# ESSAYS ON INVESTOR-MANAGER CONFLICT AND CORPORATE FINANCIAL DECISION-MAKING

By

GUOCHANG ZHANG

B. Eng., SHANGHAI JAOTONG UNIVERSITY, 1983
M. Sc., UNIVERSITY OF BRITISH COLUMBIA, 1987

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENT FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
in

THE FACULTY OF GRADUATE STUDIES

THE FACULTY OF COMMERCE AND BUSINESS ADMINISTRATION

THE UNIVERSITY OF BRITISH COLUMBIA

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

March 1992

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Commerce and Business Administration

The University of British Columbia
Vancouver, Canada

Date April 21, 1992

## Abstract

This thesis examines the role of financial policy in resolving investment conflicts between investors and managers. The method of analysis is an analytical one. The thesis first surveys two areas of research: agency-theoretical studies of corporate capital investment and capital structure theories.

The main body of the thesis consists of three essays in which various capital budgeting situations are modelled and different aspects of corporate financial policy are analysed. Essay one models an investment problem of a multiple division firm and shows that capital rationing can be used to force managers to compete for investment capital and therefore reduce their incentive to shirk. The main result is that, if a firm's investment opportunities are not highly profitable, investors may be better off with capital rationing even though rationing forces the firm to forgo some profitable projects. Essay two demonstrates that direct compensation may be ineffective in providing proper managerial incentives in the presence of the limited liability condition but managerial stock acquisition can be useful instead. The signalling and screening forms of contracting for stock acquisition are analysed and then compared. The analysis provides an explanation for the existence of insider stock ownership. Essay three considers situations where external monitoring is required to discipline managers. The need for monitoring changes the structure of corporate ownership and alters the nature of agency conflict. Within this context, debt is shown to be useful in improving firms' investment efficiency because of its risk-shifting effect. Implications and empirical evidence are discussed at the end.

## TABLE OF CONTENTS

## List of Tables

## List of Figures

## Acknowledgement

I wish to express my most sincere thanks to my supervisor Professor Alan Kraus for his inspiring guidance and support during the course of this dissertation and, in fact, throughout my entire study in the PhD program. I am also very grateful to the members of my thesis committee, Professor Paul Fisher and Professor Josef Zechner, for their help and suggestions which have been important to the progress of the thesis. Professor Ron Giammarino, whose knowledge and patience are truly appreciated, offered tremendous help in many aspects of my study. I also appreciate discussions with Ed Nosal, Neal Stoughton, Joe Williams and other seminar participants at the University of British Columbia. My special thanks also go to Professors John Hughes, Peter Cheng and Asha Sadanand who made personal efforts in encouraging and assisting my initial pursuit of a doctoral degree. For many years now, I have received constant and most kind help from Mr and Mrs John Wiebe, whose warm consideration and continual support have made my life as a foreign student specially rewarding.

Financial support from the Universith of British Columbia is gratefully acknowledged.

# Chapter 1

# Introduction and Overview

A major task of corporate managers is to make capital investment decisions on behalf of investors. Typically, since managers own only a small fraction of the securities of the firms they work for, their personal interests do not coincide with those of investors. Based on personal considerations, managers may either accept an unprofitable project or reject a profitable one. Therefore, investors must find ways to influence managerial decision-making. The purpose of this thesis is to examine how firms can adopt appropriate financial policies to resolve conflicts surrounding investment decisions between investors and managers.

There are two distinct approaches to research in dealing with investment-related conflicts. One is the principal-agent approach under which the investor-manager relationship is explicitly modelled. The analysis centers on the use of direct compensation or direct compensation in conjunction with other mechanisms such as the market for corporate control. However, there has been very limited investigation of the role of financial policies under this approach.

The other approach, typically adopted in the finance literature, mainly concentrates on divergence of interest between different groups of investors. Generally, the corporate decision maker in these models represents one of the conflicting groups. The central question is how financial policy and investment decisions are inter-related. Financial policy may influence investment decisions in two ways. First, since the allocation of future cash flows is determined by the existing capital structure, capital structure will have an effect on the investment incentives of the investor group that controls the firm. Second, the choice of financing may convey information to potential investors about asset value thereby affecting the cost of external capital. This clearly affects investment decisions as well. However, this approach has been under criticism recently because managerial compensation in these models is exogenously given. Critics argue that, in a general class of problems, there is a separation of financial structure and investment incentives if managerial compensation is optimally chosen.

This thesis takes on the task of identifying conditions in which financial policy *does* affect managerial investment incentive without relying on the assumption of exogenous compensation. The thesis consists of seven chapters. Chapter 1 (this chapter) provides an introduction and overview. Chapter 2 reviews the principal-agent literature where coverage is mainly on studies dealing with investment problems. Chapter 3 surveys capital structure theories which are based on information asymmetry and/or moral hazard. Chapters 4, 5 and 6 constitute the main body of the thesis, each of which examines a particular aspect of financial policy. Below, we provide a brief overview of the research work presented in this thesis.

