)\,\delta\,(R_E - R_L)} \equiv p_u$$

For this expression to be a proper upper bound on p, a condition stronger than $\delta R_E - R_L > 0$ is required (note that the new condition is less onerous when β and μ are not too high).

$$(1-\beta\mu)\,\delta R_E - R_L > 0$$

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L+\delta\frac{1}{2}KR_L\right]$$
$$+\beta\left[\mu\left(0+0\right)+\left(1-\mu\right)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta\left[p\left(\frac{1}{2}KR_E\right)+\left(1-p\right)\left(\frac{1}{2}KR_L\right)\right]\right)\right]$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[KR_L+0\right]+\beta\left[\mu\left(\frac{1}{2}KR_L+0\right)+\left(1-\mu\right)\left(KR_L+0\right)\right]$$

The difference is positive for

$$p>\frac{\left(1-\delta\left(1-\beta\mu\right)\right)R_L}{\beta\left(1-\mu\right)\delta\left(R_E-R_L\right)}\equiv p_l$$

For this expression to be a proper lower bound on p,

$$\delta>\frac{R_L}{\left(1-\beta\right)R_L+\beta\left(1-\mu\right)R_E}\equiv\delta^{**}$$

This condition further ensures that $p_l<p_u$. Finally, δ^{**} is less than 1 when

$$\mu<\frac{R_E-R_L}{R_E}$$

Therefore, if δ^{**} is to be less than 1, μ cannot be too high.■

Proof of Proposition 5

$\boldsymbol{\theta<\theta_l}$. Posterior beliefs and eligibility for period 2 are the same as in Proposition 1. It is important to note that competition in period 2 is no longer value-neutral since $\theta>0$. The firm, if possible, should allocate its period-2 capital budget K equally among managers, who tie for the highest posterior probability of being a good manager, without asking for a statement. I assume that the firm does not have such commitment power.

A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l. Payoff to a type-B manager from announcing l in period

1 is

$$(1-\beta)\left[0+\delta K\left(\mu R_H+(1-\mu)R_L\right)\right]+\beta\left[\begin{array}{c}\mu\left(0+\frac{1}{2}\delta K\left[\mu R_H+(1-\mu)R_L(1-\theta)\right]\right)\\+\\(1-\mu)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta K\left[\mu R_H+(1-\mu)R_L(1-\theta)\right]\right)\end{array}\right]$$

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L(1-\theta)+\frac{1}{2}\delta K\left(\mu R_H(1-\theta)+(1-\mu)R_L\right)\right]+\beta\left[\begin{array}{c}\mu\left(\frac{1}{2}KR_L(1-\theta)+0\right)\\+\\(1-\mu)\left(KR_L(1-\theta)+0\right)\end{array}\right]$$

The difference is positive for

$$\theta>\frac{-\delta\mu R_H+(1-\delta(1-\mu))R_L}{\delta\mu(1-\beta)R_H+(1+\beta(1-\delta)(1-\mu))R_L}$$

This expression further reduces to

$$\theta>\frac{R_L-\delta\left(\mu R_H+(1-\mu)R_L\right)}{\delta\mu(1-\beta)R_H+(1+\beta(1-\delta)(1-\mu))R_L}$$

Since $R_L<\delta\left[\mu R_L+(1-\mu)R_H\right]$ by assumption, the lower bound is less than zero. The condition is satisfied since $0<\theta<1$.

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L(1-\theta)+\frac{1}{2}\delta KR_L\right]+\beta\left[\mu\left(\frac{1}{2}KR_L(1-\theta)+0\right)+(1-\mu)\left(KR_L(1-\theta)+0\right)\right]$$

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[0+\delta KR_L\right]+\beta\left[\mu\left(0+\frac{1}{2}\delta KR_L(1-\theta)\right)+(1-\mu)\left(\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L(1-\theta)\right)\right]$$

The difference is

$$\frac{1}{2}KR_L\left[1-\delta-\theta\left(1+\beta\left(1-\delta-\mu\right)\right)\right]$$

Note that $1+\beta(1-\delta-\mu)>0$. Therefore the difference is positive for

$$\theta<\frac{1-\delta}{1+\beta\left(1-\delta-\mu\right)}\equiv\theta_l$$

Since the numerator $1-\delta>0$, the ratio is positive. Moreover, the denominator is greater than the numerator, leaving the upper bound for θ in the desired range, between 0 and 1.

$\boldsymbol{\theta>\theta_h}$. Posterior beliefs and eligibility for period 2 are the same as in the case of rigid capital budgets. Note that every manager with some positive probability of being a good manager would be allowed to make a statement in period 2 since every manager is conjectured to report the true type of his project.

To induce a manager with a bad project in period 2 to tell the true type of his project when facing a type-A manager who has stated h and delivered R_H in period 1 (or a manager who has stated l and delivered R_H in period 1, which is out of equilibrium)

$$\mu\left[0\right]+\left(1-\mu\right)\left[\frac{1}{2}KR_L\right]>\mu\left[\frac{1}{2}KR_L\left(1-\theta\right)\right]+\left(1-\mu\right)\left[KR_L\left(1-\theta\right)\right]$$

Simplifying the expression yields

$$\theta>\frac{1}{2-\mu}\equiv\theta_h$$

To induce a manager with a bad project in period 2 to tell the true type of his project when facing a manager who has stated l and delivered R_L in period 1 (a type-B or a type-C manager)

$$\begin{aligned}
& \frac{(1-\beta)}{\beta(1-\mu)+(1-\beta)}\left[\frac{1}{2}KR_L\right] \\
& +\frac{\beta(1-\mu)}{\beta(1-\mu)+(1-\beta)}\left[\mu(0)+(1-\mu)\left(\frac{1}{2}KR_L\right)\right] \\
> \quad & \frac{(1-\beta)}{\beta(1-\mu)+(1-\beta)}\left[KR_L(1-\theta)\right] \\
& +\frac{\beta(1-\mu)}{\beta(1-\mu)+(1-\beta)}\left[\mu\left(\frac{1}{2}KR_L(1-\theta)\right)+(1-\mu)\left(KR_L(1-\theta)\right)\right]
\end{aligned}$$

Simplifying the expression yields

$$\theta > \frac{(1-\beta\mu)}{2(1-\beta\mu)-\beta\mu(1-\mu)}$$

Simple algebra shows that

$$\max\{\frac{1}{2-\mu}, \frac{(1-\beta\mu)}{2(1-\beta\mu)-\beta\mu(1-\mu)}\} = \frac{1}{2-\mu}$$

Solving the model backwards, payoff to a type-A manager from announcing h in period 1 is

$$(1-\beta)\left[KR_H+\delta K\left(\mu R_H+(1-\mu)\frac{1}{2}R_L\right)\right]+\beta\left[\begin{array}{c}\mu\left(\frac{1}{2}KR_H+u_2\right)\\+\\(1-\mu)\left(KR_H+u_2\right)\end{array}\right]$$

where u_2 is

$$\delta K\left[\mu\left(\mu\left[\frac{1}{2}R_H\right]+(1-\mu)[0]\right)+(1-\mu)\left(\mu\left[R_H\right]+(1-\mu)\left[\frac{1}{2}R_L\right]\right)\right]$$

Payoff to a type-A manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_H(1-\theta)+\delta K\left(\mu R_H+(1-\mu)\frac{1}{2}R_L\right)\right]+\beta\left[\begin{array}{c}\mu\left(0+u_2\right)\\+\\(1-\mu)\left(\frac{1}{2}KR_H(1-\theta)+u_2\right)\end{array}\right]$$

A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L + \delta K\left(\mu R_H + (1-\mu)\frac{1}{2}R_L\right)\right] + \beta\left[\begin{array}{c}\mu\,(0+u_2)\\ + \\ (1-\mu)\left(\frac{1}{2}KR_L + u_2\right)\end{array}\right]$$

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)\left[KR_L\,(1-\theta)+0\right] + \beta\left[\mu\left(\frac{1}{2}KR_L\,(1-\theta)+0\right) + (1-\mu)\left(KR_L\,(1-\theta)+0\right)\right]$$

Ignoring period-2 payoffs to simplify the analysis, the difference is positive for

$$\theta > \frac{1}{2-\beta\mu}$$

Simple algebra shows that

$$\frac{1}{2-\mu} > \frac{1}{2-\beta\mu}$$

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)\left[\frac{1}{2}KR_L + \frac{1}{2}\delta KR_L\right] + \beta\left[\begin{array}{c}\mu\left(0+\delta K\left[\mu\,(0)+(1-\mu)\left(\frac{1}{2}R_L\right)\right]\right)\\ + \\ (1-\mu)\left(\frac{1}{2}KR_L + \delta K\left[\mu\,(0)+(1-\mu)\left(\frac{1}{2}R_L\right)\right]\right)\end{array}\right]$$

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)\left[KR_L\,(1-\theta)+0\right] + \beta\left[\mu\left(\frac{1}{2}KR_L\,(1-\theta)+0\right) + (1-\mu)\left(KR_L\,(1-\theta)+0\right)\right]$$

The difference is positive for

$$\theta > \frac{1-\delta\,(1-\beta\mu)}{2-\beta\mu}$$

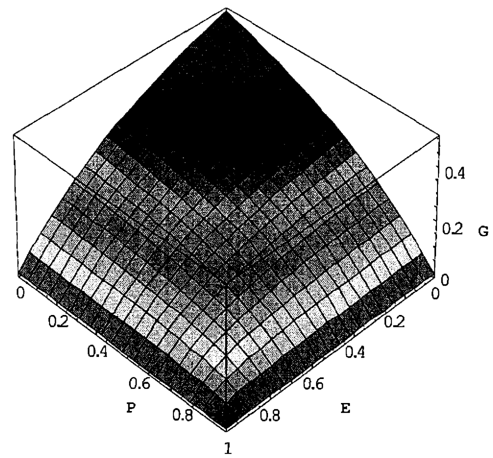


Figure 1-8: Lower bound δ^{***} in $\beta - \mu$ space

Again simple algebra shows that

$$\frac{1}{2-\mu} > \frac{1-\delta\left(1-\beta\mu\right)}{2-\beta\mu}$$

Non-overlapping. For the two regions to be non-overlapping

$$\frac{1}{2-\mu} > \frac{1-\delta}{1+\beta\left(1-\delta-\mu\right)} \Rightarrow \delta > \frac{\left(1-\beta\right)\left(1-\mu\right)}{\left(1-\beta\right)+\left(1-\mu\right)} \equiv \delta^{***}$$

Simple algebra shows that δ^{***} is less than 1 for all values of β and μ (Figure 1-8).

■

1.7.2 Three-Manager Competition

I extend the model to three managers. To simplify the analysis without diluting its message, I assume $\delta < \frac{1}{2}$. Let me define constant g as $\frac{\delta R_E}{R_L}$. There are three distinct regions.

Region I: $0 < \beta < \frac{2g-1}{1-\mu+g}$

Region II: $\frac{2g-1}{1-\mu+g} < \beta < \frac{2g-1}{g\mu}$

Region III: $\frac{2g-1}{g\mu} < \beta < 1$

Region I Equilibrium: In period 1, bad managers (type-C) exaggerate and state that they have good projects whereas good managers (type-A and type-B) state their true project types.

Region II Equilibrium: In period 1, bad managers (type-C) exaggerate and state that they have good projects, good managers with good projects (type-A) state their true project types, and good managers with bad projects (type-B) exaggerate with probability α and state their true project types with probability $1-\alpha$.

Region III Equilibrium: In period 1, both bad managers (type-C) and good managers with bad projects (type-B) exaggerate and state that they have good projects whereas good managers with good projects (type-A) state their true project types.

Region I Equilibrium. Given the conjectured BPNE, only project proposals made by type-C managers in period 1 fail to attain their stated targets and consequently reveal their managers as such. A high project outcome in period 1 reveals that the manager is a type-A manager. On the equilibrium path, project proposals by type-B managers in period 1 attain their stated targets. Therefore, the posterior beliefs after observing the statements and project results in period 1 are

$$\begin{aligned}
P(g \mid h, R_H) &= 1 \\
P(g \mid h, R_L) &= 0 \\
P(g \mid l, R_H) &= 1 \text{ (out of equilibrium)} \\
P(g \mid l, R_L) &= 1
\end{aligned}$$

Note that although the posterior $P(g \mid l, R_H)$ is out of equilibrium, it is not arbitrary. Only type-A managers can deliver R_H in period 1. These posterior beliefs determine eligibility for period 2. Lemma 1 summarizes the optimal period-2 strategy. Solving the model backwards, payoff to a type-A manager from announcing h in period 1 is

$$\begin{aligned}
&(1-\beta)^2\left[\frac{1}{3}KR_H+\delta KR_E\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_H+\frac{1}{2}\delta KR_E\right)+(1-\mu)\left(\frac{1}{2}KR_H+\frac{1}{2}\delta KR_E\right)\right] \\
&+\beta^2\left[\mu^2\left(\frac{1}{3}KR_H+\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\left(\frac{1}{2}KR_H+\frac{1}{3}\delta KR_E\right)+(1-\mu)^2\left(KR_H+\frac{1}{3}\delta KR_E\right)\right]
\end{aligned}$$

Payoff to a type-A manager from announcing l in period 1 is

$$(1-\beta)^2[0+\delta KR_E]+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)\left(0+\frac{1}{2}\delta KR_E\right)\right]$$
$$+\beta^2\left[\mu^2\left(0+\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\left(0+\frac{1}{3}\delta KR_E\right)+(1-\mu)^2\left(\frac{1}{3}KR_H+\frac{1}{3}\delta KR_E\right)\right]$$

A type-A manager clearly has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\beta)^2[0+\delta KR_E]+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)\left(0+\frac{1}{2}\delta KR_E\right)\right]$$
$$+\beta^2\left[\mu^2\left(0+\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\left(0+\frac{1}{3}\delta KR_E\right)+(1-\mu)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right)\right]$$

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\left(\frac{1}{2}KR_L+0\right)\right]$$
$$+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L+0\right)+2\mu(1-\mu)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2(KR_L+0)\right]$$

The difference is

$$(1-\beta)^2\left[\frac{2}{3}\delta KR_E-\frac{1}{3}KR_L\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{2}\delta KR_E-\frac{1}{3}KR_L\right)+(1-\mu)\left(\frac{1}{2}\delta KR_E-\frac{1}{2}KR_L\right)\right]$$
$$+\beta^2\left[\mu^2\left(\frac{1}{3}\delta KR_E-\frac{1}{3}KR_L\right)+2\mu(1-\mu)\left(\frac{1}{3}\delta KR_E-\frac{1}{2}KR_L\right)+(1-\mu)^2\left(\frac{1}{3}\delta KR_E-\frac{2}{3}KR_L\right)\right]$$
$$=\quad -\frac{1}{3}KR_L[1-2g+\beta(1-\mu+g)]$$

In region I where $\beta < \frac{2g-1}{1-\mu+g}$, the difference is positive and announcing l dominates announcing h for a type-B manager. This condition essentially implies that if the chances of facing a type-A manager or a type-B manager are not too high, a type-B manager would choose to protect his reputation for the second period and not exaggerate in period 1.

Payoff to a type-C manager from announcing h in period 1 is

$$\begin{aligned}&(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\left(\frac{1}{2}KR_L+0\right)\right]\\&+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L+0\right)+2\mu(1-\mu)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2(KR_L+0)\right]\end{aligned}$$

Payoff to a type-C manager from announcing l in period 1 is

$$\begin{aligned}&(1-\beta)^2[0+\delta KR_L]+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_L\right)+(1-\mu)\left(0+\frac{1}{2}\delta KR_L\right)\right]\\&+\beta^2\left[\mu^2\left(0+\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\left(0+\frac{1}{3}\delta KR_L\right)+(1-\mu)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)\right]\end{aligned}$$

The difference is

$$\begin{aligned}&(1-\beta)^2\left[\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_L\right)+(1-\mu)\left(\frac{1}{2}KR_L-\frac{1}{2}\delta KR_L\right)\right]\\&+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L-\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\left(\frac{1}{2}KR_L-\frac{1}{3}\delta KR_L\right)+(1-\mu)^2\left(\frac{2}{3}KR_L-\frac{1}{3}\delta KR_L\right)\right]\\=&\ \frac{1}{3}KR_L[1-2\delta+\beta(1-\mu+\delta)]\end{aligned}$$

Since $\delta < \frac{1}{2}$, the difference is positive and announcing h dominates announcing l for a type-C manager. Therefore the conjectured BPNE is indeed an equilibrium.

Region II Equilibrium. Given the conjectured BPNE, type-B managers may or may not fail to attain their stated targets in period 1. A high project outcome in period 1 reveals that the manager is a type-A manager. Therefore, the posterior beliefs after observing the statements and project results in period 1 are

$$\begin{aligned}P(g\mid h,R_H)&=1\\P(g\mid h,R_L)&=\frac{\alpha\beta(1-\mu)}{\alpha\beta(1-\mu)+(1-\beta)}\\P(g\mid l,R_H)&=1\\P(g\mid l,R_L)&=1\end{aligned}$$

These posterior beliefs determine eligibility for period 2. Lemma 1 summarizes the optimal period-2 strategy. A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

Payoff to a type-B manager from announcing l in period 1 is

$$\begin{aligned}
&(1-\beta)^2\left[0+\delta KR_E\right] \\
&+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)\alpha(0+\delta KR_E)+(1-\mu)(1-\alpha)\left(0+\frac{1}{2}\delta KR_E\right)\right] \\
&+\beta^2\left[\begin{array}{c}\mu^2\left(0+\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\alpha\left(0+\frac{1}{2}\delta KR_E\right) \\ +2\mu(1-\mu)(1-\alpha)\left(0+\frac{1}{3}\delta KR_E\right)+(1-\mu)^2\alpha^2(0+\delta KR_E) \\ +(1-\mu)^2 2\alpha(1-\alpha)\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)^2(1-\alpha)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right)\end{array}\right]
\end{aligned}$$

Payoff to a type-B manager from announcing h in period 1 is

$$\begin{aligned}
&(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right] \\
&+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\alpha\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right)+(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L+0\right)\right] \\
&+\beta^2\left[\begin{array}{c}\mu^2\left(\frac{1}{3}KR_L+0\right)+2\mu(1-\mu)\alpha\left(\frac{1}{3}KR_L+0\right) \\ +2\mu(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2\alpha^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right) \\ +(1-\mu)^2 2\alpha(1-\alpha)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2(1-\alpha)^2(KR_L+0)\end{array}\right]
\end{aligned}$$

For mixing to be an optimal response, set the two payoffs equal to each other and solve for α

$$\alpha=\frac{1-2g+\beta(1-\mu+g)}{(1+g)\beta(1-\mu)}$$

For α to be a proper mixing probability, $0<\alpha<1$,

$$\frac{2g-1}{1-\mu+g}<\beta<\frac{2g-1}{g\mu}$$

This is the relevant parameter space, region II. Before proceeding with type-C managers, I need to sort out a few conditions. First, for these boundary conditions to be satisfied, it must be that $\frac{2g-1}{1-\mu+g}<\frac{2g-1}{g\mu}$. $g>1$ satisfies this condition. Second, for β to be a proper probability in region II, $0<\beta<1$, $\frac{2g-1}{g\mu}$ must be greater than 0 and $\frac{2g-1}{1-\mu+g}$ must be less than 1. For

$\frac{2g-1}{g\mu} > 0$, $g > 1$ is again enough. For $\frac{2g-1}{1-\mu+g} < 1$, μ must be less than $2-g$. Otherwise, payoff from announcing h would never be as high as payoff from announcing l and type-B managers would never choose to mix. This condition essentially implies that if the chances of facing a type-A manager relative to a type-B manager are too high, it would never pay off to exaggerate in the first period. When $\mu > 2-g$, only region I remains.