One type of principal-agent problem is caused by agents' aversion to effort. In performing a delegated task, an agent needs to provide effort as a production input. Here, "effort" is a general term describing the quality as well as quantity of the work provided by an agent. Tension arises between the principal and the agent because effort produces output for the principal but creates a cost to the agent. To maximize his personal utility, the agent wishes to expend as little effort as possible. This is known as the shirking problem. Chapter 4 studies how the size of initial financing, which determines the scope of a firm's investment, affects managerial shirking incentives. The model depicts a two-division firm. Initially, both the owner and the divisional managers know that the divisions face positive but potentially different NPV projects. However, only the managers observe their respective project qualities. The cash flow from each project is a function of both project quality and managerial effort. Because the managers are effort averse, they have an incentive to under-report project quality as the explanation for a low output. In doing so, the managers are able to enjoy a benefit from their private information at the expense of the owner.

One way to restrain managerial shirking behavior is to impose internal capital rationing. Under a policy of capital rationing, the owner raises only a limited amount of capital so that only one of the managers can eventually undertake a project. In this case, the managers have to compete for investment capital. This reduces the managers' incentive to under-report the state since, now, under-reporting diminishes the chance of undertaking a project. Consequently, the managers' informational rents are reduced.

However, capital rationing also restricts the firm's investment activities as it always excludes at least one positive NPV project. We show that when the projects are not highly profitable, the benefit of capital rationing exceeds its cost.

While the source of the agency problem in Chapter 4 is effort-aversion, the problems in the two following chapters are due to the existence of a managerial private benefit associated with a project. Conflicts arise because the private benefit provided by a project generally is not perfectly correlated with its monetary value. Therefore, a project may not be desirable both to investors and to the manager.

Chapter 5 examines two ways of resolving the conflict: direct compensation and managerial stock acquisition. The analysis shows that, with personal limited liability for managers, direct compensation is not always effective. It is possible that shareholders may prefer to reject a project unconditionally, in which case neither shareholders nor the manager benefit from the investment opportunity. However, the manager may be able to signal the quality of the project through personal stock acquisition. Presumably, the manager has an incentive to make a personal investment in the firm's stock only if the expected return of the project is sufficiently high. It is possible that managerial stock acquisition sends a credible signal to shareholders about the true quality of the project. This information signal then helps the firm make more precise investment decisions. Therefore, managerial stock acquisition can be beneficial to both the manager and shareholders.

Two forms of stock acquisition are considered: acquisition in the stock market and that through a pre-designed contract. If the firm's shares are diversely held, it is difficult for shareholders to coordinate their trading activities in the market. This enables the manager to appropriate part of the benefit from the firm's investment via stock acquisition in the market. One way to limit the manager's gain is to design a contract ex ante which specifies the terms of potential managerial stock acquisition. This way, the manager no longer has the freedom to decide how much stock he wishes to purchase and shareholders do not have to trade with the manager at a competitive market price. It is shown that a pre-designed contract can increase both investment efficiency and shareholders' profit. One implication from the analysis in Chapter 5 is that financial mechanisms, such as managerial stock acquisition and ownership, can play a unique role in resolving agency-related problems.

Both managerial stock acquisition and direct compensation attempt to tie the monetary interest of managers to those of investors. However, income is only one aspect of a manager's utility. Managerial decisions may also be motivated by non-monetary considerations such as power and prestige. In these situations, the resolution of agency conflict may have to rely on non-monetary oriented mechanisms. One such mechanism, as considered in Chapter 6, is direct monitoring and intervention by external investors. In practice, direct intervention by outside shareholders takes place from time to time in major corporate decisions. Those shareholders with significant ownership are particularly active in monitoring managerial behavior. The central question of Chapter 6 is, given that there is a large investor monitoring corporate decisions, how does capital structure affect investment decisions? The analysis shows that risky debt can improve the firm's investment efficiency because of its risk-shifting effect, although risk-shifting is harmful to debtholders.

# Chapter 2

# Selected Principal-Agent Literature

A principal-agent relationship exists whenever two parties enter a contractual agreement in which one party (the agent) is given the authority to make decisions or perform tasks on behalf of the other (the principal). In a publicly owned firm, managers are hired to carry out business activities whose outcome affects the wealth of the firm's external investors. Therefore, the relationship between investors and managers is a typical example of the principal-agent relationship.[1]

Conflicts exist between principals and agents for the following reasons: (1) individuals are self-interested and act to advance their own well-being, possibly at the expense of others, (2) actions taken by one party may not be observable by the other, and/or (3) one party may possess more information than the other, and the party with poor access to information is unable to judge the desirability of the action taken by the better-informed party.