Payoff to a type-C manager from announcing h in period 1 is

$$
\begin{aligned}
&(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right]\\
&+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\alpha\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)+(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L+0\right)\right]\\
&+\beta^2\left[\begin{array}{c}\mu^2\left(\frac{1}{3}KR_L+0\right)+2\mu(1-\mu)\alpha\left(\frac{1}{3}KR_L+0\right)\\ +2\mu(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2\alpha^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)\\ +(1-\mu)^2 2\alpha(1-\alpha)\left(\frac{1}{2}KR_L+0\right)+(1-\mu)^2(1-\alpha)^2\left(KR_L+0\right)\end{array}\right]
\end{aligned}
$$

Payoff to a type-C manager from announcing l in period 1 is

$$
\begin{aligned}
&(1-\beta)^2\left[0+\delta KR_L\right]\\
&+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_L\right)+(1-\mu)\alpha\left(0+\delta KR_L\right)+(1-\mu)(1-\alpha)\left(0+\frac{1}{2}\delta KR_L\right)\right]\\
&+\beta^2\left[\begin{array}{c}\mu^2\left(0+\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\alpha\left(0+\frac{1}{2}\delta KR_L\right)\\ +2\mu(1-\mu)(1-\alpha)\left(0+\frac{1}{3}\delta KR_L\right)+(1-\mu)^2\alpha^2\left(0+\delta KR_L\right)\\ +(1-\mu)^2 2\alpha(1-\alpha)\left(0+\frac{1}{2}\delta KR_L\right)+(1-\mu)^2(1-\alpha)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)\end{array}\right]
\end{aligned}
$$

The difference is

$$
\begin{aligned}
& (1-\beta)^2\left[\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right] \\
& +2\beta(1-\beta)\left[\begin{array}{c}\mu\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_L\right) \\ +(1-\mu)\alpha\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right)+(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L-\frac{1}{2}\delta KR_L\right)\end{array}\right] \\
& +\beta^2\left[\begin{array}{c}\mu^2\left(\frac{1}{3}KR_L-\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\alpha\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_L\right) \\ +2\mu(1-\mu)(1-\alpha)\left(\frac{1}{2}KR_L-\frac{1}{3}\delta KR_L\right)+(1-\mu)^2\alpha^2\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right) \\ +(1-\mu)^2 2\alpha(1-\alpha)\left(\frac{1}{2}KR_L-\frac{1}{2}\delta KR_L\right)+(1-\mu)^2(1-\alpha)^2\left(\frac{2}{3}KR_L-\frac{1}{3}\delta KR_L\right)\end{array}\right] \\
= & \frac{1}{3}KR_L\left(1-2\delta+\beta\left((1-\alpha)(1-\mu)+\delta(1-\alpha(1-\mu))\right)\right)
\end{aligned}
$$

Further substituting in α, the difference is positive[42]

$$\frac{1}{3}\frac{K(g-\delta)(3-\beta\mu)}{(1+g)}>0$$

Therefore the conjectured BPNE is indeed an equilibrium.

Region III Equilibrium. Given the conjectured BPNE, only both type-B managers and type-C managers fail to deliver in period 1. A high project outcome in period 1 reveals that the manager is a type-A manager. Therefore, the posterior beliefs after observing the statements and project results in period 1 are

$$
\begin{aligned}
P(g \mid h, R_H) &= 1 \\
P(g \mid h, R_L) &= \frac{\beta(1-\mu)}{\beta(1-\mu)+(1-\beta)} \\
P(g \mid l, R_H) &= 1 \\
P(g \mid l, R_L) &= 1 \text{ (out of equilibrium)}
\end{aligned}
$$

Since a manager stating l and delivering R_L in period 1 is an out of equilibrium outcome, I need to fix the posterior belief. To make the conjectured equilibrium Cho-Kreps proof, I fix the posterior belief following such an outcome to be a good manager with probability one. These

[42]This should come as no surprise. By construction, a type-B manager has a more valuable reputation to protect than a type-C manager. Therefore whenever a type-B manager is just indifferent between protecting his reputation and exaggerating, a type-C manager will choose to exaggerate.

posterior beliefs determine eligibility for period 2. Lemma 1 summarizes the optimal period-2 strategy. A type-A manager has nothing to benefit from announcing l. He has a good project and announcing h dominates announcing l.

Payoff to a type-B manager from announcing h in period 1 is

$$(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right)\right]$$
$$+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L+0\right)+2\mu(1-\mu)\left(\frac{1}{3}KR_L+0\right)+(1-\mu)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_E\right)\right]$$

Payoff to a type-B manager from announcing l in period 1 is

$$(1-\beta)^2\left[0+\delta KR_E\right]+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)(0+\delta KR_E)\right]$$
$$+\beta^2\left[\mu^2\left(0+\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\left(0+\frac{1}{2}\delta KR_E\right)+(1-\mu)^2(0+\delta KR_E)\right]$$

The difference is

$$(1-\beta)^2\left[\frac{1}{3}KR_L-\frac{2}{3}\delta KR_E\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_E\right)+(1-\mu)\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_E\right)\right]$$
$$+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L-\frac{1}{3}\delta KR_E\right)+2\mu(1-\mu)\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_E\right)+(1-\mu)^2\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_E\right)\right]$$
$$=\frac{1}{3}KR_L(1-2g+\beta g\mu)$$

In region III where $\beta > \frac{2g-1}{g\mu}$, the difference is positive and announcing h dominates announcing l for a type-B manager.

Payoff to a type-C manager from announcing h in period 1 is

$$(1-\beta)^2\left[\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L+0\right)+(1-\mu)\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)\right]$$
$$+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L+0\right)++2\mu(1-\mu)\left(\frac{1}{3}KR_L+0\right)+(1-\mu)^2\left(\frac{1}{3}KR_L+\frac{1}{3}\delta KR_L\right)\right]$$

Payoff to a type-C manager from announcing l in period 1 is

$$(1-\beta)^2\left[0+\delta KR_L\right]+2\beta(1-\beta)\left[\mu\left(0+\frac{1}{2}\delta KR_L\right)+(1-\mu)\left(0+\delta KR_L\right)\right]$$
$$+\beta^2\left[\mu^2\left(0+\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\left(0+\frac{1}{2}\delta KR_L\right)+(1-\mu)^2\left(0+\delta KR_L\right)\right]$$

The difference is

$$\begin{aligned}&(1-\beta)^2\left[\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right]+2\beta(1-\beta)\left[\mu\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_L\right)+(1-\mu)\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right)\right]\\&+\beta^2\left[\mu^2\left(\frac{1}{3}KR_L-\frac{1}{3}\delta KR_L\right)+2\mu(1-\mu)\left(\frac{1}{3}KR_L-\frac{1}{2}\delta KR_L\right)+(1-\mu)^2\left(\frac{1}{3}KR_L-\frac{2}{3}\delta KR_L\right)\right]\\=\;&\frac{1}{3}KR_L\left(1-2\delta+\beta\delta\mu\right)\end{aligned}$$

In region III where $\beta > \frac{2g-1}{g\mu}$, the difference is positive and announcing h dominates announcing l for a type-C manager. Therefore the conjectured BPNE is indeed an equilibrium.

1.7.3 Allocative Efficiency

Full expressions, which are omitted in the text, are provided here. Allocative efficiency of two stand-alone firms is given by

$$\begin{aligned}A_{2S} &= (1-\beta)^2\left[\frac{1}{2}KR_L+\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L+\frac{1}{2}\delta KR_L\right]\\&\quad+2\beta(1-\beta)\left[\begin{array}{c}\mu\left(\frac{1}{2}KR_L+\frac{1}{2}KR_H+\frac{1}{2}\delta KR_L+\frac{1}{2}\delta KR_E\right)\\+(1-\mu)\left(\frac{1}{2}KR_L+\frac{1}{2}KR_L+\frac{1}{2}\delta KR_L+\frac{1}{2}\delta KR_E\right)\end{array}\right]\\&\quad+\beta^2\left[\begin{array}{c}\mu^2\left(\frac{1}{2}KR_H+\frac{1}{2}KR_H+\frac{1}{2}\delta KR_E+\frac{1}{2}\delta KR_E\right)\\+2\mu(1-\mu)\left(\frac{1}{2}KR_H+\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E+\frac{1}{2}\delta KR_E\right)\\+(1-\mu)^2\left(\frac{1}{2}KR_L+\frac{1}{2}KR_L+\frac{1}{2}\delta KR_E+\frac{1}{2}\delta KR_E\right)\end{array}\right]\\&= K(1+\delta)\left(R_L+\beta\mu\left(R_H-R_L\right)\right)\end{aligned}$$

Allocative efficiency under first-best integration is given by

$$\begin{aligned}
A_{2I}^{FB} &= (1-\beta)^2\left[KR_L+\delta KR_L\right] \\
&\quad +2\beta(1-\beta)\left[\begin{array}{c}\mu\left(KR_H+\delta KR_E\right)\\ +(1-\mu)\left(KR_L+\delta KR_E\right)\end{array}\right] \\
&\quad +\beta^2\left[\begin{array}{c}\mu^2\left(KR_H+\delta K\left[\mu(2-\mu)R_H+(1-\mu)^2R_L\right]\right)\\ +2\mu(1-\mu)\left(KR_H+\delta K\left[\mu(2-\mu)R_H+(1-\mu)^2R_L\right]\right)\\ +(1-\mu)^2\left(KR_L+\delta K\left[\mu(2-\mu)R_H+(1-\mu)^2R_L\right]\right)\end{array}\right]
\end{aligned}$$

The difference between A_{2I}^{FB} and A_{2S} is given by

$$\begin{aligned}
A_{2I}^{FB}-A_{2S} &= 2\beta(1-\beta)\left[\begin{array}{c}\mu\left(\frac{1}{2}K(R_H-R_L)+\frac{1}{2}\delta\mu K(R_H-R_L)\right)\\ +(1-\mu)\left(\frac{1}{2}\delta\mu K(R_H-R_L)\right)\end{array}\right] \\
&\quad +\beta^2\left[\begin{array}{c}\mu^2\left(\delta\mu(1-\mu)K(R_H-R_L)\right)\\ +2\mu(1-\mu)\left(\frac{1}{2}K(R_H-R_L)+\delta\mu(1-\mu)K(R_H-R_L)\right)\\ +(1-\mu)^2\left(\delta\mu(1-\mu)K(R_H-R_L)\right)\end{array}\right] \\
&= (1+\delta)\left[\beta(1-\beta)\mu+\beta^2\mu(1-\mu)\right]K(R_H-R_L)>0
\end{aligned}$$

Allocative efficiency under second-best integration is given by

$$\begin{aligned}
A_{2I}^{SB} &= (1-\beta)^2\left[KR_L+\delta KR_L\right] \\
&\quad +2\beta(1-\beta)\left[\mu\left(\frac{1}{2}KR_L+\frac{1}{2}KR_H+\delta KE[R]\right)+(1-\mu)\left(KR_L+\delta KE[R]\right)\right] \\
&\quad +\beta^2\left[\mu^2\left(KR_H+\delta KE[R]\right)+2\mu(1-\mu)\left(KR_H+\delta KE[R]\right)+(1-\mu)^2\left(KR_L+\delta KE[R]\right)\right]
\end{aligned}$$

The difference between A_{2I}^{SB} and A_{2I}^{FB} is given by

$$\begin{aligned}
A_{2I}^{SB}-A_{2I}^{FB} &= -2\beta(1-\beta)\left[\mu\left(\frac{1}{2}K(R_H-R_L)\right)\right]-\beta^2\left[\delta\mu(1-\mu)K(R_H-R_L)\right] \\
&= -\left[\beta(1-\beta)\mu+\delta\beta^2\mu(1-\mu)\right]K(R_H-R_L)<0
\end{aligned}$$

The difference between A_{2I}^{SB} and A_{2S} is given by

$$\begin{aligned} A_{2I}^{SB} - A_{2S} &= 2\beta(1-\beta)\left[\mu\left(\frac{1}{2}\delta K(R_E - R_L)\right) + (1-\mu)\left(\frac{1}{2}\delta K(R_E - R_L)\right)\right] \\ &\quad +\beta^2\left[2\mu(1-\mu)\left(\frac{1}{2}K(R_H - R_L)\right)\right] \\ &= \left[\beta^2\mu(1-\mu) + \delta\beta(1-\beta)\mu\right]K(R_H - R_L) > 0 \end{aligned}$$

Allocative efficiency for three managers in the mixing region (region II) is given by

$$\begin{aligned} A_{3I}^{SB} &= (1-\beta)^3\left[KR_L + \delta KR_L\right] \\ &\quad +3\beta(1-\beta)^2\left[\begin{array}{c} \mu\left[\frac{2}{3}KR_L + \frac{1}{3}KR_H + \delta KR_E\right] \\ +(1-\mu)\left[\begin{array}{c} \alpha\left(KR_L + \delta\left(\frac{2}{3}KR_L + \frac{1}{3}KR_E\right)\right) \\ +(1-\alpha)(KR_L + \delta KR_E) \end{array}\right] \end{array}\right] \\ &\quad +3\beta^2(1-\beta)\left[\begin{array}{c} \mu^2\left[\frac{1}{3}KR_L + \frac{2}{3}KR_H + \delta KR_E\right] \\ +2\mu(1-\mu)\left[\begin{array}{c} \alpha\left(\frac{2}{3}KR_L + \frac{1}{3}KR_H + \delta KR_E\right) \\ +(1-\alpha)\left(\frac{1}{2}KR_L + \frac{1}{2}KR_H + \delta KR_E\right) \end{array}\right] \\ +(1-\mu)^2\left[\begin{array}{c} \alpha^2\left(KR_L + \delta\left(\frac{1}{3}KR_L + \frac{2}{3}KR_E\right)\right) \\ +2\alpha(1-\alpha)(KR_L + \delta KR_E) \\ +(1-\alpha)^2(KR_L + \delta KR_E) \end{array}\right] \end{array}\right] \\ &\quad +\beta^3\left[\begin{array}{c} \mu^3\left[KR_H + \delta KR_E\right] \\ +3\mu^2(1-\mu)\left[\begin{array}{c} \alpha\left(\frac{1}{3}KR_L + \frac{2}{3}KR_H + \delta KR_E\right) \\ +(1-\alpha)(KR_H + \delta KR_E) \end{array}\right] \\ +3\mu(1-\mu)^2\left[\begin{array}{c} \alpha^2\left(\frac{2}{3}KR_L + \frac{1}{3}KR_H + \delta KR_E\right) \\ +2\alpha(1-\alpha)\left(\frac{1}{2}KR_L + \frac{1}{2}KR_H + \delta KR_E\right) \\ +(1-\alpha)^2(KR_H + \delta KR_E) \end{array}\right] \\ +(1-\mu)^3\left[KR_L + \delta KR_E\right] \end{array}\right] \end{aligned}$$

Allocative efficiency under the rigid scheme is given by

$$\begin{aligned}
A_{2I}^{RS} &= (1-\beta)^2 \left[\nu (KR_L) + (1-\nu)(KR_L)\right] \\
&\quad +2\beta(1-\beta)\left[\begin{array}{c} \mu\left(\nu\left[KR_H\right] + (1-\nu)\left[\frac{1}{2}KR_H + \frac{1}{2}KR_L\right]\right) \\ +(1-\mu)\left(\nu\left[KR_L\right] + (1-\nu)\left[KR_L\right]\right) \end{array}\right] \\
&\quad +\beta^2\left[\begin{array}{c} \mu^2\left(\nu\left[KR_H\right] + (1-\nu)\left[KR_H\right]\right) \\ +2\mu(1-\mu)\left(\nu\left[KR_H\right] + (1-\nu)\left[\frac{1}{2}KR_H + \frac{1}{2}KR_L\right]\right) \\ +(1-\mu)^2\left(\nu\left[KR_L\right] + (1-\nu)\left[KR_L\right]\right) \end{array}\right] \\
&\quad +\delta\left[\begin{array}{c} (1-\beta)^2 (KR_L) \\ +2\beta(1-\beta)\left(\mu\left[KR_E\right] + (1-\mu)\left[\frac{1}{2}KR_E + \frac{1}{2}KR_L\right]\right) \\ ++\beta^2\left(\mu^2\left[KR_E\right] + 2\mu(1-\mu)\left[KR_E\right] + (1-\mu)^2\left[KR_E\right]\right) \end{array}\right]
\end{aligned}$$

1.7.4 n-Manager Competition

I analyze the nature of equilibria where type-B managers choose to exaggerate with probability α. As argued in the previous section, whenever type-B managers are just indifferent between exaggerating and not exaggerating, type-C managers will choose to exaggerate. Also as argued in the previous sections, type-A managers have nothing to benefit from announcing l so they always announce h.

In what follows, subscripts i, j, and k denote

$$\begin{aligned}
i &= \text{number of type-A or type-B agents out of } n-1 \text{ competing agents} \\
j &= \text{number of type-B agents out of } i \\
k &= \text{number of type-B agents announcing } h \text{ out of } j
\end{aligned}$$

Payoff to a type-B manager from announcing l in period 1 is

$$\sum_{i=0}^{n-1}\binom{n-1}{i}\beta^i(1-\beta)^{n-1-i}\sum_{j=0}^{i}\binom{i}{j}(1-\mu)^j\mu^{i-j}\sum_{k=0}^{j}\binom{j}{k}\alpha^k(1-\alpha)^{j-k}\left[u(i,j,k,l)\right]$$

where

$$\begin{aligned} u(i,j,k,l) &= \frac{1}{n}KR_L + \frac{1}{i-k+1}\,\delta KR_E \quad \text{if } i=n-1,\ j=n-1, \text{ and } k=0 \\ &= 0+\frac{1}{i-k+1}\delta KR_E \quad \text{otherwise} \end{aligned}$$

Payoff to a type-B manager from announcing h in period 1 is

$$\sum_{i=0}^{n-1}\binom{n-1}{i}\beta^i(1-\beta)^{n-1-i}\sum_{j=0}^{i}\binom{i}{j}(1-\mu)^j\mu^{i-j}\sum_{k=0}^{j}\binom{j}{k}\alpha^k(1-\alpha)^{j-k}\left[u(i,j,k,h)\right]$$

where

$$\begin{aligned} u(i,j,k,h) &= \frac{1}{n-j+k}KR_L + \frac{1}{n}\delta KR_E \quad \text{if } i=j=k \\ &= \frac{1}{n-j+k}KR_L + 0 \quad \text{otherwise} \end{aligned}$$

Without loss of generality, normalize $u(i,j,k,l)$ and $u(i,j,k,h)$ by KR_L. Then

$$\begin{aligned} u(i,j,k,l) &= \frac{1}{n}+\frac{1}{i-k+1}g \quad \text{if } i=n-1,\ j=n-1, \text{ and } k=0 \\ &= 0+\frac{1}{i-k+1}g \quad \text{otherwise} \end{aligned}$$

and

$$\begin{aligned} u(i,j,k,h) &= \frac{1}{n-j+k}+\frac{1}{n}g \quad \text{if } i=j=k \\ &= \frac{1}{n-j+k}+0 \quad \text{otherwise} \end{aligned}$$

To find α, set the two payoffs equal to each other. The result is a polynomial of order $n-2$.

$$\sum_{i=0}^{n-2}a_i^n\alpha^i = 0$$

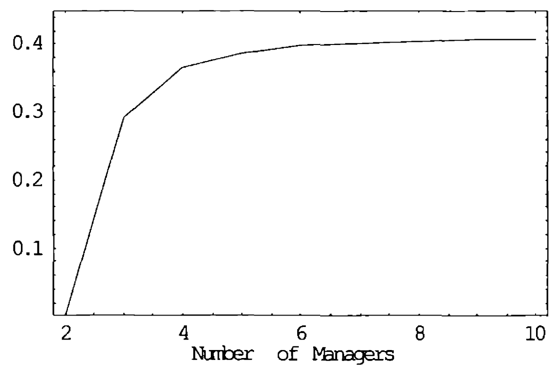
Polynomial coefficients are given by

$$a_i^n = \beta^i (1-\mu)^i \left(\sum_{j=0}^{n-2-i} \binom{i+j}{j} \beta^j \left((-1)^j \binom{n-1}{i+1+j} g - (-1)^i (1-\mu)^j \right) \right)$$

The polynomial has $n-2$ roots, some of them real, some of them imaginary. Numerical analysis shows that the real roots increase as n increases.