## 2.1 Analysis of Delegated Production Problems

Research on the investor-manager conflict initially focused on problems where the task of the manager is to provide effort (an input) for a given production process.[2] Managerial effort is a productive factor. However, as effort is undesirable for the manager, he tends to expend as little effort as possible, which results in a shirking problem. Although both investors and the

[1]Two main reasons for the existence of the investor-manager relationship are limited individual wealth and risk-aversion.

[2]Examples include Shavel [1979], Holmstrom [1979], and Grossman and Hart [1983].

manager can agree on the socially optimal effort level, their conflict cannot be perfectly solved by contracting. There are two reasons for this. First, the manager's effort is unobservable by investors, which rules out the possibility that effort be specified by a contract. Second, since outcome is determined by external factors as well as managerial effort, investors cannot infer effort level from outcome. This implies that the contract can only be written on variables which are imperfect signals of effort.

Two opposing factors have to be taken into account in contract design: managerial incentive and risk sharing. A higher effort level generates a greater output. To encourage the manager to work diligently, compensation has to be sensitively related to output. On the other hand, since the manager is risk averse, a compensation rule with wide variations in payoff imposes a large risk on the manager which is also undesirable. The optimal compensation contract must trade off the benefit of risky compensation against the loss in risk sharing it creates.

Typically, principal-agent production problems are broadly formulated. It is difficult to get specific predictions about the equilibrium compensation contract. Nonetheless, there are a few general results coming out of the analyses. First, the optimal compensation contract should include only those variables which contain information about effort. Second, a variable should be incorporated into the contract if and only if its information content is not fully represented by variables already included in the contract. In a multiperiod framework, compensation may depend on the agent's performance in previous periods as well as in the current period even if production in each period is totally independent of other periods.[3] In the case of multiple agents, the outcome of one agent may affect compensation to another.[4] In general, restrictive conditions are required for the optimal contract to exhibit simple properties such as monotonicity and linearity. For literature surveys in this area, see Rees [1985] and Hart and Holmstrom [1987].

[3]see Lambert [1983] and Radner [1985].

[4]see Demski and Sappington [1984] and Bhattacharya and Guasch [1988].

## 2.2 Analysis of Delegated Capital Investment Problems

More recently, agency problems surrounding capital investment have also been under investigation. While the nature of the conflict in investment is no different from that in production, there is an important technical difference. In a production setting, the manager's decision is to choose an input (effort) for a given production process. In other words, the output function is exogenously given, only input is to be chosen by the manager. In an investment setting, however, the decision is whether or not to accept a project. Hence, the output function becomes endogenous. Furthermore, unlike effort which is not observed by investors, investment decisions may be observed publicly.

The studies reviewed below use either managerial compensation or compensation in conjunction with other mechanisms to resolve the investment conflict.

### 2.2.1 Models employing only direct compensation

In the models contained in this subsection, only managerial compensation is considered in examining the manager's investment behavior.

Lambert [1986] shows that either over- or under-investment inefficiencies can exist when a risk-averse manager chooses between a risky project and a riskless one. The manager can expend effort to produce information about the risky project. Since effort is privately costly to the manager, a shirking problem exists as in the production setting discussed earlier. Furthermore, even if the manager exerts effort and learns the profitability of the risky project, the manager will not necessarily select the project preferred by investors. The compensation contract has to motivate the manager not only to search for project-related information but also to make a correct investment decision. As in the production setting, the optimal contract involves a tradeoff between proper managerial incentive and risk sharing. The main result of Lambert [1986] is that, depending on the specific parameters, either under-investment or over-investment may occur in equilibrium. The investment inefficiencies are easy to understand. For example, in an extreme case where the risky project is highly profitable (ex ante) and would be accepted in most states, then it may be optimal simply to accept the risky project unconditionally without incurring the investigation cost; therefore, the equilibrium involves over-investment. On the other hand, if the risky project would be rejected in most of the states, it may be optimal to instruct the manager to reject it in all states, which results in under-investment. In this model, under-investment can be eliminated if there is costless communication between the manager and investors.

While Lambert [1986] studies a moral hazard problem, a number of other studies concern the effect of managerial reputation/ability on project selection. In these models, performance-based ex post compensation is generally ruled out. Instead, compensation is made at the beginning of each period according to the manager's perceived ability.