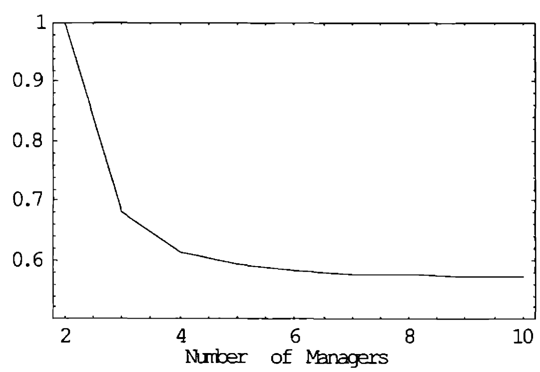
$$\alpha'(n) > 0$$

The following graph illustrates the monotonicity of $\alpha(n)$ for $\beta = .95$, $\mu = .05$, $g = 1.25$.



Mixing Probability α

In addition, the next graph shows how the space of parameters for β, where the mixing equilibrium arises, expands with n.



Mixing Parameter Space for β

1.7.5 Incentive Contracts

In this section, I formalize the idea that incentive contracts necessary to achieve truthful reporting can be very expensive, even with only two managers. I do this by first conjecturing an equilibrium where every manager reports his true project type in both periods and then by specifying the least costly incentive contract that eliminates any profitable deviation from the conjectured equilibrium.

Let $\langle w_t \rangle$ be the incentive contract that specifies a payment at time t contingent on a manager's report and subsequent project outcome. As commonly assumed, limited liability requires each element of $\langle w_t \rangle$ to be positive.

Since in my model the only profitable deviation for a manager is to state that he has a good project when in fact he has a bad one, the least costly incentive contract reduces to a simple incentive contract in which a manager receives a strictly positive payment for reporting a bad project when he has a bad project and nothing otherwise. Let w_t be this payment at time t.

Solving the model backwards, the payment necessary in period 2 to induce truthful reporting by a manager, who has a bad project and is facing another manager with a posterior probability p of being good, is

$$\begin{aligned} w_2 &= (1-p)\left[KR_L - \frac{1}{2}KR_L\right] + p\left[\mu\left(\frac{1}{2}KR_L - 0\right) + (1-\mu)\left(KR_L - \frac{1}{2}KR_L\right)\right] \\ &= \frac{1}{2}KR_L \end{aligned}$$

In period 1, the payment necessary to induce truthful reporting by a type-C manager is

$$\begin{aligned} w_1 &= (1-\beta)\left[KR_L - \frac{1}{2}KR_L - \frac{1}{2}\delta KR_L - \delta w_2\right] \\ &\quad + \beta\left[\begin{array}{c} \mu\left(\frac{1}{2}KR_L - 0 - \mu(0) - (1-\mu)\left(\frac{1}{2}\delta KR_L\right) - \delta w_2\right) \\ +(1-\mu)\left(KR_L - \frac{1}{2}KR_L - \mu(0) - (1-\mu)\left(\frac{1}{2}\delta KR_L\right) - \delta w_2\right) \end{array}\right] \\ &= \frac{1}{2}KR_L\left[1 - \delta\left(2 - \beta\mu\right)\right] \end{aligned}$$

Note that the payment necessary to induce truthful reporting by a type-B manager in period 1 is strictly lower than w_1 since, in contrast to a type-C manager, a type-B manager may have a better project idea in period 2. Also note that the limited liability constraint binds when $\delta > \frac{1}{2-\beta\mu}$. In that case, w_1 equals zero.

The expected cost of the incentive contract is

$$\begin{aligned}
& (1-\beta)^2 2[w_1+\delta w_2] + 2\beta(1-\beta)\begin{bmatrix} \mu(w_1+\delta w_2[1+(1-\mu)]) \\ +(1-\mu)(2w_1+\delta w_2[1+(1-\mu)]) \end{bmatrix} \\
& +\beta^2 \begin{bmatrix} \mu^2\left(0+\delta\left[\mu^2(0)+2\mu(1-\mu)(w_2)+(1-\mu)^2(2w_2)\right]\right) \\ +2\mu(1-\mu)\left(w_1+\delta\left[\mu^2(0)+2\mu(1-\mu)(w_2)+(1-\mu)^2(2w_2)\right]\right) \\ +(1-\mu)^2\left(2w_1+\delta\left[\mu^2(0)+2\mu(1-\mu)(w_2)+(1-\mu)^2(2w_2)\right]\right) \end{bmatrix} \\
= \; & 2(1-\beta\mu)[w_1+\delta w_2]
\end{aligned}$$

Substituting in w_1 and w_2 yields

$$\begin{aligned}
& 2(1-\beta\mu)(w_1+\delta w_2) \\
= \; & 2(1-\beta\mu)\left[\frac{1}{2}KR_L(1-\delta(2-\beta\mu))+\delta\left(\frac{1}{2}KR_L\right)\right] \\
= \; & K(1-\beta\mu)[1-\delta(1-\beta\mu)]
\end{aligned}$$

For δ, β and μ low enough, the expected cost approaches K, the firm's capital budget.■

Chapter 2

Integration and Allocation of Resources: Empirical Evidence

2.1 Introduction

In this chapter, I test some of the empirical predictions of the theory developed in Chapter 1 regarding the use of organizational processes to solve agency problems arising from specialized knowledge in the capital budgeting process. The predictions mostly follow from the idea that, absent perfect information about the right course of action at higher levels of management, firms use organizational processes and structure as design tools to indirectly improve managerial behavior and reduce agency costs.

This research agenda certainly would not be interesting if information were perfect and contracts were complete (and costless). But as a vast literature on organizations indicates organizations are riddled with high levels of informational asymmetry.[1] Managers who are much closer to markets certainly seem to have more information and expertise than managers who are at higher levels. Such specialized knowledge has two major consequences. First, managers who collect and provide critical information for certain decisions have an incentive to misrepresent the facts if and when the very same decisions affect their interests.[2] Second, the resulting decisions are usually suboptimal and consequently destroy significant corporate value.

[1] Bower (1970), Chandler (1962), Crozier (1967).

[2] Jensen (2001) provides evidence of widespread misrepresentation in the budgeting process.

The analysis presented in Chapter 1 shows how organizational processes and structure can indirectly minimize costs arising from such self-interested behavior in the context of capital budgeting. To recap, I consider the problem of an uninformed corporate headquarters that relies on communication from specialist managers to allocate resources. Since managers are assumed to prefer a larger capital budget over a smaller capital budget, they make exaggerated statements to increase funding for their projects. That is, when faced with internal competition for corporate resources, they exaggerate the quality of their projects and as a result adversely affect allocative efficiency. Of course, corporate staff can always spend more effort and be more vigilant in detecting exaggeration to deter managers from misrepresenting in the first place. But specialized knowledge typically makes detection difficult and expensive. Instead, I argue that a corporate headquarters can improve managerial behavior in a less direct way by altering the capital budgeting game. More relevant to the aim of this chapter, I argue that many organizational processes and structures that we observe in practice can be seen as changing the rules of the game to limit self-interested managerial behavior and make managers more forthcoming in their communication.

Building on this argument, I consider a number of organizational remedies. First, I show that a firm can improve the quality of internal communication and allocative efficiency by making some portion of its capital budget non-contingent. By allocating a portion of the capital budget before managers get a chance to make their statements, a firm can reduce the adverse effects of internal competition. Second, I show that the chance of job rotation to a possibly more profitable set of assets gives hope to those managers, who find themselves currently assigned to bad assets, and makes them more forthcoming. Third, I show how centralization can improve behavior by getting managers to engage in team production that is successful only if communication is accurate. When a manager in a centralized firm thinks about making an exaggerated statement, he takes into account not only the reputational consequences but also the disruptive effect that his misleading statements may have on team production. These ideas provide several empirical hypotheses that can be tested using widely available data. This chapter tests some of these hypotheses.

There is a large empirical literature that explores the effect of integration on the allocation of resources. Most of the work so far has focused on investigating the nature of the effect in different settings; see Gertner, Powers and Scharfstein (1999), Khanna and Tice (2001), Lamont (1997), Maksimovic and Phillips (2001), Ozbas (2001b), Scharfstein (1998), Schoar (2001), Shin and Stulz (1998). A relatively new literature is now starting to link these observed effects to specialized knowledge. Berger, Miller, Petersen, Rajan and Stein (2001) find that large banks are less inclined than small banks to make relationship loans that are based on soft information. This chapter can be seen as providing further evidence regarding the difficulty of transmitting specialized knowledge in large organizations.

The chapter proceeds as follows. In Section 2, I explain the hypotheses in some detail. Section 3 describes the data. In Section 4, I outline the empirical methodology and present the main results. I provide concluding remarks in Section 5.

2.2 Hypotheses

I test the following empirical predictions of the theory developed in Chapter 1.[3]

Hypothesis 1 *An integrated firm should have a more rigid capital budget than a non-integrated firm.*

Hypothesis 2 *A diversified integrated firm should have a more rigid capital budget than a focused integrated firm.*

Hypothesis 3 *A smaller segment of an integrated firm should have a more rigid divisional capital budget than a larger segment.*

Hypothesis 1 follows directly from Proposition 3 of the previous chapter. By restraining internal competition, an integrated firm can improve the quality of communication from managers and achieve higher allocative efficiency. The idea has clear parallels to the influence cost perspective of Milgrom and Roberts (1988) which makes the argument that an organization may optimally constrain potential communication channels and use less information because this reduces the managers' temptation to engage in costly and wasteful activities to influence decisions. Similarly, an integrated firm may optimally use less information because this reduces the managers' temptation to make exaggerated statements.

Hypothesis 2 is based on the informal observation that organizational remedies that induce

[3] I repeat discussion of these hypotheses from Chapter 1 for completeness.

better managerial behavior are more difficult to put into practice at a diversified integrated firm that is made up of unrelated businesses than a focused integrated firm that is made up of related businesses. The difficulty in implementing organizational remedies such as job rotation and centralization may simply be an issue of feasibility than anything else. It is hard to imagine what can be centralized in a firm made up of unrelated businesses. Also it is hard to imagine that a manager with expertise in one particular business can be rotated easily to a completely unrelated one. Unable to use these organizational remedies effectively, one would expect a diversified integrated firm to use rigidity more so than a focused integrated firm. From an empirical perspective, Hypothesis 2 provides a more stringent test than Hypothesis 1 by using an observed variation in the composition of integrated firms.

Hypothesis 3 provides an interesting test of the importance of specialized knowledge on which Chapter 1 builds. It is important to note that the hypothesis is more of a conjecture and not a formal prediction. Nevertheless, the underlying assumption is fairly simple. We, human beings, have limited cerebral and sensory capabilities.[4] This imperfection means that our capacity to acquire specialized knowledge is limited. Faced with such a constraint, it would be only optimal to ration that capacity, and use it on areas and topics where the returns are the highest. In the case of a corporate headquarters, that area and topic would be the larger segments of the firm to which a significant portion of corporate resources is committed. And as a result, the degree of informational asymmetry would be relatively less for the larger segments than for the smaller segments. Of course, there are other reasons that would make the degree of informational asymmetry higher for the smaller segments. For example, the smaller segments may simply be newer to the firm. Or perhaps they are located further away from corporate headquarters.[5] In any case, the underlying reason for having a rigid divisional capital budget would be the same, namely the lack of specialized knowledge about the smaller segments at higher levels of management.

To test these hypotheses, I rely on publicly available accounting information reported in periodic financial statements filed with the Securities and Exchange Commission – FASB Statement

[4] Simon (1955), Jensen and Meckling (1992).

[5] In fact it would very interesting to test the effect of distance if the data were available. In addition, it would be interesting to investigate how distance as a factor has changed over time. Petersen and Rajan (2000) investigate a similar question and find that the distance between small firms and their lenders have increased with advances in computing and communications.

No.14, Financial Reporting for Segments of a Business Enterprise, requires a firm to report basic segment-level accounting data such as sales, assets, operating profits, depreciation and capital spending for every distinct business that constitutes more than 10 percent of total sales. These segments typically have a senior top manager who translates very nicely into the specialist manager in Chapter 1. These segments also help determine whether a firm is integrated or not. If a firm reports only one segment, I consider it to be a non-integrated firm. If instead a firm reports more than one segment, I consider it to be an integrated firm. Admittedly, this simple approach has some drawbacks. It seems that firms have quite a bit of discretion despite the FASB ruling in choosing what to report as separate segments. Especially, it seems that some integrated firms choose not to report separate segments for a variety of reasons, e.g. more competitive secrecy, less public scrutiny, etc.[6] Of course, one would ideally like to have more detailed data to determine whether a firm is integrated or not. Also more extensive data on capital budgeting procedures, organizational structure, personnel policies and so forth would be more useful but such data are not in the public domain. With this shortcoming in mind, there are still interesting data to be explored.

2.3 Data

All of my data come from the segment files of the Compustat database. These files provide basic segment-level accounting data as well as a pair of Standard Industrial Classification (SIC) codes for each segment. To avoid typographical errors, I cross-validate the observations in the segment files with the observations in the annual files and drop observations for which the sum of reported segment assets are not within 25 percent of total assets in the annual files. In addition, I apply a battery of standard filters which are summarized in Table I.

To determine whether an integrated (multi-segment) firm is focused or diversified, I follow the grouping methodology developed in Ozbas and Scharfstein (2000). This methodology improves on the two-digit SIC code approach used in much of the empirical finance literature to relate segments.[7] The methodology first identifies significant horizontal and vertical linkages in

[6] See Villalonga (2001), Lichtenberg (1993). Any misclassification arising from such corporate discretion should make it harder to find the effects predicted by Hypotheses 1-3. To the extent that some integrated firms are mixed into the non-integrated subsample, one would expect the estimated coefficients to get closer, not apart.

[7] It is well known that the two-digit approach is somewhat limited when it comes to identifying vertical

the U.S. economy based on the Make and Uses Tables of the Input-Output Benchmark Survey conducted by the Bureau of Economic Analysis every five years. Segments that operate in related industries are then grouped together using a combinatory algorithm. An integrated firm is classified as focused if all of its segments can be grouped together using the horizontal and vertical linkages. Otherwise it is classified as diversified. Further details about the methodology are available in Ozbas and Scharfstein (2000).

2.4 Empirical Methodology

The main objective in all of the regressions is to find out whether a certain subsample of segments have more rigid capital budgets than another subsample as suggested by Hypotheses 1-3. For this purpose, I use primarily two variables, namely industry capital spending and segment depreciation. In my regressions, industry capital spending proxies for investment opportunities in an industry and one naturally would expect a non-rigid capital budget to have high sensitivity to it. While the use of industry capital spending as a proxy for investment opportunities in an industry represents a departure from the standard Q-regressions in the empirical corporate finance literature, industry capital spending is far less noisy and has much higher explanatory power than industry measures based on firm-Q. Another advantage of this approach is that it uses data from both integrated and non-integrated firms, and addresses a common criticism made against the Q-approach which uses data from only non-integrated firms.[8] Segment depreciation meanwhile proxies for a segment's tendency to make investments towards maintaining a given set of business as opposed to a tendency to make investments when and if attractive. One would expect a rigid capital budget to have exactly this feature: fixed capital allocations that come regardless of investment opportunities and go towards maintaining the business. In addition, segment depreciation can be seen as representing a credible and hard piece of information that helps to reduce the degree of informational asymmetry that drives the

relationships. This is because the SIC numbering system appears to have a horizontal focus. For example, drilling oil wells and other exploration services have the same two-digit SIC code, but the next vertical stage of petroleum refining does not.

[8] The problem with the Q-approach is that we do not observe market prices for different parts of an integrated firm and therefore rely on non-integrated (single-segment) firms to construct industry-Q. With the industry capital spending approach, there is no such constraint because we observe segment-level capital spending for both sets of firms.

model in Chapter 1.

I estimate variants of the following basic regression:

$$cxs_{i(j)t} = a_i + b_t + c * deps_{it} + d * mcxs_{jt} + e * cfs_{it} \tag{2.1}$$

The dependent variable $cxs_{i(j)t}$ is the sales-normalized capital spending of segment i (operating in industry j) in year t. a_i and b_t capture segment and time fixed effects, respectively. Regression results confirm the importance of including these fixed effects to capture the unmodeled heterogeneity among segments. Other explanatory variables are $deps_{it}$, the sales-normalized depreciation of segment i in year t, and $mcxs_{jt}$, the median sales-normalized capital spending in industry j in year t. cfs_{it}, sales-normalized cash flow, is included purely as a control variable since it is a well-established determinant of capital spending, although regression results show that the proper inclusion of segment fixed effects dramatically reduces the estimated coefficient. Using segment assets instead of segment sales to normalize the equation variables do not result in any qualitative difference.

2.4.1 Integration and Rigidity

The results in Table II are in line with Hypothesis 1. Non-integrated firms are more responsive to investment opportunities and have less rigid capital budgets than integrated firms. In all of the specifications, the coefficient on $mcxs_{jt}$ for single-segment firms is higher than the coefficient on $mcxs_{jt}$ for multi-segment firms. In addition, the coefficient on $deps_{it}$ for single-segment firms is lower than the coefficient on $deps_{it}$ for multi-segment firms.

Interestingly, there is evidence that the rigidity effect is magnified for larger segments. Odd-numbered specifications in Table II exclude segments with less than \$20 million in sales whereas even-numbered specifications exclude segments with less than \$50 million. The coefficient on $mcxs_{jt}$ ($deps_{it}$) in even-numbered specifications is generally lower (higher) than the coefficient on $mcxs_{jt}$ ($deps_{it}$) in odd-numbered specifications. Interpreting the model more broadly would generate a similar prediction. As a firm or a segment gets bigger, one would expect the degree of informational asymmetry to get larger and make rigid capital budgets more efficient.

The inclusion of segment fixed effects in specifications (3), (4), (7) and (8) results in dramatic changes in the estimated coefficients, suggesting that there is a significant amount of unmodeled heterogeneity among segments. One important point to note is the large decline on the coefficient for cfs_{it} which has been and continues to be the subject of much debate started by Fazzari, Hubbard and Petersen (1987). Despite the quantitative changes, however, the qualitative difference between the two subsamples remains the same.

As a final test, I pool the two subsamples and run the following regression to find out whether the quantitative differences are statistically significant:

$$\begin{aligned} cxs_{i(j)t} &= a_i + b_t + \gamma * integrated_{it} \\ &\quad + c_{non-integrated} * deps_{it} + c_{integrated} * deps_{it} * integrated_{it} \\ &\quad + d_{non-integrated} * mcxs_{jt} + d_{integrated} * mcxs_{jt} * integrated_{it} \\ &\quad + e_{non-integrated} * cfs_{it} + e_{integrated} * cfs_{it} * integrated_{it} \end{aligned} \tag{2.2}$$

where $integrated_{it}$ is a dummy variable equal to one if segment i in year t is part of an integrated firm. The results of this pooled regression are reported in Table III. Integrated firms indeed have more rigid capital budgets than non-integrated firms as evidenced by statistically significant coefficients $c_{integrated}$ (positive) and $d_{integrated}$ (negative).[9]

2.4.2 Diversification and Rigidity

To investigate the effect of diversification on segment-level investment responsiveness, I rerun the same basic regression in (2.1) separately for focused and diversified integrated firms. The two subsamples are formed using the grouping algorithm mentioned in the data subsection. An integrated firm is classified as focused if the combinatory algorithm can group together all of its segments using the horizontal and vertical linkages inferred from the Make and Uses Tables of the Input-Output Benchmark Survey. Otherwise it is classified as diversified.

The results reported in Table IV confirm the basic insight of Hypothesis 2. Focused integrated firms are more responsive to investment opportunities and have less rigid capital budgets

[9] In regressions not reported here, I form industry-matched subsamples of non-integrated and integrated firms and find similar results. This robustness check confirms that the results are not being driven by heterogeneity in industry specific slopes. Results are available from the author upon request.

than diversified integrated firms. In all of the specifications, the coefficient on $mcxs_{jt}$ for focused multi-segment firms is higher than the coefficient on $mcxs_{jt}$ for diversified multi-segment firms. In addition, the coefficient on $deps_{it}$ for focused multi-segment firms is lower than the coefficient on $deps_{it}$ for diversified multi-segment firms.

The effect of segment size on rigidity is less obvious this time. Again, odd-numbered specifications exclude segments with less than $20 million in sales whereas even-numbered specifications exclude segments with less than $50 million. The coefficient on $deps_{it}$ in odd-numbered specifications is generally lower than the coefficient on $deps_{it}$ in the even-numbered specifications. But the effect on the coefficient for $mcxs_{jt}$ is mixed. In fact, the coefficient on $mcxs_{jt}$ gets larger for focused multi-segment firms when the threshold is increased from column (3) to column (4). Once again, the inclusion of segment fixed effects in specifications (3), (4), (7) and (8) results in quantitatively striking changes. It is clear that any regression that does not account for the unmodeled heterogeneity among segments is bound to produce biased coefficients.[10]

As a final test, I pool the two subsamples and run the following regression to determine whether the quantitative differences between focused and diversified firms are statistically significant:

$$\begin{aligned} cxs_{i(j)t} = {} & a_i + b_t + \gamma * diversified_{it} \\ & + c_{focused} * deps_{it} + c_{diversified} * deps_{it} * diversified_{it} \\ & + d_{focused} * mcxs_{jt} + d_{diversified} * mcxs_{jt} * diversified_{it} \\ & + e_{focused} * cfs_{it} + e_{diversified} * cfs_{it} * diversified_{it} \end{aligned} \tag{2.3}$$

where $diversified_{it}$ is a dummy variable equal to one if segment i in year t is part of a diversified integrated firm. The results, which are reported in Table V, show that diversified integrated firms indeed have more rigid capital budgets than focused integrated firms as evidenced by statistically significant coefficients $c_{diversified}$ (positive) and $d_{focused}$ (negative). It is interesting to note that the coefficients are magnified for specifications (2) and (4) which have larger segments than specifications (1) and (3).

[10]Most, if not all, of the unmodeled heterogeneity among segments seems to be at the industry level. This is not surprising since one would have expected it to be technology-based.

2.4.3 Relative Size and Rigidity

In Table VI, I run regressions of the form

$$\begin{aligned} cxs_{i(j)t} &= a_i + b_t + rsize_{it} \\ &+c_0 * deps_{it} + c_1 * deps_{it} * rsize_{it} \\ &+d_0 * mcxs_{jt} + d_1 * mcxs_{jt} * rsize_{it} \\ &+e_0 * cfs_{it} + e_1 * cfs_{it} * rsize_{it} \end{aligned} \tag{2.4}$$

where $rsize_{it}$ is the relative size of the segment, defined as segment assets divided by total assets and takes on a value between 0 and 1. By using segment assets instead of segment sales to define relative size, I aim to avoid spurious correlation with the dependent variable. Note that this specification is essentially the same as in (2.1) except that all the explanatory variables are now interacted with the variable $rsize_{it}$.

The results in the first and second columns of Table VI are in line with Hypothesis 3. Larger segments seem to be more responsive to investment opportunities and appear to have less rigid capital budgets than smaller segments, indicated by a positive coefficient on $mcxs_{jt} * rsize_{it}$ and a negative coefficient on $deps_{it} * rsize_{it}$. Moreover, comparing the coefficients in specifications (3)-(4) with the coefficients in specifications (5)-(6), the effect seems to be more pronounced in diversified integrated firms than focused integrated firms. The estimated coefficients on $mcxs_{jt} * rsize_{it}$ and $deps_{it} * rsize_{it}$ for diversified integrated firms are generally bigger in magnitude than the corresponding coefficients for focused integrated firms. One would have predicted this as a corollary of Hypothesis 2 since Table IV and V already had provided evidence suggesting a higher degree of informational asymmetry in diversified integrated firms.

I next consider the possibility that the results in Table VI are driven by heterogeneity in absolute size that is not captured by segment fixed effects. For example, one might argue that segments that are small in relative terms are also small in absolute terms. Then to the extent that segments that are small in absolute terms have more rigid capital budgets than segments that are large in absolute terms, the coefficients on $mcxs_{jt} * rsize_{it}$ and $deps_{it} * rsize_{it}$ may simply reflect an absolute effect and not a relative effect predicted by Hypothesis 3.

I address this issue in Table VII. Specifically, for every year, I first classify segments into three groups based on their relative size and then match segments below the 33rd percentile with segments above the 66th percentile, provided that they operate in the same two-digit SIC industry and have sales within 20 percent of each other. Although the matching procedure reduces the sample size significantly, there is still enough power to conclude that segments that are larger in relative terms are still more responsive to investment opportunities and have less rigid capital budgets than segments that are small in relative terms, even after controlling for absolute size and industry, indicated by a positive coefficient on $mcxs_{jt} * large_{it}$ and a negative coefficient on $deps_{it} * large_{it}$. Again the effect seems to be more pronounced in diversified integrated firms. Also, I check for the possibility that segments that are small in relative terms have lower productivity than larger segments and find that smaller segments are in fact slightly more productive than larger segments as measured by return on assets (EBIT/Assets): 10.2% versus 9.7%.

2.4.4 Stale Information

Finally, I investigate whether integrated firms use stale information such as lagged industry capital spending to overcome their problems associated with informational asymmetry. That is, I investigate whether integrated firms try to make use of observable hard information such as lagged industry capital spending even though it does not reflect the new investment opportunities in the industry. In Table VIII, I run the following regressions:

$$cxs_{i(j)t} = a_i + b_t + c * deps_{it} + d_c * mcxs_{jt} + d_l * mcxs_{j(t-1)} + e * cfs_{it} \tag{2.5}$$

$$\log cxs_{i(j)t} = \gamma \log sales_{it} + a_i + b_t + c * deps_{it} + d_c * mcxs_{jt} + d_l * mcxs_{j(t-1)} + e * cfs_{it} \tag{2.6}$$

I leave out segment depreciation in specifications (1), (2), (5) and (6) to assess the pure role played by lagged industry capital spending. The results weakly suggest that integrated firms use stale information whereas non-integrated firms do not. It seems that there is not enough power in the linear specifications which are presented in odd-numbered columns. Although the sign of the estimated coefficients on $mcxs_{j(t-1)}$ indicates some use of stale information by multi-segment firms, the effect is not large enough to reach statistical significance. For the log specifications presented in even-numbered columns, the coefficient on $mcxs_{j(t-1)}$ is large and statistically significant for multi-segment firms. Even after controlling for segment depreciation in column (8), the evidence suggests that multi-segment firms use stale information in their investments.

To find out whether the difference between integrated and non-integrated firms is statistically significant and to perhaps improve power for the linear specification, I pool the two subsamples and run regressions that interact all of the explanatory variables with the integration dummy variable. Again, I leave out segment depreciation in specifications (1) and (2) to assess the pure role played by lagged industry capital spending. The results, which are reported in Table IX, show that integrated firms indeed use stale information, evidenced by a statistically significant coefficient on $mcxs_{j(t-1)} * integrated_{it}$ in specifications (1), (2) and (4).

2.5 Conclusion

This chapter has tested some of the empirical predictions of Chapter 1 regarding the use of organizational processes to solve agency problems arising from specialized knowledge in the capital budgeting process. The findings are mostly supportive. First, the central prediction that integrated firms should have more rigid capital budgets than non-integrated firms is born in the data. One important consequence is that integrated firms are less responsive to investment opportunities than non-integrated firms. Second, the effects are magnified for diversified integrated firms that operate in unrelated lines of business. This finding confirms the hypothesis that diversified integrated firms, unable to use various organizational solutions effectively, would make more use of rigidity as an organizational solution. Third, smaller segments appear to have more rigid divisional capital budgets than larger segments. Perhaps this is the most striking evidence regarding the prevalence of specialized knowledge as one would naturally expect a corporate headquarters to be less informed about its smaller segments in general. Finally, integrated firms appear to use stale but hard information such as lagged industry capital spending in their investments to overcome agency problems arising from specialized knowledge.

Much empirical work remains to be done. Ideally, one would like to have more extensive data on organizational processes and structure such as capital budgeting systems and personnel policies. Unfortunately, such data are typically not in the public domain. But there are some potential exceptions. For example, the organization chart collection of the Conference Board can provide some useful information about organizational structure. Proxy statements, 10Ks and corporate directories can provide useful information about personnel policies.

One thing seems clear. If we are to truly understand the effect of integration on the allocation of resources, we need a deeper understanding of how organizational processes and structure affect managerial behavior.

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Table I: Descriptive Statistics [a]

Sample:	Single-Segment		Multi-Segment		Focused [b]		Diversified	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sales ($ mils)	924.5	4355.2	1074.4	4293.2	969.2	3633.3	1156.6	4744.4
Assets ($ mils)	995.3	4523.5	903.2	3104.7	859.6	2749.2	937.4	3356.4
Capital Spending ($ mils)	86.8	479.2	74.8	303.9	69.5	267.2	79.0	329.7
Depreciation ($ mils)	56.9	369.7	49.3	208.5	45.5	176.4	52.3	230.5
Cash Flow ($ mils)	147.3	716.9	145.9	527.1	140.8	493.8	149.9	551.7
Sales Normalized Variables								
Capital Spending	.0838	.1152	.0743	.1071	.0756	.1074	.0734	.1070
Depreciation	.0504	.0694	.0478	.0691	.0482	.0666	.0475	.0710
Cash Flow	.1348	.1278	.1434	.1199	.1464	.1202	.1410	.1196
Median Industry Capital Spending [c]	.0616	.0638	.0616	.0641	.0612	.0613	.0619	.0663
Relative Size	—	—	.3730	.2666	.4161	.2714	.3392	.2578
N obs	40192		50815		22304		28511	

[a]Segment-level data from Compustat Segment Files (1980-1998). To avoid typographical errors, the segment files are cross-validated with the annual files. Observations for which the sum of segment assets is not within 25 percent of the total assets reported in the annual files are excluded. Also excluded are:

1. Segments with SIC code greater than or equal to 6000 which are mainly financial and services industries.
2. Segments with name "other".
3. Segments with primary SIC code equal to zero.
4. Segments with incomplete data.
5. Segments with anomalous accounting data: (i) zero depreciation, (ii) capital spending greater than sales, (iii) capital spending less than zero.
6. Segments with sales less than $20 million or assets less than $5 million.
7. Segments with only one observation which is insufficient to identify segment fixed effects

[b]A multi-segment firm is classified as focused if all of its segments operate in related businesses. Otherwise, it is classified as diversified. Two segments are related if they can be linked horizontally or vertically based on the Input-Output Benchmark Survey of the Bureau of Economic Analysis.

[c]Industry is defined at the level of two-digit SIC codes. Sample excludes segments in financial and services industries. Also excluded are segments that set the median industry capital spending.

Table II
Integration and Segment-Level Investment Responsiveness [a]

Sample:	Single-Segment Firms				Multi-Segment Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Depreciation	.4148	.5805	.0023	.0032	.4579	.6763	.1071	.1935
	(4.36)	(8.63)	(0.09)	(0.07)	(4.64)	(10.66)	(3.80)	(5.25)
Median Industry Capital Spending	.5921	.4957	.8925	.8079	.4561	.3687	.6063	.5865
	(10.62)	(12.91)	(12.42)	(10.26)	(11.30)	(10.94)	(11.35)	(11.46)
Cash Flow	.2009	.1919	.0334	.0393	.2031	.1754	.0610	.0538
	(10.24)	(9.29)	(3.00)	(2.59)	(10.03)	(11.13)	(4.18)	(3.40)
Segment F.E.	No	No	Yes	Yes	No	No	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.4797	.5209	.7512	.7681	.4197	.4525	.7197	.7276
N obs	40192	31502	40192	31502	50815	42564	50815	42564

[a]Notes:

1. Sample excludes segments with sales less than $20 million in odd-numbered specifications and $50 million in even-numbered specifications.
2. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Table III
Effect of Integration on
Segment-Level Investment Responsiveness [a]

Pooled Regressions	(1)	(2)	(3)	(4)
Integrated	-.0062	-.0059	-.0016	-.0018
	(4.71)	(4.37)	(0.53)	(0.62)
Depreciation	.4100	.5745	-.0104	.0105
	(4.37)	(8.70)	(0.42)	(0.27)
*Depreciation * Integrated*	.0499	.1047	.1263	.1868
	(1.51)	(1.72)	(3.32)	(4.80)
Median Industry Capital Spending	.5950	.4989	.8143	.7800
	(10.74)	(13.26)	(14.00)	(12.17)
*Median Industry Capital Spending * Integrated*	-.1381	-.1299	-.1505	-.1607
	(4.70)	(3.09)	(3.75)	(3.04)
Cash Flow	.2019	.1933	.0370	.0498
	(10.23)	(9.23)	(3.33)	(3.38)
*Cash Flow * Integrated*	.0016	-.0176	.0224	.0026
	(0.12)	(1.02)	(1.51)	(0.16)
Segment F.E.	No	No	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
R^2	.4484	.4848	.7287	.7417
N obs	91007	74066	91007	74066

[a]Notes:

1. Sample excludes segments with sales less than $20 million in odd-numbered specifications and $50 million in even-numbered specifications.
2. Integrated is a dummy variable equal to one if the segment is part of a multi-segment firm.
3. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry level.

Table IV
Diversification and Segment-Level Investment Responsiveness [a]

Sample:	Focused Multi-Segment Firms				Diversified Multi-Segment Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Depreciation	.4154	.5590	.0040	.0317	.4856	.7801	.1337	.2908
	(5.21)	(5.96)	(0.14)	(0.92)	(3.63)	(9.88)	(3.30)	(4.37)
Median Industry Capital Spending	.5232	.4632	.6779	.6945	.4130	.3028	.5866	.5601
	(16.65)	(11.34)	(8.15)	(9.32)	(7.27)	(7.65)	(9.25)	(9.87)
Cash Flow	.2145	.1967	.0553	.0155	.1945	.1550	.0297	.0362
	(9.18)	(8.16)	(2.94)	(0.83)	(8.84)	(10.39)	(1.76)	(1.94)
Segment F.E.	No	No	Yes	Yes	No	No	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.4177	.4384	.7446	.7518	.4237	.4689	.7197	.7556
N obs	22304	18646	22304	18646	28511	23918	28511	23918

[a]Notes:

1. Sample excludes segments with sales less than $20 million in odd-numbered specifications and $50 million in even-numbered specifications.
2. A multi-segment firm is classified as focused if all of its segments operate in related businesses. Otherwise, it is classified as diversified. Two segments are related if they can be linked horizontally or vertically based on the Input-Output Benchmark Survey of the Bureau of Economic Analysis.
3. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Table V
Effect of Diversification on Segment-Level Investment Responsiveness [a]

Pooled Regressions	(1)	(2)	(3)	(4)
Diversified	.0044	.0034	.0059	.0053
	(2.24)	(1.69)	(2.87)	(2.46)
Depreciation	.4133	.5585	.0657	.1426
	(5.21)	(6.01)	(2.61)	(3.37)
*Depreciation * Diversified*	.0742	.2227	.0662	.1188
	(0.67)	(1.81)	(2.04)	(1.93)
Median Industry Capital Spending	.5235	.4632	.6521	.6816
	(16.50)	(11.42)	(12.02)	(12.93)
*Median Industry Capital Spending * Diversified*	-.1110	-.1607	-.0661	-.1352
	(2.19)	(3.54)	(1.92)	(3.78)
Cash Flow	.2139	.1959	.0859	.0692
	(9.15)	(8.14)	(5.02)	(3.63)
*Cash Flow * Diversified*	-.0190	-.0403	-.0453	-.0275
	(0.91)	(1.60)	(2.95)	(1.56)
Segment F.E.	No	No	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
R^2	.4208	.4556	.7201	.7282
N obs	50815	42564	50815	42564

[a] Notes:

1. Sample excludes segments with sales less than $20 million in odd-numbered specifications and $50 million in even-numbered specifications.
2. Diversified is a dummy variable equal to one if the segment is part of a diversified multi-segment firm.
3. A multi-segment firm is classified as focused if all of its segments operate in related businesses. Otherwise, it is classified as diversified. Two segments are related if they can be linked horizontally or vertically based on the Input-Output Benchmark Survey of the Bureau of Economic Analysis.
4. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry level.