Campbell, Chan and Marino [1989] examine the use of different types of contracts when managerial ability is unknown to all parties. They employ a two-period model whose structure is otherwise similar to that of Lambert [1986]. In period one, the manager may choose to expend effort to discover the project quality, and in period two the risky project is either accepted or rejected in favor of the riskless project. The differences from the Lambert [1986] model are: project quality also reflects managerial ability which is initially unknown to both the principal and the manager; information about quality/ability may be revealed by managerial effort; and the information, once generated, becomes public (in Lambert, the manager learns project quality for certain if a fixed effort is expended, and the information is private to the manager). The revealed managerial ability will be used to determine the manager's compensation for the next period. The authors show the following results: if a spot contract is used in which the compensation always equals the manager's perceived ability, then the manager expends zero effort because the manager expects to receive no benefit from his costly effort; if the manager is risk neutral, a long term contract which sufficiently rewards high ability managers induces the first-best effort level; if the manager is risk averse, the optimal contract provides partial insurance both against the uncertainty in ability and against downward wage revisions over time, because there is a trade-off between risk-sharing and providing the incentive to discover project quality/ability.

The model of Campbell, Chan and Marino [1990] is a variation on their [1989] model, but now the manager receives information about project quality/ability privately and costlessly. Both the principal and the manager are risk-neutral and only linear contracts are considered. They show that there is a unique linear contract which induces the manager to make the first-best investment decision. In that contract, the manager is paid according to his perceived (average) ability. However, the optimal linear contract is subject to an adverse selection problem in a competitive environment; the high-ability managers, who are underpaid with this contract, will leave for other firms. This, of course, assumes that managerial ability is not firm specific. The authors then show that a performance-standard scheme can solve the adverse selection problem. The scheme allows the manager to choose a target performance. The higher the target, the higher the share of total outcome distributed to the manager but with a lower fixed component. Managers with different abilities voluntarily separate themselves with more capable ones selecting more ambitious targets.

### 2.2.2 Models employing direct compensation in conjunction with other mechanisms

Several studies have suggested the roles of financial policy and of the market for corporate control in disciplining managers.

In Holmstrom and Ricart i Costa [1986], investors allocate investment capital based on the information reported by the manager, which they interpret as capital rationing. The manager privately receives information about the quality of a risky project. Then he may either choose to report the information to the owner truthfully or not to report; that is, the manager can withhold but not misrepresent. The return of the project is determined not only by the project quality but also by the manager's ability. Therefore, return conveys information about the manager's ability; hence, it will affect the manager's compensation in the next period. The conflict exists mainly because project return and managerial ability are not perfectly correlated. Because of the manager's risk-aversion, the optimal wage contains a put option on the value of the manager's human capital, i.e., the wage is downward rigid. Such a wage structure, however, causes the manager to undertake undesirable projects if he is not sufficiently risk-averse. Therefore, the owner must withhold capital if a bad state is reported. An important assumption in this model is that the manager cannot misrepresent the state.

Hirshleifer and Thakor [1989] demonstrate that managerial concerns for reputation (about ability) cause managers to avoid risky projects in favor of safer but less profitable ones. They suggest that, although risk-avoiding behavior is harmful on its own account, it can be used as a precommitment for shareholders not to engage in risk-taking activities caused by the existence of debt. The model has two periods; the manager may choose a project in each period. The basic assumptions are: project selection is only observed by the manager; investors may or may not observe the success or failure of the project. A reputation effect exists if investors observe project outcome because the observed outcome will be used to re-evaluate the manager. Reputation building causes the (bad type) manager to avoid more risky but also more profitable projects. The risk-avoiding behavior of the manager, however, becomes desirable when the firm has debt outstanding because it serves as a precommitment by shareholders not to undertake excessively risky projects. The question not addressed is why there is a risk-shifting effect associated with debt if the manager alone selects the project (especially with ex ante compensation).

Boot [1989] examines the role of corporate control in motivating managers to divest bad projects. The manager in this model may be of either a good or a bad type. There are three periods. In period one, the manager decides whether or not to select a project of unknown quality. A good-type manager has a better chance of selecting a profitable project. Next, the manager learns the quality of the selected project. At this point (still in period one), the manager has the option to cancel the project, and may re-select another one if the old project is cancelled. In periods two and three, the manager has to operate the project inherited from period one. At the beginning of each period, the manager is paid a wage which is a linear function of his perceived type. There exists a universally divine sequential equilibrium in which (i) both types of managers choose a project initially, (ii) the good type always cancels an unprofitable project and reinvests but the bad is indifferent about whether or not to cancel an unprofitable project and, hence, randomizes the decision to divest, and (iii) the market lowers its valuation of the manager's ability upon observing a cancellation of a project. The good type is better off by cancelling an unprofitable project in period one in spite of the unfavorable reaction of the market, since he expects a good chance of selecting a profitable project in the second period which helps to enhance the value of his human capital in the third period. Boot then shows that the threat of takeover by another firm improves the efficiency of the divestiture decision. It is assumed that a raider can obtain information about project quality with a cost.

In Wilson [1990], investors are able to control divisional managers' investment by a proper internal financial slack. There are both good and bad projects available ex ante for divisional managers to choose from. Investment conflicts arise since project profitability is inversely related to managerial private benefit of a project. Therefore, divisional managers favor unprofitable projects over profitable ones. It is assumed that external capital is more costly than internal capital because of adverse selection problems. After the initial investment in a project, a noisy signal is observed publicly. If the signal is favorable, the project should be continued regardless of whether external or internal capital is used. If the signal is unfavorable, however, the project should be continued only if internal capital is available. A divisional manager is able to enjoy private benefit only if his project is continued. Clearly, the managers' incentive to choose bad projects decreases as the firm's financial slack becomes smaller; that is, managers are less likely to choose bad projects if they anticipate that there is a great probability of project cancellation because the firm has limited internal capital. This result has various implications for corporate financial policies such as payout ratio and capital rationing. One assumption, which seems to be restrictive in this model, is that the monetary return of a project is inversely related to its private benefit to the manager. If we think of managerial human capital as part of private benefit, a better performance generally leads to a more favorable evaluation of the manager. The relationship would more likely be positive, though imperfect in many situations. Another assumption is that the market cannot observe signals about project quality since otherwise there would not be an additional cost of external financing related to the adverse selection problem.

These studies have provided interesting insights into the use of various mechanisms in resolving the agency-related investment conflict. Nonetheless, this area of research is still at its initial stage. Of particular importance to this thesis is the fact that there has been limited examination of financial policies such as capital structure and ownership structure in the principal-agent context.

# Bibliography


[1] Antle, R., and A. Smith, 1986, "An empirical investigation of the relative performance evaluation of corporate executives", *Journal of Accounting Research 24: 1-39*

[2] Arrow, K., 1985, "The economics of agency", in J. Pratt and R. Zeckhauser (eds.), *Principals and Agents: The Structure of Business*, pp. 37–51, Boston: Harvard Business School Press

[3] Baron, D., and R. Myerson, 1982, "Regulating a monopolist with unknown costs", *Econometrica 50:* 911–30

[4] Bhattacharya, S. and Guarch 1988, "Heterogeneity, tournaments, and hierarchies", *Journal of Political Economy*, vol.96, no.4

[5] Boot, A., 1989, "Why hang on to losers: divestitures and takeovers", *working paper*, Indiana University

[6] Campbell, T., Y.-S. Chan, and A. Marino, 1990, "Incentive contracts for managers who discover and manage investment projects", *Journal of Economic Behavior and Organization*

[7] Campbell, T., Y.-S. Chan, and A. Marino, 1989 "When is it optimal to blow the whistle on yourself?", *working paper*, University of Southern California

[8] Campbell, T., and A. Marino, 1989, "On the incentive for managers to make myopic investment decisions", *working paper*, University of Southern California

[9] Fama, E., 1980, "Agency problems and the theory of firm", *Journal of Political Economy 88*:288–307

[10] Gale, D., and M. Hellwig, 1985, "Incentive compatible debt contracts: the one-period problem", *Review of Economic Studies 52*: 647–64

[11] Gjesdal, F., 1982, "Information and incentives: the agency information problem", *Review of Economic Studies 49*: 373–90

[12] Green, J., and N. Stokey, 1983, "A comparison of tournaments and contracts", *Journal of Political Economy 91*: 349–64

[13] Grossman, S., and O. Hart, 1981, "Implicit contracts, moral hazard and unemployment", *American Economic Review (Papers and Proceedings) 71*: 301–8

[14] Grossman, S., and O. Hart, 1983, "An analysis of principal-agent problem", *Econometrica 51*: 7–45

[15] Harris, M., and A. Raviv, 1979, "Optimal incentive contracts with imperfect information", *Journal of Economic Theory 20*: 231–59

[16] Hart, O., and B. Holmstrom, 1987, "The theory of contracts", in T.F. Bewley, ed., *Advances in Economic Theory: Fifth World Congress*

[17] Hirshleifer, D., and A. Thakor, 1989, "Managerial Reputation, project choice and debt", *working paper #14-89*, Anderson Graduate School of Management at UCLA

[18] Holmstrom, B., 1979, "Moral hazard and observability", *Bell Journal of Economics 10*: 74–91

[19] Holmstrom, B., 1979, "Moral hazard in teams", *Bell Journal of Economics 13*: 324–40

[20] Holmstrom, B. and P. Milgrom, 1985, "Aggregation and linearity in the provision of intertemporal incentives", *Econometrica*, vol.55, no.2: 303-328

[21] Holmstrom, B., and Ricart i Costa, 1986, "Managerial incentives and capital management", *Quarterly Journal of Economics 101*: 835–60

[22] Holmstrom, B., and L. Weiss, 1985, "Managerial incentives, investment and aggregate implication: scale effects", *Review of Economic Studies 52*: 403–26