Table VI
Relative Size and Segment-Level Investment Responsiveness [a]

Sample:	Integrated		Focused		Diversified	
	(1)	(2)	(3)	(4)	(5)	(6)
Relative Size	.0107	.0215	.0357	.0468	.0106	.0127
	(1.51)	(2.73)	(2.26)	(2.66)	(1.31)	(1.33)
Depreciation	.2120	.3969	.1136	.1561	.1904	.4165
	(4.24)	(6.63)	(1.90)	(2.33)	(3.07)	(3.74)
*Depreciation * RS*	-.2936	-.4990	-.2360	-.2344	-.1938	-.4185
	(3.47)	(4.16)	(2.07)	(2.11)	(1.68)	(1.87)
Median Industry Capital Spending	.3625	.3687	.4587	.5438	.3626	.3547
	(6.23)	(6.73)	(4.85)	(5.27)	(5.37)	(5.23)
*Median Industry Capital Spending * RS*	.6598	.5770	.5259	.3595	.6669	.5806
	(5.76)	(5.15)	(2.42)	(1.54)	(5.41)	(4.45)
Cash Flow	.0373	.0217	.0517	-.0024	.0219	.0112
	(2.15)	(1.22)	(1.98)	(0.09)	(0.90)	(0.43)
*Cash Flow * RS*	.0573	.0765	.0001	.0377	.0290	.0748
	(1.56)	(1.90)	(0.00)	(0.59)	(0.54)	(1.26)
Segment F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.7230	.7310	.7471	.7542	.7488	.7578
N obs	50815	42564	22304	18646	28511	23918

[a]Notes:

1. Sample excludes segments with sales less than $20 million in odd-numbered specifications and $50 million in even-numbered specifications.
2. Relative size is defined as segment assets as a percentage of total firm assets.
3. A multi-segment firm is classified as focused if all of its segments operate in related businesses. Otherwise, it is classified as diversified. Two segments are related if they can be linked horizontally or vertically based on the Input-Output Benchmark Survey of the Bureau of Economic Analysis.
4. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Table VII
Effect of Relative Size on Segment-Level Responsiveness (Industry and Size Matched) [a]

Sample:	Focused			Diversified		
	Small	Large	Pooled	Small	Large	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)
Large			-.0101			-.0084
			(2.16)			(2.42)
Depreciation	.6534	.5342	.6632	1.0158	.6999	1.0142
	(3.85)	(4.62)	(3.86)	(16.45)	(8.75)	(16.47)
*Depreciation * Large*			-.1457			-.3136
			(0.83)			(4.12)
Median Industry Capital Spending	.3378	.4897	.3290	.1814	.4412	.1826
	(6.72)	(9.24)	(6.44)	(4.09)	(13.01)	(4.13)
*Median Industry Capital Spending * Large*			.1739			.2575
			(2.32)			(4.58)
Cash Flow	.0800	.1857	.0819	.0630	.1477	.0628
	(2.15)	(7.29)	(2.19)	(2.70)	(4.66)	(2.69)
*Cash Flow * Large*			.1029			.0849
			(2.42)			(2.31)
Segment F.E.	No	No	No	No	No	No
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.4713	.5012	.4903	.5425	.6006	.5792
N obs	2923	2923	5846	3970	3970	7940

[a]Notes:

1. Relative size is defined as segment assets as a percentage of total firm assets.
2. Segments with relative size below the 33rd percentile are matched with segments above the 66th percentile.
3. Two segments in a given year are matched if they are in the same two-digit SIC industry and their sales are within 20 percent of each other.
4. Large is a dummy variable equal to one if the relative size of the segment is above the 66th percentile.
5. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Table VIII
Use of Stale Information [a]

Sample:	Single-Segment Firms				Multi-Segment Firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Median Industry Capital Spending	.8870	5.2856	.8870	5.2874	.5604	4.1762	.5757	4.2767
	(8.44)	(12.43)	(8.38)	(12.42)	(6.18)	(9.10)	(6.33)	(9.47)
Lagged Median Industry Capital Spending	-.0124	.2547	-.0124	.2533	.0538	.9348	.0453	.8810
	(0.13)	(0.64)	(0.13)	(0.64)	(0.69)	(2.40)	(0.58)	(2.25)
Depreciation			-.0001	.0189			.1100	.7138
			(0.01)	(0.20)			(3.88)	(3.62)
Cash Flow	.0342	.8959	.0553	.8969	.0549	.6476	.0589	.6719
	(2.94)	(9.93)	(2.94)	(9.93)	(3.69)	(7.20)	(3.91)	(7.39)
Model	Linear	Log	Linear	Log	Linear	Log	Linear	Log
Segment F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.7510	.9242	.7556	.9248	.7232	.9317	.7244	.9319
N obs	38884	38801	38884	38801	47577	47436	47577	47436

[a] Notes:

1. Odd and even-numbered columns estimate linear and log models, respectively.
2. Also included in the log specifications is log(sales).
3. Sample excludes segments with sales less than $20 million.
4. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Table IX
Effect of Integration on the Use of Stale Information [a]

Pooled Regressions	(1)	(2)	(3)	(4)
Integrated	.0011	.0874	-.0014	.0546
	(0.40)	(1.38)	(0.47)	(0.85)
Median Industry Capital Spending	.8226	5.1586	.8444	5.3142
	(8.03)	(12.80)	(8.37)	(12.58)
*Median Industry Capital Spending * Integrated*	-.2280	-.7425	-.2459	-.8715
	(2.90)	(1.77)	(3.30)	(2.06)
Lagged Median Industry Capital Spending	-.0547	.2412	-.0355	.3758
	(0.59)	(0.69)	(0.39)	(1.06)
*Lagged Median Industry Capital Spending * Integrated*	.1526	.9126	.1126	.6337
	(1.83)	(2.09)	(1.46)	(1.72)
Depreciation			-.0090	-.0757
			(0.37)	(0.71)
*Depreciation * Integrated*			.1268	.8929
			(3.33)	(3.49)
Cash Flow	.0354	1.0520	.0391	1.0760
	(3.04)	(11.56)	(3.43)	(11.73)
*Cash Flow * Integrated*	.0201	-.4276	.0168	-.4486
	(1.36)	(4.03)	(1.14)	(4.23)
Model	Linear	Log	Linear	Log
Segment F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
R^2	.7303	.9268	.7311	.9269
N obs	86461	86237	86461	86237

[a]Notes:

1. Odd and even-numbered columns estimate linear and log models, respectively.
2. Also included in the log specifications are log(sales) and its interaction with integration.
3. Sample excludes segments with sales less than $20 million.
4. Integrated is a dummy variable equal to one if the segment is part of a multi-segment firm.
5. t-statistics are in parentheses. t-statistics are corrected for clustering of observations at the industry and year level.

Chapter 3

Integration and Investment: Evidence from Diversified Oil Companies

3.1 Introduction

Considerable amount of research indicates that there are significant financing spillovers across segments of an integrated firm. Shin and Stulz (1998) investigate the determinants of segment investment behavior and find that the investment of the smallest segments is affected by the cash flow of other segments. In a more controlled setting, Lamont (1997) finds that oil companies reduced their nonoil investments compared to the median industry investment following the 1986 oil shock. These and other related empirical findings about the workings of internal capital markets have prompted further empirical and theoretical research with the objective of understanding whether the observed empirical patterns reflect efficient transfer of funds across segments. The interest in the topic is understandable since corporate investment is undoubtedly the most important economic decision made by firms.

In this chapter, I analyze the investment behavior of nonoil segments of oil companies from 1980 to 1995. My main objective is to further our understanding about the functioning of internal capital markets in a controlled setting where integration is mostly lateral and, more importantly, where there is an observable and outside measure of shocks to profits. Oil companies with their investments outside the oil industry fit these requirements very well. One hopes that the insights gained in such a controlled setting will eventually better guide the much broader research question about the effect of integration on corporate investment.

By looking at an extended time period, I hope to gain further insight into the nonoil investment behavior of oil companies, both leading up to and following the 1986 oil shock. The period from 1980 to 1995 is an especially interesting period to study since the oil industry seems to epitomize the empire-building excesses observed during this period. In addition, the period covers both a negative and a positive shock in 1986 and 1990, respectively. Needless to say, understanding the effects of a positive shock is just as important as understanding the effects of a negative one.

My main findings can be summarized as follows. First, there is strong evidence that oil companies reduced their nonoil investments *prior* to the 1986 oil shock. Compared to capital expenditure reductions in 1986, which Lamont (1997) investigates in detail, I find that the reductions in 1985 prior to the oil shock were much deeper and more significant. Unfortunately, this finding casts doubt on Lamont's key assumption that the oil price crash was unanticipated. Moreover, I perform numerous robustness checks and find that the reductions in 1986 do not pass conventional levels of statistical significance. The reductions in 1985 prior to the oil shock, on the other hand, appear to be much more robust. Furthermore, I analyze a novel dataset of chemical plants in the U.S. for independent evidence and find that units owned by oil companies experienced significant reductions in investment not in 1986 but in 1985. This finding pertaining to the chemical units of oil companies is suggestive of inefficiencies in the workings of internal capital markets of diversified oil companies since one would expect the decline in oil prices from 1981 to 1986 to make projects in the chemical industry more attractive, not less. At the same time, the more general finding is suggestive of oil companies choosing to defend against an expected downturn in their core business by cutting investment in their noncore businesses.

Second, there appears to be other large reductions in nonoil investment in 1983 and 1992. The overall reduction in 1983, although not as large as the one in 1985, reflects the same general downward trend in the oil business at the time. The reduction in 1992, however, is surprising since it comes after a positive shock to oil prices following the Gulf War. Such an outcome for nonoil segments raises potentially interesting conjectures about the priority that core segments seem to get over noncore segments for internal funds. I discuss these possibilities as well as a number of interesting avenues for future research in conclusion.

There is a growing empirical literature that has goals similar to those of this chapter. For simplicity, I classify the empirical evidence regarding the efficiency of internal capital markets into positive versus negative.[1] The conflicting categorization should not be taken to imply contradiction since most of the results pertain to a specific type of integration, namely related (horizontal and vertical) versus unrelated (lateral) integration. In the positive category, Khanna and Tice (2001) find that discount divisions of horizontally integrated retail firms respond to Wal-Mart's entry into their markets in a way consistent with efficient reallocation of funds. Maksimovic and Phillips (2001) use plant-level Census data and find supportive evidence for their neoclassical maximizing model. Their results, however, do not differentiate between the three types of integration. In the negative category, Scharfstein (1998) finds that conglomerate firms invest more in low-Q and less in high-Q businesses when compared to pure stand-alone firms. Gertner, Powers and Scharfstein (1999) find that spun-off units in high-Q businesses subsequently increase their investments. Rajan, Servaes and Zingales (2001) find a strong relationship between diversity in investment opportunities and the conglomerate discount documented by Lang and Stulz (1994), Berger and Ofek (1995), and Lins and Servaes (1999).[2] Schoar (2001) finds that the overall net effect of diversification on firm productivity is negative. Ozbas (2001b) finds that integration generally, and lateral integration especially, makes firms less sensitive to investment opportunities.

The rest of the chapter proceeds as follows. Section 2 describes the data and the sample selection procedure for Sections 3 and 4. In section 3, I present results that are broadly consistent with Lamont (1997). In section 4, I analyze the full period from 1980 to 1995. Finally, I

[1] The theoretical literature can also be classified into two groups for simplicity, dark versus bright-side theories. See Rajan, Servaes and Zingales (2000) and Scharfstein and Stein (2000) for dark-side arguments that predict inefficient transfer of funds across segments. See Stein (1997), Matsusaka (2001), and Maksimovic and Phillips (2001) for bright-side arguments. Ozbas (2001a) provides an alternative to both sides where transfer of funds across segments is inefficient from a first-best point of view but is efficient with respect to the informational constraints that come with specialization in knowledge and expertise on the part of those responsible for generating project ideas. Finally, see Stein (2001) for an excellent survey.

[2] It is important to point out that the conglomerate discount appears to be more of a recent phenomenon. There is evidence suggestive of value-enhancing diversification during the conglomerate merger wave of the 1960s and 1970s, see Matsusaka (1993), and Hubbard and Palia (1999).

provide concluding remarks in Section 5.

3.2 Data

I use the Compustat segment files to study the investment behavior of nonoil segments of oil companies. The segment files provide annual segment-level financial variables such as sales, operating profit, depreciation, capital spending and assets for corporate segments that constitute more than 10 percent of total sales. In addition, the segment files provide a pair of Standard Industrial Classification (SIC) codes for each segment.

For the analysis presented in section 3, I follow the same selection procedure described in Lamont (1997). Briefly, a firm is classified as oil-dependent if more than 25 percent of its operating cash flow in 1985 came from the oil extraction business (two-digit SIC code 13). This screen is intended to identify a sample of firms that are likely to have been affected by the 1986 oil shock. Table I lists the sample of nonoil segments generated by the selection procedure. I end up with 49 nonoil segments, more than the 39 reported by Lamont (1997).

Section 4 extends the analysis to the 1980-1995 period, and uses the same selection procedure as in Section 3. The only modification that I make to is to relax the 25 percent cash flow threshold and include a firm if it reports any asset or sales in the oil extraction business. This modification is intended to generate a stable sample of oil firms in a period of volatile profitability in the oil business.[3]

3.3 Nonoil Investment in 1985-1986

In this section, I report evidence that is broadly in agreement with the findings of Lamont (1997). Looking at Table I, it is clear that most nonoil segments reduced investment following the oil shock. Also clear from Table I is the fact that nonoil segments experienced significant improvement in operating cash flow in 1986. Table II presents raw segment investment and cash flow broken out by year, namely 1985 and 1986. Raw investment declined from about 9 percent (of sales) in 1985 to about 6.6 percent of in 1986 whereas cash flow improved from about 12.7

[3]For completeness, I provide a description of the selection procedure in the appendix.

percent in 1985 to about 15.7 percent in 1986. As can be seen in Table III, the decline in raw investment of 2.4 percent is statistically significant. Moreover, the decline remains statistically significant after adjusting for industry. To make the necessary industry adjustment, I use more or less the same method outlined in Lamont (1997). Specifically, I subtract the median change in I/S of a control group of segments that operated in the same industry but were owned by firms that did not have an oil-related segment.[4] Table IV shows that the improvement in raw cash flow of 2.9 percent too is statistically significant. Again, the improvement remains statistically significant after adjusting for industry-wide changes in cash flow.

Next, I look at industry-adjusted level of investment and cash flow in more detail. Table V presents mean industry-adjusted investment in 1985 and 1986. The mean decline of 2.1 percent from 1985 to 1986 is statistically significant and is strikingly similar to the 2.2 percent decline reported in Table III. This serves as a good robustness check since the mechanics of calculating the figures presented in Table V are quite different from that in Table III. Essentially, the difference is due to the use of median values in adjusting for industry.[5]

$$Median\,(\Delta\,(I/S)) \neq \Delta\,(Median\,(I/S)) \tag{3.1}$$

$$\Downarrow$$

$$\underbrace{\Delta\; I/S - Median\,(\Delta\,(I/S))}_{\text{Table III}} \neq \underbrace{\Delta\;(I/S - Median\,(I/S))}_{\text{Table V}} \tag{3.2}$$

Interestingly enough, the mean level of industry-adjusted investment at 1.1 percent after the oil shock is still above industry norms, although it is not statistically different from zero. This puts the oil shock under a somewhat different light. It appears that the effect of the oil shock was to reduce the extent of overinvestment relative to industry, and not cause underinvestment. This is in contrast to the findings in Lamont (1997) which show underinvestment in 1986. The difference is due to the sample being analyzed. Restricting attention to those nonoil segments analyzed in Lamont (1997) yields similar results.

As a final point, the improvement in industry-adjusted cash flow of 1.6 percent in Table

[4] Again for completeness, I provide in the appendix a detailed description of the algorithm used for selecting the control group of segments.

[5] If mean values were used instead, there would be no difference. However, there are many I/S outliers, hence the use of median values.

VI is statistically significant. Again this serves as a good robustness check for the results in Table IV. There do not seem to a big difference between industry-adjusted changes in levels and changes in industry-adjusted levels.

3.4 Overinvestment Before and After the 1986 Oil Shock

To further explore the somewhat negative findings documented in the previous section regarding overinvestment and low profitability in nonoil segments of oil companies, I extend the analysis to the 1980-1995 period. By looking at an extended period, I hope to gain more insight into the nonoil investment behavior of oil-dependent companies, both leading up to and following the 1986 oil shock. The period from 1980 to 1995 is a particularly interesting period to study as the oil industry seems to epitomize the conglomerate excesses observed during this period. In addition, the period covers both a negative shock and a positive shock in 1986 and 1990, respectively. Needless to say, understanding the effects of a positive shock is just as important as understanding the effects of a negative shock.

Before going into the expanded analysis, it is worth pointing out the effect that various thresholds have on the analysis. For example, one of the significant thresholds in the previous section was the requirement that firms have at least 25 percent of their cash flow in 1985 come from the oil extraction business. However, there are many other firms that have a segment in the oil extraction business but fail to meet the 25 percent threshold, because either these operations are not very profitable or other parts of the firm are extremely profitable. One could indeed imagine using a different threshold, say 20 percent or 10 percent. Instead of imposing a certain threshold, I let the data choose its own. Table VII repeats the analysis of the previous section for four different levels. The first column looks at the full universe of firms that have a segment in the oil extraction business. As it turns out, some of them were losing money in their oil extraction segment – the threshold is -2.6 percent. For this sample, the decline in nonoil investment is not statistically significant. In fact, the decline is statistically insignificant in all of the columns. The only ones that come close to statistical significance are the last two columns that have 50th and 75th percentile as sample thresholds and, incidentally, the 25 percent threshold used in the previous section falls just in between. Using this threshold seems to excludes almost over 70 percent of nonoil segments that are owned by firms with an oil extraction segment. With this caveat in mind, I report results for several different thresholds based on the data itself.

Table VIII presents results for the extended period from 1980 to 1995. I report four panels A, B, C and D which have thresholds that are determined annually. One important change that I make is to construct the threshold as a percentage of assets in the oil extraction business rather than cash flow. The purpose of this modification is to generate a stable sample in what essentially is a period of volatile profitability in the oil business.

One immediate and striking finding in Table VIII is the large decline in investment in 1985 that occurs before the oil shock in 1986. Looking at the full sample, the decline of 1.6 percent in investment before the oil shock is in fact greater than the decline of 0.7 percent after the oil shock. Moreover, the decline before the oil shock is statistically significant whereas the decline after the oil shock is not. Furthermore, the results reported in panels B, C and D indicate that the difference is more pronounced for higher thresholds. The decline in investment after the oil shock reaches statistical significance only in Panel C where the threshold is the 50th percentile.

Other interesting years that stand out are 1983, 1990 and 1992. Especially the decline in 1983 is just as steep and robust as the decline in 1985. This result is interesting for two reasons. First, 1983 comes two years after oil prices peaked in 1981. One potential conjecture is that oil companies already had set their 1982 capital budgets before the peak and did not feel the urgency to change them as oil prices kept decreasing in 1981 from \$50 to \$40 per barrel (see Figure 1). Oil companies were awash with cash and, even at these lower prices, oil was still a good industry to be in. However, when it was time to set their 1983 capital budgets, there was convincing evidence that oil prices were on their way down (\$35 per barrel by mid-1982) and that perhaps caution was necessary. Second, there do not seem to a similar decline in 1984 although oil prices kept decreasing. Interestingly enough, oil prices first declined to a low level of \$27 per barrel in the first quarter of 1983, only to climb back up to \$32 per barrel temporarily by mid-year. After that oil prices sank below \$30 per barrel and reached its lowest level of \$8 per barrel in the third quarter of 1986.

There is not an obvious reason for the increase in nonoil investment in 1990 except to note that oil prices temporarily increased to about \$40 per barrel following Iraq's invasion of Kuwait.

It is important to note that the invasion was perhaps a more exogenous event than the oil shock in 1986 since even the most sophisticated secret services were caught off-guard. It is hard to imagine that the increase in nonoil investment could have been put into place following such a late profit windfall in 1990. The decrease in nonoil investment in 1992, however, is interesting since it comes after a positive shock to oil prices following the invasion of Kuwait. One potential conjecture is that oil companies needed their internal funds for the now more attractive core oil business and therefore had to put their noncore businesses on a diet.

Next, I restrict the control group to single-segment firms. Table IX is similar to Table VIII except that the control group is composed of single-segment firms. One would ideally like to ensure that the measured changes in nonoil investment are due to outside events, and not due to potential internal capital market redistributions that take place in multi-segment firms. Following this slight change, the decline in nonoil investment in 1986 is all but eliminated. In addition, most years except 1983 and 1985 lose statistical significance. Perhaps one major reason for this is the now smaller universe of segments with which the matching procedure has to work. Remember that the procedure first tries to find a matching segment based on both primary and secondary SIC codes at the four-digit level and then gradually relaxes the matching precision until at least five matching segments are found. With less number of segments available as a control group, the matching procedure becomes less precise and consequently produces more noisy results.

Lastly, I look at segments in the chemicals industry (two-digit SIC code 28) as a subsample. Given its reliance on oil and by-products of oil as inputs, the chemicals industry is an especially interesting industry to consider. One would imagine that the decline in oil prices would make the industry more attractive and lead to increased investment.[6] Also the subsample constitutes the largest single industry in the whole analysis, so it deserves special attention. Table X presents the results. As for previous robustness checks, the reduction in investment in 1986 is all but gone and has turned into a slight increase of 0.6 percent. Meanwhile, the reduction of 3.7 percent in 1985 is much larger than the full sample. However, it is not statistically significant. The results are qualitatively similar when the control group is restricted to single-segment firms.

[6] Of course, there is always the possibility of profit margins being counter-cyclical, see Chevalier and Scharfstein (1996). However, accounts in industry and trade journals such as Chemical Week, Chemical Market Reporter, and Chemical Engineering seem to indicate that the profit margins are pro-cyclical.

3.4.1 Too Many Significant Years?

Before drawing any further conclusions, I address an econometric issue that one might naturally raise for the analysis presented so far: why are there so many years in which the mean industry-adjusted change in investment is statistically significant? Could it be that simple OLS standard errors are somehow biased?

Simple OLS standard errors are known to be biased for differences-in-differences estimators that use many years of serially correlated outcomes and interventions.[7] Do my results reflect such a bias? The answer is a fortunate no since the differences-in-differences estimator used here compares after to before with just one observation per segment and identifies an effect, to the extent there is any, off of the cross-sectional variation. So simple OLS standard errors are fine.

Perhaps then, it is the assumption of normality that needs to be checked. Note that there are less than 30 observations in some cases and the t-stats rely on the assumption of normality when the sample is that small. Figure 2, which shows the kernel density estimate of industry-adjusted change in I/S (dashed line) versus the normal distribution with matching mean and standard deviation (solid line), suggests that one needs to be cautious when using simple OLS standard errors to make small sample inferences. While the distribution is centered at -0.49 percent with a standard deviation of 9 percent (and slight skewness to the right, -0.63), it is extremely peaked (kurtosis 18.88) relative to the normal distribution. And the Kolmogorov-Smirnov test of the equality of distributions easily rejects the null of normality with matching mean and standard deviation (see Table XI).

To address this potential small sample inference problem, I compute bootstrapped confidence intervals for mean industry-adjusted change in I/S reported in Table VIII. For each year, I perform 10,000 replications. In each replication for a given year, I draw a random sample of equal size (with replacement) from the original sample and then calculate a mean value. After 10,000 replications, I pick the 5th and 95th percentile observations from the empirical distribution of calculated means to form the bootstrapped confidence intervals. The results from this exercise are presented in Table XII. 1983, 1985, 1990 and 1992 continue to stand out. 1986

[7] See for example Bertrand, Duflo and Mullainathan (2001).

reaches statistical significance only in Panel C. All in all, conclusions from Table VIII remain unchanged.

With more confidence in the robustness of my results, I turn next to a dataset of petrochemical plants in the U.S. for further evidence. The primary objective is to look for independent confirmation of whether the decline in nonoil investment happened before or after the 1986 oil shock.

3.4.2 Petrochemicals Industry

The analysis in this subsection is based on a comprehensive dataset of petrochemical plants in the U.S.[8] The dataset is useful for a variety of research questions. More pertinent for the analysis, the dataset provides detailed capacity data at the unit level as well as flags for potentially interesting events such as acquisitions, divestitures, shut-downs, stand-bys, etc. Needless to say, this represents a tremendous improvement over Compustat segment files which report only new capital spending.

Using the company name provided in the dataset, I am able to find the corresponding company identifier in Compustat and determine whether the unit is owned by a firm that has an oil extraction segment. Panel A of Table XIII presents the event summary for units owned and operated by firms that do not have an oil extraction segment. It is clear that nothing out of the ordinary happened at these firms before and after the oil shock. If anything, scale-ups outnumbered scale-downs by 113 to 50 in 1985 and 94 to 46 in 1986. Oil firms presented in Panel B, by contrast, had a much smaller scale-up to scale-down ratio in 1985. Also unit sales reached the highest level for the period. It is important to note that 1986 was not a particularly bad year at all. Oil firms had a much better scale-up to scale-down ratio and came nowhere close to the 1985 pace in terms of divestitures.

To find out whether the observed patterns are statistically significant, I run two ordered probit models in Table XIV. The first model tests an ordered probit model for three outcomes – scale down, maintain, scale up (in the order stated). The second model adds one more, sold,

[8] I am grateful to David Scharfstein for sharing this data provided by SRI Chemical & Health Business Services of SRI Consulting, a market-research and consulting firm based in Menlo Park, California.

before scale down. Specifically, the following maximum-likelihood model is estimated:

$$\Pr(outcome_i = k) = \Pr(c_{k-1} < \alpha + \beta * Oil + \varepsilon_i < c_k) \tag{3.3}$$

where ε_i is assumed to be normally distributed. *Oil* is a dummy variable equal to one if the unit is owned by a firm that has an oil extraction segment. As expected, the coefficient on *Oil* is negative, large in magnitude and statistically significant for 1985 in both models. In comparison, the coefficient on *Oil* is positive and small in magnitude for 1986. This result represents yet another piece of evidence suggesting that oil companies reduced their nonoil investments much more significantly *before* the oil shock. There are also significant negative coefficients in 1993 and 1994 which add to the conjecture of oil companies neglecting their nonoil businesses.

In addition, there are interesting patterns around the 1986 oil shock regarding the number of greenfield projects undertaken by oil and non-oil firms. For oil firms, the number peaks at 73 in 1985 and then falls to 10 in 1986 and 11 in 1987, whereas for non-oil firms, the number stays at a steady 60 and 69 in 1985 and 1986, respectively, and then jumps to a massive 141 in 1987. Given the 18-month lead time typical of greenfield projects in this industry, one can usefully triangulate the timing of project approval at the two types of firms and compare their response to the decline in oil prices that improves profitability directly by reducing the cost of a major input. For example, for the number of greenfield projects undertaken by oil firms to peak at 73 in 1985, they must have approved a lot of greenfield projects in 1983 or 1984. Similarly, for the number to fall drastically in 1986 and 1987, the decision to cut back must have been made in 1984 or 1985 which, by the way, lends further support to the main finding of this chapter that oil firms curtailed their nonoil investments well before the 1986 oil shock. In contrast, for the number of greenfield projects undertaken by non-oil firms to jump to an astonishing 141 in 1987, they must have approved a lot of projects in 1985 and 1986, undoubtedly in response to falling oil prices that make petrochemicals projects more attractive. That there is such an overwhelming asymmetry between oil and non-oil firms in their response to increasing profitability in the industry, the conclusion must be that there were gross inefficiencies in the workings of internal capital markets of oil firms during the period surrounding the 1986 oil shock.

3.4.3 Unconditional Test

This last subsection investigates a somewhat conservative question: how different was any one year compared to the whole period 1980-1985? That is, I investigate whether mean industry-adjusted change in I/S in a particular year is statistically any different from the whole period 1980-1995. My goal is to identify years that truly stand out from the rest.

To compute critical values for each test, I run 10,000 monte-carlo simulations. In each run, I draw a random sample of equal size (with replacement) from the whole period 1980-1995 and then calculate a mean value. After 10,000 runs, I pick the 5th and 95th percentile observations from the empirical distribution of calculated means as the unconditional critical values and check if the observed mean falls outside of the critical range. The results from this exercise are presented in Table XV.

With the exception of 1985, 1983 and 1990 continue to stand out in most panels. 1985 becomes significant in Panel D which restricts the analysis to firms most heavily invested in oil. Note that some years have different critical values despite having the same sample size. This is not a mistake and is due to my computing the critical values separately for each year. Differences arise simply due to the random nature of the simulations. Again, the results corroborate the strength of the findings documented in previous sections.

3.5 Conclusion

Corporate investment is undoubtedly the most important economic decision made by firms. There is now considerable evidence suggesting that integration, whether related or unrelated, fundamentally affects the way firms behave. In the case of unrelated integration, empirical evidence is predominantly negative. The results in this chapter add to the negative findings of Scharfstein (1998), Gertner, Powers and Scharfstein (1999), Rajan, Servaes and Zingales (2001), Schoar (2001) and Ozbas (2001b).

The chapter's central findings can be summarized as follows. First, looking at Compustat segment files, it is clear that the reduction in nonoil investment of oil companies in 1985 was far more significant than the reduction in 1986. This conclusion is robust to the use of different thresholds, and to reasonable and natural sample restrictions on the control group of segments. In addition, the reduction is more pronounced in the chemical industry which is the single largest group represented in the analysis. Moreover, an independent dataset of petrochemical plants in the U.S. shows that oil companies indeed reduced their nonoil investments more significantly in 1985. This finding alone is suggestive of inefficiencies in the workings of internal capital markets of diversified oil companies since the decline in oil prices from 1981 to 1986 made projects in the chemical industry more attractive, not less. Furthermore, all this casts doubt on the assumption that the oil price crash was unanticipated. An argument based on pure-coincidence to explain the reduction in 1985 does not seem plausible since investment above industry norms appears to be the normal course of business for most of the period. The more plausible explanation is that the oil price crash was anticipated to a certain degree and that oil companies chose to protect against an expected downturn in their core business by cutting investment in their noncore businesses.

Second, oil companies appear to have curtailed their nonoil investments again in 1992. Such a reduction is surprising since it comes after a positive shock to oil prices following the Gulf War. Based on the response of oil companies to the decline in oil prices in the 1980s, one would have expected an increase in nonoil investments, not a decrease. One potential conjecture is that oil companies needed their internal funds for the now more attractive core oil business and therefore had to put their noncore businesses on a diet. Another possibility is that the added political uncertainty in the Middle East surrounding their core business may have prompted oil companies to take a defensive posture again at the expense of their noncore businesses. Either way, the analysis seems to indicate that diversified oil companies follow an investment hierarchy in which the funding needs of the core take absolute priority over the funding needs of the noncore.

The real consequences of an investment hierarchy in diversified firms is an idea that is often discussed in the popular press but is not well developed in the literature. The analysis presented in this chapter provides a starting point. Admittedly, the evidence is limited in scope. One can potentially extend the analysis to commodity producing firms with lateral investments. Alternatively, instances of lateral integration can be identified more generally by using the Input-

Output Benchmark Survey of the Bureau of Economic Analysis as in Ozbas (2001b). Finally, the dataset on petrochemical plants, used in this chapter to provide independent confirmation for the main results, can usefully be exploited to further our understanding of the effect of vertical, horizontal and lateral integration on corporate investment.

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3.6 Appendix

3.6.1 Selection Procedure

In this appendix, I provide a detailed description of the procedure followed for selecting nonoil segments of oil companies. As in Lamont (1997), the analysis is restricted to firms with a high ex-ante probability of being profoundly affected by changes in the price of oil. Specifically, a firm is defined to be oil-dependent if (i) it has a segment with either primary or secondary SIC code in the oil extraction industry (two-digit SIC code 13), and (ii) it derives at least 25 percent of its cash flow from the oil extraction industry. Both primary and secondary SIC codes are used in the determination of this threshold. If a segment reports a primary SIC code of 13, all of its cash flow is assumed to be from oil extraction. If instead a segment reports only a secondary SIC code of 13, half of its cash flow is assumed to be from oil extraction. It is worth emphasizing that the measures are intended to be ex-ante. For this reason, it is important that the selection criteria are applied to lagged variables. For example, to identify a set of firms for 1986, the selection criteria uses 1985 data.

After identifying the set of firms that are oil-dependent, the next step entails the selection of segments that are not related to oil. Similar to Lamont (1997), I exclude segments that are involved in the refining (two-digit SIC code 29), transporting (two-digit SIC code 46, three-digit SIC code 492), and selling (wholesale three-digit SIC code 517, retail three-digit SIC code 554, retail three-digit SIC code 598) of oil and related products. In addition, I exclude segments that are involved in the manufacturing of oil and gas field machinery (four-digit SIC code 3533) and mining of alternative energy sources (uranium four-digit SIC code 1094, coal two-digit SIC code 12). Finally, I exclude segments with SIC code greater than or equal to 6000 which are mainly financial and services industries.

Some segments are reported more than once. This happens due to a variety of reasons such as mergers and acquisitions, reporting as a separate subsidiary or a separate group, etc. The following is a summary of these special exclusions:

1. Royal Dutch Petroleum-NYSE: drop cusip 78025C10, 82256710, 82270360, 82263500.

2. Tenneco Inc: drop cusip 88035300, 88045100.

3. CMS: drop cusip 21051800.
4. Enron: drop cusip 29399Y10.
5. Mobil Corp: drop cusip 60708000.
6. Canadian Pacific Ltd: drop cusip 13690010.
7. One exception is Canadian Occidental. Apparently, Canadian Occidental was not part of Occidental's consolidated statements at the time.

Some segments are adversely affected by the oil shock because they either provided services to the oil industry or were located in a region heavily dependent on oil. These segments too are excluded because they are somewhat oil-related. Again, the following is a summary of these exclusions:

1. Pennzenergy's sulphur business, cusip 70931Q10, segment id 7
2. Mitchell's real estate business in Houston, cusip 60659230, segment id 13
3. Rowan's aviation business mostly serving Gulf of Mexico and Alaska, cusip 77938210, segment id 2
4. Nicor's marine engineering segment serving the oil industry, cusip 65408610, segment id 5

Finally, I apply a standard set of data filters. First, I cross-validate the segment files with the annual files and drop segments for which the sum of segment assets in a given year is not within 25 percent of the total assets reported in the annual files. This is intended to avoid the typographical errors that seem to be common in the segment files. Then I exclude:

1. Segments with name "other".
2. Segments with primary SIC code equal to zero.
3. Segments with incomplete data.

4. Segments with anomalous accounting data: (i) zero depreciation, (ii) capital spending greater than sales.

5. Segments with sales less than $50 million or assets less than $5 million.

3.6.2 Matching Procedure

Before selecting a control group of segments, I apply the same set of data requirements outlined in detail above. For the empirical test to be as powerful as possible, it is important that the control group of segments is also not affected by the oil shock. Then I look for segments with matching four-digit primary and secondary SIC codes. If there are at least five such segments, the search stops. Otherwise, I relax the matching criteria to four-digit primary and three-digit secondary SIC codes and so forth until the procedure yields at least five matching segments. The exact search sequence is as follows (P and S stand for primary and secondary, respectively): 4P4S, 4P3S, 4P2S, 3P4S, 3P3S, 3P2S, 2P4S, 2P3S, 2P2S.