[23] Kreps, D., and R. Wilson, 1982, "Reputation and imperfect information", *Journal of Economic Theory 27*: 253–79

[24] Laffont, J-J., and E. Maskin, 1982, "Theory of incentives: an overview", in W. Hildenbrand (ed.) *Advances in Economic Theory*, pp. 31–94. Cambridge: Cambridge University Press

[25] Laffont, J-J., and J. Torile, 1986, "Using cost observation to regulate firms", *Journal of Political Economy 94*: 614–41

[26] Lambert, R., 1983, "Long-term contracting and moral hazard", *Bell Journal of Economics 14*: 441–52

[27] Lambert, R., 1983, "Executive effort and selection of risky projects", *Rand Journal of Economics 16*: 77–88

[28] Lazear, E., and S. Rosen, 1981, "Rank-order tournaments as optimum labour contracts", *Journal of Political Economy 89*: 841–64

[29] Mirrlees, J., 1971, "An exploration in the theory of optimum income taxation", *Review of Economic Studies 38*: 175–208

[30] Mirrlees, J., 1975, "The theory of moral hazard of unobservable behavior–Part 1", Nuffield College, Oxford.

[31] Mirrlees, J., 1976, "The optimal structure of authority and incentives within an organization",*Bell Journal of Economics 7*: 105–31

[32] Murphy, K., 1986, "Incentives, learning and compensation: a theoretical and empirical investigation of managerial labour contracts", *Rand Journal of Economics 17*: 59–76

[33] Myerson, R., 1979, "Incentive compatibility and the bargaining problem", *Econometrica 47*: 61–74

[34] Myerson, R., 1982, "Optimal coordination mechanisms in generalized principal-agent problems", *Journal of Mathematical Economics 10*: 67-81

[35] Radner, R., 1985, "Repeated principal-agent games with discounting", *Econometrica 53*: 1173–98

[36] Rees, R., 1985, "The theory of principal and agent: part I", *Bulletin of Economic Research*, vol.37:3-26

[37] Rogerson, W., 1985a, "Repeated moral hazard", *Econometrica 53*: 69–76

[38] Rogerson, W., 1985b, "The first-order approach to principal-agent problems", *Econometrica 53*: 1357–68

[39] Rosen, S., 1985, "Implicit contracts: a survey", *Journal of Economic Literature 23*: 1144–75

[40] Ross, S., 1973, "The economic theory of agency: the principal's problem", *American Economic Review 63*: 134–9

[41] Shavell, S., 1979, "Risk-sharing and incentives in principal and agent relationship", *Bell Journal of Economics 10*: 55–73

[42] Spence, M., and R. Zeckhauser, 1971, "Insurance, information and individual action", *American Economic Review (Papers and Proceedings) 61*: 380–7

[43] Wilson, P., 1990, "Public ownership, delegated project selection and financial policy", *working paper*, Indiana University

[44] Wolfson, M., 1985, "Empirical evidence of incentive problems and their mitigation in oil and tax shelter programs", in J. Pratt and R. Zeckhauser (eds.) *Principals and Agents: The Structure of Business*, pp. 101–25, Boston: Harvard Business School Press

# Chapter 3

# Theories of Corporate Capital Structure

This chapter reviews existing theories of capital structure. Roughly speaking, there are two main streams of capital structure theories, one based on tax-related arguments and the other on agency conflict and information asymmetry. Since the approach adopted in this thesis belongs to the second stream, the survey in this chapter covers only capital structure theories based on information asymmetry and/or moral hazard. A common feature of these theories is that they recognize conflicts between different investor groups and between investors and managers. Two possible reasons for the conflicts are: (1) divergence of interests between managers and investors and between shareholders and debtholders, and (2) information asymmetry between existing investors and potential investors. The papers reviewed below are subjectively classified into different categories by the nature of the problem.

## 3.1 Impact of Debt on Investment Incentives

This group of models analyse a firm's investment incentive under an exogenously given capital structure. The existing capital structure affects how future cash flows are allocated between shareholders and debtholders. Since shareholders are interested only in the part of return that they receive rather than the firm's overall return, their investment decisions become distorted.

Jensen and Meckling [1976] argue that the existence of risky debt causes shareholders to accept excessively risky (and unprofitable) projects. Due to the limited liability condition, the equityholders can unload the downside loss but reap the upside gain. Therefore, levered equity can be viewed as a call option on the firm's assets. The option pricing theories suggest a positive relation between the value of the call option and the variance of return on the underlying asset. Therefore, a negative NPV project with a large return variance may be acceptable to equityholders. This risk-taking effect of debt, also called the asset-substitution effect, is demonstrated in a formal model by Green [1984].