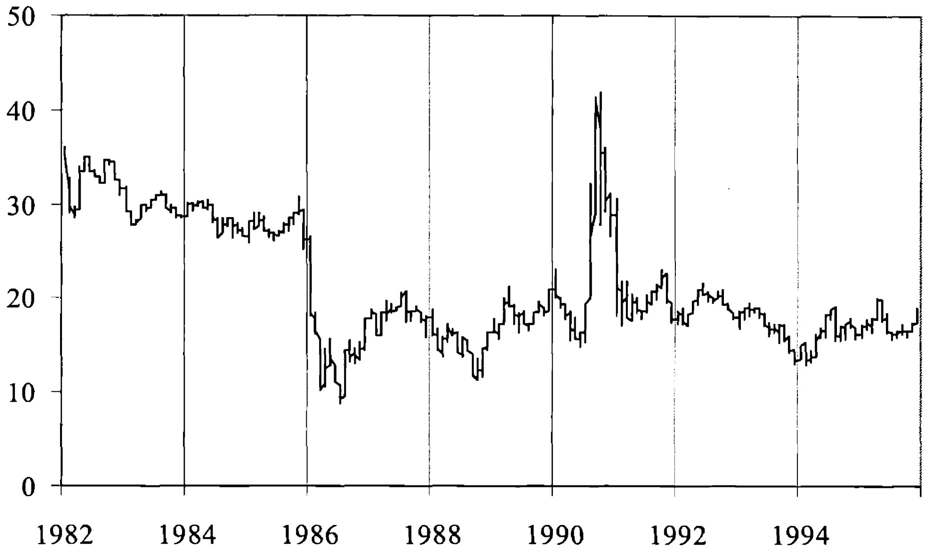

Figure 3-1: Price of Brent Oil ($)

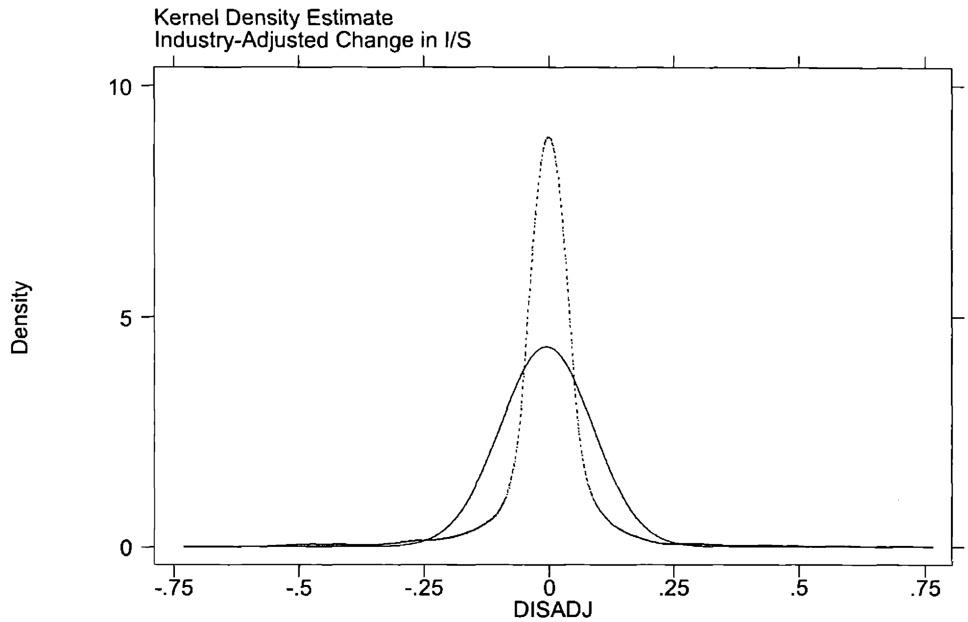

Figure 3-2: Kernel Density Estimate vs. Normal Distribution

Table I
Nonoil Segments of Oil Companies: 1985-1986 [a]

	Company	Segment	Δ I/S	Δ CF/S	1985 Sales (Mil $)	SIC Code Primary	SIC Code Secondary
1	Amoco Corp	Chemicals	3.55	6.06	2905	2860	2820
2	Atlantic Richfield Co	Spec & Intermediate Chemical	2.38	3.41	2155	2869	2865
3	Baker-Hughes Inc	Mining	-4.31	-0.75	276	3532	3569
4	Basix Corp	Print Communications	1.47	-9.87	51	2750	2721
5	Burlington Northern Santa Fe	Forest Products	-1.60	1.55	258	2411	2421
6	Burlington Northern Santa Fe	Railroad	-6.63	-4.27	4098	4011	6519
7	Cabot Corp	SPEC Chemicals & Materials	-1.40	5.62	712	2895	3339
8	Canadian Occidental	Chemicals	9.94	1.75	65	2812	2899
9	Carling O'Keefe Ltd	Brewing-Beer	-5.12	2.33	596	2082	7941
10	Chemfirst Inc	Fertilizer	0.00	-10.10	72	2873	5191
11	Chemfirst Inc	Industrial Chemicals	4.38	-5.03	79	2865	2873
12	Chevron Corp	Chemicals	-1.30	6.05	2246	2869	2865
13	Coastal Corp	Trucking	-1.22	1.19	335	4213	4212
14	Crown Central	Convenience Stores	-0.59	0.25	309	5412	5541
15	Du Pont	Agricultural-Industrial Chemical	-0.67	10.72	3388	2879	2819
16	Du Pont	Biomedical Products	0.19	3.08	1016	3844	3841
17	Du Pont	Fibers	1.43	10.77	4483	2824	2297
18	Du Pont	Polymer Products	-0.69	3.53	3379	2821	3081
19	Enterra Corp	Products	-0.88	-2.11	64	3569	3561
20	Fina Inc	Petrochemicals & Plastics	-0.95	9.36	405	2821	2911
21	Freeport McMoran Inc	Gold	-1.72	16.69	54	1041	
22	Grace (W.R.) & Co	General Business	-0.91	0.42	787	2066	5192
23	Grace (W.R.) & Co	Specialty Chemicals	-1.21	-1.01	2254	2800	3086
24	Gulf Canada Corp	Forest Products	-1.24	0.13	787	2621	2672
25	Halliburton Co	Industrial Engr-Constr Serv	-0.62	-2.96	1311	1629	8711
26	Homestake Mining	Gold	-16.64	12.11	169	1041	
27	Imperial Oil Ltd	Chemicals	0.81	4.08	542	2860	2870
28	Kerr-McGee Corp	Chemicals	-2.33	5.22	483	2812	2816
29	Litton Industries Inc	Advanced Electronic Systems	2.84	-5.65	1863	3812	3679
30	Litton Industries Inc	Marine Engineering & Prodtn	-0.32	0.05	975	3731	
31	Minstar Inc	Pleasure Boats	-1.48	-0.11	239	3732	3731
32	Minstar Inc	Sports Products	-2.68	0.46	110	3949	3151
33	Minstar Inc	Transportation & Warehousing	-1.52	0.14	298	4214	4213
34	Mobil Corp	Chemical	-0.40	4.86	2266	3081	2821
35	Mobil Corp	Retail Merchandising	-0.88	2.57	6073	5311	5961
36	Newmont Mining Corp	Gold	-46.69	15.72	102	1041	
37	Occidental Petroleum Corp	Chemical Products	-1.19	2.87	1621	2812	2874
38	Placer Dome Inc	Mining	-0.43	1.10	221	1041	1021
39	Royal Dutch/Shell Group	Chemicals	-1.12	8.49	5121	2800	2820
40	Schlumberger Ltd	Measurement & Control	-4.33	3.93	2153	3820	7373
41	Sparton Corp	Defense Electronics	0.46	16.65	79	3812	
42	Tenneco Inc	Automotive	0.77	1.65	1074	3714	5531
43	Tenneco Inc	Construction-Farm Equipment	-0.83	8.09	2697	3523	3531
44	Tenneco Inc	Natural Resources & Other	-1.77	4.26	2215	2631	
45	Tenneco Inc	Shipbuilding	-1.80	0.00	1801	3731	3610
46	Unocal Corp	Chemicals	-2.39	0.44	1217	2873	2999
47	Unocal Corp	Geothermal	-6.42	-3.69	270	4961	
48	Unocal Corp	Metals	-9.41	-3.42	129	1099	1061
49	Zapata Corp	Fishing & Related Processing	-10.29	16.45	93	2048	2077
	Average		-2.36	2.92	1304		

[a] Δ I/S and Δ CF/S are changes in segment investment and cash flow to sales ratios from 1985 to 1986. Cash flow is defined as operating profit plus depreciation. Ratios are expressed in percentage points.

Table II
Raw Segment I/S and CF/S Levels, 1985-1986 [a]

	I/S		CF/S	
	1985	1986	1985	1986
N obs	49	49	49	49
Mean	0.0894	0.0658	0.1274	0.1566
t-statistic	(5.72)	(7.98)	(8.45)	(10.11)
p-value	(0.00)	(0.00)	(0.00)	(0.00)

[a]Notes: I is segment capital spending, CF is segment cash flow and S is segment sales.

Table III
Change in I/S, 1985-1986 [a]

	Raw	Industry Adjusted
N obs	49	49
Mean	-0.0236	-0.0210
t-statistic	(2.19)	(2.01)
p-value	(0.03)	(0.05)
N positive	11	13
p-value	(0.00)	(0.00)

[a]Notes: Change in I/S from 1985 to 1986. I and S are segment capital spending and sales, respectively. Industry-adjusted change in I/S is calculated by subtracting the median change in I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. Number positive is a binomial 2-sided test of the null hypothesis that the observations are independent with equal probability of being positive or negative.

Table IV
Change in CF/S, 1985-1986 [a]

	Raw	Industry Adjusted
N obs	49	49
Mean	0.0292	0.0239
t-statistic	(3.30)	(2.74)
p-value	(0.00)	(0.01)
N positive	36	34
p-value	(0.00)	(0.01)

[a]Notes: Change in CF/S from 1985 to 1986. CF and S are segment cash flow and sales, respectively. Industry-adjusted change in CF/S is calculated by subtracting the median change in CF/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. Number positive is a binomial 2-sided test of the null hypothesis that the observations are independent with equal probability of being positive or negative.

Table V
Industry-Adjusted Level of I/S, 1985-1986 [a]

I/S	1985	1986	Δ
N obs	49	49	49
Mean	0.0326	0.0114	-0.0212
t-statistic	(2.22)	(1.43)	(2.08)
p-value	(0.03)	(0.16)	(0.04)
N positive	27	28	14
p-value	(0.57)	(0.39)	(0.00)

[a]Notes: Industry-adjusted I/S in 1985 and 1986. I and S are segment capital spending and sales, respectively. Industry-adjusted I/S is calculated by subtracting the median I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. The last column is the change in industry adjusted I/S from 1985 to 1986. Number positive is a binomial 2-sided test of the null hypothesis that the observations are independent with equal probability of being positive or negative.

Table VI
Industry-Adjusted Level of CF/S, 1985-1986 [a]

I/S	1985	1986	Δ
N obs	49	49	49
Mean	-0.0074	0.0085	0.0159
t-statistic	(0.61)	(0.74)	(1.78)
p-value	(0.55)	(0.46)	(0.08)
N positive	24	28	30
p-value	(1.00)	(0.39)	(0.15)

[a]Notes: Industry-adjusted CF/S in 1985 and 1986. CF and S are segment cash flow and sales, respectively. Industry-adjusted CF/S is calculated by subtracting the median CF/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. The last column is the change in industry adjusted CF/S from 1985 to 1986. Number positive is a binomial 2-sided test of the null hypothesis that the observations are independent with equal probability of being positive or negative.

Table VII
Change in Industry-Adjusted Level of I/S, Δ1985-1986 [a]

POCF Percentile	0%	25%	50%	75%
POCF Cutoff (%)	-2.61	5.49	22.85	53.27
N obs	108	81	55	27
Mean	-0.0074	-0.0052	-0.0153	-0.0294
t-statistic	(1.07)	(0.71)	(1.55)	(1.65)
p-value	(0.29)	(0.48)	(0.13)	(0.11)
N positive	48	36	18	9
p-value	(0.29)	(0.37)	(0.01)	(0.12)

[a]Notes: Change in industry adjusted I/S from 1985 to 1986. I and S are segment cash flow and sales, respectively. Sample cutoffs are based on POCF which is the percentage of total firm cash flow coming from the oil extraction industry (expressed in percentage points). Industry-adjusted I/S is calculated by subtracting the median I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. Number positive is a binomial 2-sided test of the null hypothesis that the observations are independent with equal probability of being positive or negative.

Table VIII
Industry-Adjusted Change in I/S [a]

Panel A: Full Sample

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	0.42	0.34	0.00	0.46	0.13	0.66	0.52	0.03	0.56	0.26	0.33	0.20	0.29	0.97	0.98
N obs	194	153	201	204	161	108	99	116	114	106	96	90	89	72	72
Raw I/S (t-1)	0.1163	0.1016	0.1082	0.0792	0.0919	0.0846	0.0871	0.1031	0.1052	0.0950	0.1359	0.1117	0.0976	0.1007	0.100[illegible]
Raw I/S (t)	0.1148	0.0984	0.0775	0.0795	0.0772	0.0719	0.0812	0.1139	0.0961	0.1096	0.1220	0.0949	0.0946	0.1091	0.106[illegible]
Change in raw I/S	-0.0015	-0.0032	-0.0308	0.0004	-0.0147	-0.0127	-0.0060	0.0108	-0.0091	0.0145	-0.0139	-0.0168	-0.0030	0.0084	0.005[illegible]
Industry-adjusted change in I/S	-0.0042	0.0024	-0.0166	-0.0029	-0.0160	-0.0073	-0.0030	0.0044	-0.0115	0.0169	-0.0082	-0.0132	-0.0067	0.0085	-0.002[illegible]
t-statistic	(0.53)	(0.36)	(2.85)	(0.41)	(2.02)	(1.09)	(0.46)	(0.47)	(1.38)	(1.82)	(0.84)	(1.78)	(0.99)	(0.65)	(0.25)
p-value	0.595	0.716	0.005	0.686	0.045	0.277	0.645	0.639	0.170	0.071	0.404	0.078	0.326	0.516	0.805

Panel B: Sample Cutoff at 25 Percentile

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	5.18	5.68	5.87	6.43	4.18	4.33	4.86	3.93	5.62	4.87	5.76	10.91	7.08	7.85	11.88
N obs	146	115	153	154	121	83	75	87	87	80	73	68	68	54	54
Raw I/S (t-1)	0.1192	0.1033	0.1141	0.0791	0.0938	0.0811	0.0757	0.1052	0.1165	0.0995	0.1586	0.1174	0.0992	0.0979	0.080[illegible]
Raw I/S (t)	0.1187	0.1036	0.0792	0.0828	0.0765	0.0691	0.0771	0.1223	0.1056	0.1219	0.1420	0.0964	0.0951	0.0951	0.093[illegible]
Change in raw I/S	-0.0005	0.0003	-0.0349	0.0037	-0.0172	-0.0120	0.0013	0.0172	-0.0109	0.0223	-0.0166	-0.0210	-0.0041	-0.0028	0.013[illegible]
Industry-adjusted change in I/S	-0.0044	0.0051	-0.0189	0.0002	-0.0187	-0.0083	0.0028	0.0098	-0.0131	0.0245	-0.0107	-0.0166	-0.0097	-0.0030	0.003[illegible]
t-statistic	(0.45)	(0.63)	(2.89)	(0.02)	(1.86)	(1.14)	(0.56)	(0.83)	(1.23)	(2.11)	(0.84)	(1.80)	(1.14)	(0.23)	(0.41)
p-value	0.656	0.532	0.004	0.981	0.066	0.259	0.577	0.410	0.222	0.038	0.403	0.077	0.257	0.819	0.687

[a]Notes: Industry-adjusted change in I/S for the period 1980-1995. I and S are segment cash flow and sales, respectively. Industry-adjusted change in I/S is calculated by subtracting the median change in I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment. Sample selection is based on percentage of total firm assets in the oil extraction industry. POASSET cutoff, expressed in percentage points, is determined annually.

Table VIII (cont.)
Industry-Adjusted Change in I/S

Panel C: Sample Cutoff at 50 Percentile

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	13.64	19.51	20.10	16.11	10.13	16.80	13.58	13.05	13.59	12.80	15.23	16.84	16.07	19.51	17.58
N obs	99	78	101	102	83	54	51	58	57	54	48	45	47	37	36
Raw I/S (t-1)	0.1077	0.1025	0.1217	0.0780	0.0875	0.0882	0.0668	0.1203	0.1349	0.1036	0.1615	0.1111	0.0906	0.0862	0.0709
Raw I/S (t)	0.1190	0.1112	0.0808	0.0795	0.0652	0.0693	0.0719	0.1331	0.1211	0.1156	0.1412	0.0909	0.0858	0.0806	0.0895
Change in raw I/S	0.0113	0.0086	-0.0409	0.0015	-0.0223	-0.0189	0.0051	0.0128	-0.0138	0.0120	-0.0203	-0.0202	-0.0048	-0.0056	0.0187
Industry-adjusted change in I/S	0.0116	0.0134	-0.0268	-0.0025	-0.0219	-0.0173	0.0024	0.0035	-0.0183	0.0134	-0.0194	-0.0110	-0.0081	-0.0007	0.0138
t-statistic	(0.99)	(1.23)	(3.54)	(0.24)	(1.90)	(1.72)	(0.39)	(0.21)	(1.18)	(1.21)	(1.20)	(0.89)	(0.72)	(0.07)	(1.38)
p-value	0.323	0.221	0.001	0.812	0.061	0.091	0.695	0.835	0.242	0.232	0.237	0.378	0.475	0.943	0.177

Panel D: Sample Cutoff at 75 Percentile

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	28.82	37.65	35.82	30.68	27.25	35.82	28.03	29.98	35.03	31.59	35.71	31.92	34.99	35.50	33.34
N obs	51	39	51	51	43	29	27	29	29	27	24	23	23	19	18
Raw I/S (t-1)	0.1373	0.1206	0.1155	0.0781	0.0912	0.0789	0.0558	0.1558	0.1458	0.1214	0.1779	0.1176	0.0912	0.0904	0.0756
Raw I/S (t)	0.1595	0.1225	0.0863	0.0681	0.0541	0.0674	0.0650	0.1677	0.1195	0.1465	0.1575	0.0761	0.0975	0.0816	0.0864
Change in raw I/S	0.0222	0.0018	-0.0292	-0.0099	-0.0371	-0.0115	0.0092	0.0119	-0.0263	0.0252	-0.0204	-0.0415	0.0063	-0.0088	0.0108
Industry-adjusted change in I/S	0.0269	0.0069	-0.0138	-0.0129	-0.0364	-0.0097	0.0092	-0.0006	-0.0259	0.0227	-0.0177	-0.0286	0.0106	-0.0039	0.0100
t-statistic	(1.26)	(0.41)	(1.57)	(0.85)	(1.99)	(1.38)	(0.96)	(0.02)	(0.95)	(1.15)	(1.27)	(1.34)	(0.99)	(0.33)	(0.88)
p-value	0.214	0.684	0.122	0.397	0.053	0.177	0.345	0.984	0.349	0.260	0.218	0.194	0.331	0.749	0.393

Table IX
Industry-Adjusted Change in I/S
(Control Group Excludes Multi-Segment Firms) [a]

Panel A: Full Sample

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	0.42	0.34	0.00	0.46	0.13	0.66	0.52	0.03	0.56	0.26	0.33	0.2	0.29	0.97	0.98
N obs	153	122	181	187	147	96	95	114	109	98	92	89	85	69	70
Raw I/S (t-1)	0.1052	0.0902	0.0967	0.0748	0.0878	0.0785	0.0899	0.1036	0.1078	0.0980	0.1377	0.1127	0.0971	0.0967	0.1015
Raw I/S (t)	0.0941	0.0831	0.0733	0.0730	0.0758	0.0722	0.0838	0.1139	0.0986	0.1139	0.1233	0.0958	0.0934	0.1119	0.1069
Change in raw I/S	-0.0110	-0.0071	-0.0234	-0.0018	-0.0119	-0.0064	-0.0061	0.0103	-0.0092	0.0159	-0.0144	-0.0169	-0.0037	0.0152	0.0053
Industry-adjusted change in I/S	-0.0099	0.0006	-0.0096	-0.0090	-0.0118	-0.0002	-0.0010	0.0036	-0.0093	0.0147	-0.0098	-0.0112	-0.0053	0.0146	0.0023
t-statistic	(1.66)	(0.10)	(1.57)	(1.61)	(1.48)	(0.04)	(0.14)	(0.38)	(1.04)	(1.45)	(0.94)	(1.48)	(0.84)	(1.31)	(0.20)
p-value	0.098	0.917	0.119	0.110	0.140	0.972	0.887	0.702	0.300	0.151	0.348	0.141	0.405	0.194	0.840

Panel B: Sample Cutoff at 50 Percentile

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
POASSET Cutoff (%)	13.64	20.14	20.07	15.76	9.51	15.62	13.58	13.48	14.97	12.87	15.26	16.87	16.07	19.74	17.79
N obs	77	61	92	95	74	50	49	57	56	49	47	45	45	35	36
Raw I/S (t-1)	0.0892	0.0879	0.1013	0.0697	0.0756	0.0688	0.0688	0.1221	0.1370	0.1046	0.1602	0.1111	0.0872	0.0854	0.0709
Raw I/S (t)	0.0812	0.0834	0.0694	0.0705	0.0581	0.0622	0.0740	0.1354	0.1231	0.1199	0.1376	0.0909	0.0812	0.0820	0.0895
Change in raw I/S	-0.0080	-0.0046	-0.0319	0.0008	-0.0176	-0.0066	0.0052	0.0132	-0.0139	0.0153	-0.0226	-0.0202	-0.0059	-0.0034	0.0187
Industry-adjusted change in I/S	-0.0075	0.0028	-0.0192	-0.0060	-0.0171	-0.0024	0.0021	0.0032	-0.0168	0.0125	-0.0213	-0.0086	-0.0070	-0.0037	0.0155
t-statistic	(0.91)	(0.31)	(2.39)	(0.71)	(1.60)	(0.51)	(0.31)	(0.20)	(1.02)	(1.00)	(1.23)	(0.67)	(0.70)	(0.51)	(1.51)
p-value	0.363	0.757	0.019	0.479	0.114	0.610	0.759	0.845	0.311	0.323	0.226	0.505	0.486	0.612	0.141

[a]Notes: Industry-adjusted change in I/S for the period 1980-1995. I and S are segment cash flow and sales, respectively. The control group used for the industry adjustment consists of single-segment firms only. Sample selection is based on percentage of total firm assets in the oil extraction industry. POASSET cutoff, expressed in percentage points, is determined annually. Industry-adjusted change in I/S is calculated by subtracting the median change in I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment.