Myers [1977] also studies the investment incentive of a levered firm, but arrives at a different kind of incentive problem. Without any debt, shareholders provide all the investment capital and receive all future returns. A project is undertaken whenever it has a positive NPV. When there is debt outstanding, shareholders may still have to contribute all the investment capital, but now have to share the returns with debtholders. This reduces the shareholders' incentive to invest and leads them to forego some positive NPV projects.

## 3.2 Financing Choice as an Informational Signal

In financial signalling models, existing investors (represented by an insider) need to issue securities to external investors in order to finance a new project. An implicit assumption is that existing investors are unable to provide all the necessary funds. The insider has more information than outsiders either about the value of assets in place or about the new investment or both. Therefore, the insider knows the true value of the security, but outsiders' evaluation is based on the average of all possible types of firms which enter the market. If an identical security is issued by several different types, the security is overvalued for some types and undervalued for others. Undervaluation hurts existing shareholders; hence, the insider wishes to minimize it. The way to do this is to offer a distinctive security package which sends an implicit signal that the firm is of a good type. A necessary and sufficient condition for the signal to be credible is that bad types do not find it in their interests to duplicate the security package offered by a good type. In other words, mimicking is costly for bad types.

### 3.2.1 Financing choice with given investment decisions

The signalling models covered in this subsection have the common feature that firms need to finance a given profitable project by issuing securities to outside investors. Therefore, the optimal investment decision is publicly known, and there are no investment inefficiencies. Also, if the equilibrium is fully separating, there is no loss in financing for any type. However, the equilibrium may still be costly for other reasons such as under-diversification (Leland and Pyle [1977]).

Leland and Pyle [1977] are among the first to apply the signalling technique to corporate finance. There is an insider (owner-manager) who wishes to raise capital to build a firm. The owner chooses a combination of external equity and debt and retains a fraction of the equity. The debt is on the owner's personal account and is assumed to be default-free. There is information asymmetry about the true mean return of the firm. If the mean return is high and if the owner does not signal, the firm's securities will be undervalued. Therefore, the motive for signalling is to avoid under-valuation. The cost of signalling comes from under-diversification of risk for the owner. Leland and Pyle derive a fully separating equilibrium in which the owner whose firm has a higher mean return retains a larger fraction of equity. However, the relationship between the debt level and the firm type is positive only under special conditions.

While signalling is costly in Leland and Pyle, other studies show that costless financial signalling is possible.

In Heinkel [1982], the insider (entrepreneur) needs to raise a known amount of capital to finance a valuable project. A combination of risky debt and equity is chosen for financing the project. The insider signals the project type by choosing a certain amount of debt. The size of debt then determines the necessary amount of external equity. To avoid mimicking across types, it requires that debt and external equity of each type not be overvalued simultaneously. This implies the following condition on return distribution: firms with higher mean returns also have higher variances of return; therefore, those types with higher equity values must have lower debt values.

Brennan and Kraus [1987] examine costless signalling from a different perspective. Specifically, their purpose is to derive the properties of the *net* payoff function of financing in a costless signalling equilibrium. Here, financing decisions include not only issuing new securities but also retiring part or all of the existing ones. The main results are: if the returns of different firm-types satisfy the first-order stochastic dominance condition, then, in a fully separating equilibrium, the net payoff function of financing by any interior type must be nonmonotonic in return; and if the returns of different types are characterized by the condition of mean-preserving spread, the net payoff function of the financing package by any interior type is neither convex nor concave.

The authors offer an example of two firm-types. Both types have outstanding debt at the time of financing. The return of the good type first-order stochastically dominates that of the bad type. Therefore, both the debt and equity of the good type are more valuable than those of the bad one. In the costless fully revealing equilibrium, the good type issues new equity to finance the project and retire the existing debt. The bad type issues equity only. In equilibrium, the good type has no incentive to mimic the bad one since its equity would be undervalued, and the bad type will not mimic the good one either because it would lose more in paying off overvalued debt than it would gain from issuing overpriced equity.

Another model of costless signalling is presented by Constantinides and Grundy [1989]. All firms face a new project which requires external financing. The firms initially are financed by equity, a fraction of which is owned by an insider and the rest by outside investors. The insider seeks to maximize the expected payoff to his currently owned stock. Financing options include issuance of a general security and repurchase of outside stock. It is assumed that the insider is prohibited from purchasing any new security for personal holding or selling his existing holding. In equilibrium, each firm undertakes a positive NPV project. It is shown that the new security is neither straight debt nor equity, but has the characteristics of a convertible debt. For each firm, mimicking a better type makes stock repurchase too expensive, and mimicking a worse type makes the new security too underpriced.

### 3.2.2 Interaction between financing and investment decisions

In this subsection, we turn to models where the investment decision is endogenously determined jointly with the financing decision. Because of the possibilities of mispricing, a particular firm-type may either gain or lose from financing. There are two possible kinds of investment inefficiency. In one kind, unprofitable projects are undertaken in equilibrium because, for some firms, the gain from mispricing is greater than the loss in the project. The other is the rejection of profitable projects since the under-valuation of new securities would be too great to be compensated for by the gain from investment.