Table X
Industry-Adjusted Change in I/S of Chemical Segments [a]

Panel A: Chemical Subsample, Unrestricted Control Group

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
N obs	42	33	39	37	28	24	23	23	24	27	23	23	26	20	21
Raw I/S (t-1)	0.1075	0.0962	0.0900	0.0701	0.0904	0.0599	0.0569	0.0800	0.0694	0.0857	0.1315	0.1186	0.0868	0.0720	0.0516
Raw I/S (t)	0.0955	0.0961	0.0549	0.0843	0.0627	0.0659	0.0607	0.0832	0.0753	0.1087	0.1116	0.0816	0.0655	0.0537	0.0665
Change in raw I/S	-0.0120	-0.0002	-0.0352	0.0142	-0.0276	0.0059	0.0038	0.0031	0.0059	0.0230	-0.0199	-0.0370	-0.0213	-0.0183	0.0149
Industry-adjusted change in I/S	-0.0087	-0.0011	-0.0103	0.0102	-0.0374	0.0062	0.0039	-0.0097	-0.0036	0.0179	-0.0163	-0.0308	-0.0162	-0.0192	0.0062
t-statistic	(0.66)	(0.12)	(1.04)	(0.58)	(1.57)	(0.93)	(0.75)	(0.83)	(0.36)	(1.69)	(1.30)	(2.11)	(1.58)	(2.66)	(1.12)
p-value	0.513	0.906	0.304	0.568	0.128	0.362	0.461	0.416	0.723	0.103	0.207	0.046	0.128	0.015	0.278

Panel B: Chemical Subsample, Single-Segment Control Group

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
N obs	42	33	39	37	28	24	23	23	24	27	23	23	26	20	21
Raw I/S (t-1)	0.1075	0.0962	0.0900	0.0701	0.0904	0.0599	0.0569	0.0800	0.0694	0.0857	0.1315	0.1186	0.0868	0.0720	0.0516
Raw I/S (t)	0.0955	0.0961	0.0549	0.0843	0.0627	0.0659	0.0607	0.0832	0.0753	0.1087	0.1116	0.0816	0.0655	0.0537	0.0665
Change in raw I/S	-0.0120	-0.0002	-0.0352	0.0142	-0.0276	0.0059	0.0038	0.0031	0.0059	0.0230	-0.0199	-0.0370	-0.0213	-0.0183	0.0149
Industry-adjusted change in I/S	-0.0122	0.0124	-0.0165	0.0093	-0.0284	0.0069	0.0037	-0.0071	-0.0072	0.0159	-0.0192	-0.0271	-0.0201	-0.0195	0.0114
t-statistic	(0.94)	(1.40)	(1.65)	(0.53)	(1.18)	(1.00)	(0.69)	(0.62)	(0.78)	(1.51)	(1.39)	(1.95)	(1.98)	(2.81)	(2.12)
p-value	0.351	0.172	0.108	0.598	0.250	0.329	0.495	0.539	0.446	0.143	0.180	0.064	0.059	0.011	0.047

[a]Notes: Industry-adjusted change in I/S of chemical segments for the period 1980-1995. Given the small sample size, no sample cutoff is applied. The control group used for the industry adjustment consists of only single-segment firms in Panel B. Industry-adjusted change in I/S is calculated by subtracting the median change in I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment.

Table XI
Summary Statistics
Industry Adjusted Δ I/S [a]

N	1875
Mean	-0.0049
Std Dev	0.0915
Skewness	-0.6309
Kurtosis	18.8816
Distribution	
Min	-0.7057
1%	-0.3903
5%	-0.1311
10%	-0.0651
25%	-0.0205
50%	-0.0004
75%	0.0174
90%	0.0567
95%	0.0984
99%	0.2873
Max	0.7403
Kolmogorov-Smirnov Test	
D-stat	-2.6404
p-value	0.0000

[a]Notes: Summary statistics for industry-adjusted change in I/S for the period 1980-1995. I and S are segment cash flow and sales, respectively. Industry-adjusted change in I/S is calculated by subtracting the median change in I/S of a control group of segments that were in the same industry but were owned by companies that did not have an oil-related segment.

Table XII
Bootstrapped Confidence Intervals
Industry-Adjusted Change in I/S [a]

Panel A: Full Sample

Year	Ind Adj Δ I/S	N	Bootstrapped 90% CI		Different From Zero
1981	-0.0042	194	-0.0174	0.0086	No
1982	0.0024	153	-0.0087	0.0133	No
1983	-0.0166	201	-0.0262	-0.0072	Yes
1984	-0.0029	204	-0.0142	0.0086	No
1985	-0.0160	161	-0.0297	-0.0039	Yes
1986	-0.0073	108	-0.0187	0.0031	No
1987	-0.0030	99	-0.0143	0.0068	No
1988	0.0044	116	-0.0112	0.0196	No
1989	-0.0115	114	-0.0258	0.0015	No
1990	0.0169	106	0.0024	0.0327	Yes
1991	-0.0082	96	-0.0252	0.0070	No
1992	-0.0132	90	-0.0256	-0.0018	Yes
1993	-0.0067	89	-0.0184	0.0036	No
1994	0.0085	72	-0.0121	0.0305	No
1995	-0.0027	72	-0.0212	0.0147	No

[a]Notes: This table presents bootstrapped confidence intervals for estimated mean industry-adjusted change in I/S. For each year, 10,000 bootstrap replications are performed. In each replication for a given year, a random sample of equal size (N) is drawn (with replacement) from the original sample and then a mean value is calculated. The bootstrapped confidence intervals are the 5th and 95th percentile observations from the empirical distribution of calculated means after 10,000 replications.

Table XII
Bootstrapped Confidence Intervals
Industry-Adjusted Change in I/S (cont.)

Panel B: Sample Cutoff at 25th Percentile

Year	Ind Adj Δ I/S	N	Bootstrapped 90% CI		Different From Zero
1981	-0.0044	146	-0.0205	0.0119	No
1982	0.0051	115	-0.0082	0.0185	No
1983	-0.0189	153	-0.0297	-0.0084	Yes
1984	0.0002	154	-0.0139	0.0149	No
1985	-0.0187	121	-0.0364	-0.0033	Yes
1986	-0.0083	83	-0.0211	0.0026	No
1987	0.0028	75	-0.0049	0.0113	No
1988	0.0098	87	-0.0099	0.0291	No
1989	-0.0131	87	-0.0314	0.0038	No
1990	0.0245	80	0.0067	0.0445	Yes
1991	-0.0107	73	-0.0334	0.0084	No
1992	-0.0166	68	-0.0324	-0.0020	Yes
1993	-0.0097	68	-0.0243	0.0029	No
1994	-0.0030	54	-0.0252	0.0177	No
1995	0.0033	54	-0.0095	0.0169	No

Table XII
Bootstrapped Confidence Intervals
Industry-Adjusted Change in I/S (cont.)

Panel C: Sample Cutoff at 50th Percentile

Year	Ind Adj Δ I/S	N	Bootstrapped 90% CI		Different From Zero
1981	0.0116	99	-0.0069	0.0321	No
1982	0.0134	78	-0.0047	0.0314	No
1983	-0.0268	101	-0.0400	-0.0149	Yes
1984	-0.0025	102	-0.0198	0.0145	No
1985	-0.0219	83	-0.0424	-0.0042	Yes
1986	-0.0173	54	-0.0356	-0.0029	Yes
1987	0.0024	51	-0.0069	0.0131	No
1988	0.0035	58	-0.0243	0.0299	No
1989	-0.0183	57	-0.0441	0.0062	No
1990	0.0134	54	-0.0038	0.0321	No
1991	-0.0194	48	-0.0485	0.0040	No
1992	-0.0110	45	-0.0320	0.0079	No
1993	-0.0081	47	-0.0272	0.0081	No
1994	-0.0007	37	-0.0157	0.0142	No
1995	0.0138	36	-0.0014	0.0308	No

Table XII
Bootstrapped Confidence Intervals
Industry-Adjusted Change in I/S (cont.)

Panel D: Sample Cutoff at 75th Percentile

Year	Ind Adj Δ I/S	N	Bootstrapped 90% CI		Different From Zero
1981	0.0269	51	-0.0062	0.0622	No
1982	0.0069	39	-0.0209	0.0337	No
1983	-0.0138	51	-0.0281	0.0001	No
1984	-0.0129	51	-0.0383	0.0107	No
1985	-0.0364	43	-0.0679	-0.0093	Yes
1986	-0.0097	29	-0.0212	0.0017	No
1987	0.0092	27	-0.0043	0.0261	No
1988	-0.0006	29	-0.0504	0.0456	No
1989	-0.0259	29	-0.0721	0.0153	No
1990	0.0227	27	-0.0054	0.0569	No
1991	-0.0177	24	-0.0411	0.0034	No
1992	-0.0286	23	-0.0655	0.0028	No
1993	0.0106	23	-0.0061	0.0284	No
1994	-0.0039	19	-0.0223	0.0158	No
1995	0.0100	18	-0.0062	0.0291	No

Table XIII
Petrochemicals Database
Event Summary [a]

Panel A: Non-Oil Firms

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
N of active units, BOY	797	817	832	755	721	739	747	769	815	831	854	890	891	948	973	1022
Add																
New units (greenfield/acquired)	54	101	41	36	67	60	69	141	80	75	75	31	76	72	68	89
Resume	0	0	0	0	0	0	0	1	6	2	3	0	0	0	1	1
Subtract																
Idled	0	0	2	1	3	7	5	7	2	0	0	7	2	6	0	1
Merged	0	0	1	0	9	2	1	14	7	0	5	0	1	6	2	8
Scrap	28	81	88	61	28	37	14	9	20	14	9	13	16	13	6	18
Sold	6	3	22	8	7	11	36	66	49	47	25	7	6	20	10	16
Unexplained	0	-2	-5	0	-2	5	9	0	8	7	-3	-3	6	-2	-2	0
N of active units, EOY	817	832	755	721	739	747	769	815	831	854	890	891	948	973	1022	1069
Scale up	66	75	94	54	67	113	94	105	116	136	141	144	99	196	161	206
Maintain	658	567	570	602	552	486	528	515	563	557	594	608	675	636	732	691
Scale down	36	78	47	28	52	50	46	39	24	24	61	44	50	38	32	71
Reorganization	3	13	8	1	3	33	22	14	33	53	17	67	40	33	30	10
Conversion/Move	0	0	0	0	0	0	1	0	1	0	2	0	2	0	0	1

[a]Notes: Based on a comprehensive dataset of petrochemical plants in the U.S.

Table XIII (cont.) Petrochemicals Database Event Summary

Panel B: Oil Firms

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
N of active units, BOY	594	601	610	617	581	569	577	554	538	543	533	549	561	581	587	599
Add																
New units (greenfield/acquired)	24	32	31	9	26	73	10	11	20	15	38	28	37	20	26	-16
Resume	0	1	0	0	0	0	2	1	2	0	0	0	0	1	0	0
Subtract																
Idled	1	0	1	4	0	2	3	2	1	3	3	1	1	2	0	0
Merged	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scrap	16	22	26	37	22	15	14	3	2	9	11	11	5	5	0	8
Sold	0	2	1	4	16	45	17	21	11	9	3	2	6	15	15	25
Unexplained	0	0	4	0	0	-3	-1	-2	-3	-4	-5	-2	-5	7	1	0
N of active units, EOY	601	610	617	581	569	577	554	538	543	533	549	561	581	587	599	550
Scale up	41	53	83	43	35	53	67	85	118	109	88	96	63	66	66	139
Maintain	512	489	442	496	469	383	416	410	367	385	409	377	445	467	373	378
Scale down	23	32	50	33	37	66	17	23	20	23	16	29	36	23	62	19
Reorganization	0	3	7	0	2	5	43	10	17	2	3	33	5	2	71	27
Conversion/Move	1	0	0	0	0	0	0	0	2	3	0	0	0	1	0	3

Table XIV
Petrochemicals Database
Ordered Probit [a]

	Model I		Model II	
Year	N obs	Coefficient	N obs	Coefficient
1980	1336	-0.0312	1342	0.0153
		(0.39)		(0.19)
1981	1294	0.1259	1299	0.1211
		(1.72)		(1.67)
1982	1286	-0.0265	1309	0.0895
		(0.37)		(1.30)
1983	1256	-0.0854	1268	-0.0496
		(1.05)		(0.63)
1984	1212	-0.0881	1235	-0.1621
		(1.13)		(2.16)
1985	1151	-0.3093	1207	-0.4482
		(4.20)		(6.44)
1986	1168	0.0927	1221	0.1187
		(1.20)		(1.66)
1987	1177	0.0581	1264	0.1894
		(0.77)		(2.78)
1988	1208	0.1693	1268	0.2847
		(2.27)		(4.10)
1989	1234	0.0225	1290	0.1693
		(0.31)		(2.47)
1990	1309	0.1150	1337	0.1805
		(1.62)		(2.61)
1991	1298	0.0194	1307	0.0394
		(0.27)		(0.56)
1992	1368	-0.0309	1380	-0.0449
		(0.43)		(0.63)
1993	1426	-0.2878	1461	-0.2705
		(4.09)		(4.05)
1994	1426	-0.3700	1451	-0.3829
		(5.21)		(5.59)
1995	1504	0.2043	1545	0.0741
		(3.12)		(1.19)

[a] Model I tests ordered probit of scale down/maintain/scale up. Model II tests sold/scale down/maintain/scale up.

Table XV
Unconditional Test
Industry-Adjusted Change in I/S [a]

Panel A: Full Sample

Year	Ind Adj Δ I/S	N	Distribution 5%	95%	Outside 5%-95%
1981	-0.0042	194	-0.0158	0.0057	No
1982	0.0024	153	-0.0172	0.0072	No
1983	-0.0166	201	-0.0157	0.0055	Yes
1984	-0.0029	204	-0.0156	0.0056	No
1985	-0.0160	161	-0.0170	0.0069	No
1986	-0.0073	108	-0.0200	0.0093	No
1987	-0.0030	99	-0.0203	0.0101	No
1988	0.0044	116	-0.0190	0.0087	No
1989	-0.0115	114	-0.0188	0.0093	No
1990	0.0169	106	-0.0199	0.0095	Yes
1991	-0.0082	96	-0.0204	0.0104	No
1992	-0.0132	90	-0.0208	0.0108	No
1993	-0.0067	89	-0.0213	0.0108	No
1994	0.0085	72	-0.0228	0.0128	No
1995	-0.0027	72	-0.0229	0.0127	No

[a] Notes: This table presents unconditional critical values to test statistical difference between mean industry-adjusted change in I/S in a particular year and the whole period 1980-1995. To derive critical values for each test, 10,000 monte-carlo runs are performed. In each run, a random sample of equal size (N) is drawn (with replacement) from the whole period 1980-1995 and then a mean value is calculated. The unconditional critical values are the 5th and 95th percentile observations from the empirical distribution of calculated means after 10,000 runs.

Table XV
Unconditional Test
Industry-Adjusted Change in I/S (cont.)

Panel B: Sample Cutoff at 25th Percentile

Year	Ind Adj Δ I/S	N	Distribution 5%	95%	Outside 5%-95%
1981	-0.0044	146	-0.0178	0.0085	No
1982	0.0051	115	-0.0198	0.0098	No
1983	-0.0189	153	-0.0174	0.0080	Yes
1984	0.0002	154	-0.0174	0.0077	No
1985	-0.0187	121	-0.0189	0.0096	No
1986	-0.0083	83	-0.0218	0.0126	No
1987	0.0028	75	-0.0225	0.0138	No
1988	0.0098	87	-0.0216	0.0121	No
1989	-0.0131	87	-0.0215	0.0122	No
1990	0.0245	80	-0.0225	0.0126	Yes
1991	-0.0107	73	-0.0231	0.0136	No
1992	-0.0166	68	-0.0239	0.0143	No
1993	-0.0097	68	-0.0239	0.0141	No
1994	-0.0030	54	-0.0264	0.0164	No
1995	0.0033	54	-0.0268	0.0162	No

Table XV
Unconditional Test
Industry-Adjusted Change in I/S (cont.)

Panel C: Sample Cutoff at 50th Percentile

Year	Ind Adj Δ I/S	N	Distribution 5%	95%	Outside 5%-95%
1981	0.0116	99	-0.0210	0.0103	Yes
1982	0.0134	78	-0.0233	0.0124	Yes
1983	-0.0268	101	-0.0207	0.0101	Yes
1984	-0.0025	102	-0.0209	0.0099	No
1985	-0.0219	83	-0.0223	0.0116	No
1986	-0.0173	54	-0.0265	0.0154	No
1987	0.0024	51	-0.0275	0.0157	No
1988	0.0035	58	-0.0258	0.0150	No
1989	-0.0183	57	-0.0263	0.0156	No
1990	0.0134	54	-0.0265	0.0161	No
1991	-0.0194	48	-0.0284	0.0172	No
1992	-0.0110	45	-0.0292	0.0174	No
1993	-0.0081	47	-0.0283	0.0176	No
1994	-0.0007	37	-0.0320	0.0204	No
1995	0.0138	36	-0.0320	0.0209	No

Table XV
Unconditional Test
Industry-Adjusted Change in I/S (cont.)

Panel D: Sample Cutoff at 75th Percentile

Year	Ind Adj Δ I/S	N	Distribution 5%	95%	Outside 5%-95%
1981	0.0269	51	-0.0293	0.0196	Yes
1982	0.0069	39	-0.0323	0.0228	No
1983	-0.0138	51	-0.0289	0.0195	No
1984	-0.0129	51	-0.0291	0.0197	No
1985	-0.0364	43	-0.0307	0.0218	Yes
1986	-0.0097	29	-0.0363	0.0271	No
1987	0.0092	27	-0.0381	0.0285	No
1988	-0.0006	29	-0.0366	0.0271	No
1989	-0.0259	29	-0.0370	0.0265	No
1990	0.0227	27	-0.0390	0.0277	No
1991	-0.0177	24	-0.0403	0.0299	No
1992	-0.0286	23	-0.0410	0.0305	No
1993	0.0106	23	-0.0418	0.0308	No
1994	-0.0039	19	-0.0454	0.0351	No
1995	0.0100	18	-0.0460	0.0353	No