Myers and Majluf [1984] consider a situation where the insider knows the exact value of the existing asset and that of the potential project, but the market knows neither. The NPV of the new project is assumed to be positive for all types. The insider acts in the interest of the existing investors. If the firm issues external equity to finance the new project, the equity will be underpriced when the value of the existing asset is high. It is possible that, from the existing investors' perspective, the underpricing more than offsets the gain from the new project, in which case the insider will choose to forego the positive NPV project, creating an under-investment problem. A similar situation occurs with external debt financing. However, under certain conditions, the magnitude of debt mispricing is less than that of equity. Firms whose existing assets have high value, which would be severely undervalued in equity financing, will choose debt over equity. This then leaves only previously overvalued firms in the pool of equity financing. Anticipating this, the market then rationally rejects any equity financing. In equilibrium, all types finance the project through debt. Due to decreases in underpricing, some firms which would have foregone the new project with equity financing will now accept the project with debt financing. Therefore, investment efficiency improves with debt financing. However, an under-investment problem still exists. Clearly, no under-investment would occur if the firm could finance the project with internal funds. An implication is that firms prefer internal capital to external capital and, if external funding is required, prefer debt to equity. This sequence of financing order is referred to by Myers [1984] as the pecking order theory. The analysis also explains that firms may be justified in building financial slack.

Noe [1988], on the other hand, shows that firms may not always prefer external debt to external equity. For a very good type, under-pricing occurs with either debt or equity financing. The extent to which a security is underpriced really depends on the probability distribution of the types issuing the same security. Noe's result suggests that debt-related underpricing may or may not be smaller than equity-related underpricing.

Narayanan [1988] points out the problem of over-investment due to adverse selection. The model assumes information asymmetry about the new project but not about the asset in place. The NPV of the project may be either positive or negative. As in the above models, because of the average pricing rule followed by the competitive market, some firms will be over-valued and others under-valued. This implies the possibility that some negative NPV projects may be undertaken when over-valuation from financing is sufficiently great.

Heinkel and Zechner [1990] illustrate that investment inefficiency caused by the adverse selection problem in financing can be reduced or eliminated by an appropriate choice of capital structure before the new project arrives. Their model structure is similar to Narayanan [1988], i.e., a firm needs external financing for a new project whose profitability is known only by the insider. The insider's objective is to maximize the expected return to the existing shareholders. The main difference is that the firm is allowed to choose its capital structure endogenously before information asymmetry about the new project exists. Heinkel and Zechner show that there is an over-investment problem if the firm is initially fully equity-financed, as in Narayanan [1988]. However, the authors demonstrate that the overinvestment problem can be eliminated by a proper debt-equity combination in the initial financing. The reason is that the existence of debt reduces the shareholders' investment incentives as in Myers [1977], which balances the over-investment incentive caused by adverse selection.

## 3.3 Capital Structure with both Moral Hazard and Adverse Selection

So far, we have reviewed models with only the adverse selection problem. This subsection reviews two papers which consider both moral hazard and adverse selection.

In Darrough and Stoughton's [1986] model, adverse selection is, as in previous models, caused by information asymmetry related to external financing, and moral hazard results from the fact that the insider is required to supply a privately costly effort for the production purpose. The insider raises capital by issuing debt and equity to outside investors, and the proceeds are invested in a risk-free asset, providing one source of return. The effort of the insider provides a second source of return at a constant marginal rate ($\mu$), but the insider bears a cost of effort in monetary terms. Furthermore, the total return is additively affected by a random shock with standard deviation $\sigma$. The precise values of $\mu$ and $\sigma$ are known only by the insider. The financial signal consists of the level of promised debt payment and the fraction of equity retained. The insider's objective is to maximize the expected utility of the payoff from the retained equity minus the cost of effort. The analysis is focused on the class of fully separating equilibria. They show that if $\mu^2 = \sigma$, then a fully revealing equilibrium exists in which the fraction of equity retained by the insider is inversely related to the riskiness of return.

John's [1987] model also contains moral hazard and adverse selection: adverse selection is due to information asymmetry about the support of the return distribution of a new project at the time of financing, and moral hazard results from information asymmetry about the probability distribution of the return subsequent to the financing. The firm needs to raise a fixed amount of capital to finance the new project. The financing package consists of debt and external equity. The insider's objective is to maximize the expected payoff of the retained equity. After financing, the probability distribution of the project return is realized and privately observed by the insider. Due to the existence of risky debt, the insider has the incentive to undertake the project even if it has a negative NPV. The main results are that optimal financing involves both risky debt and equity, that the promised debt payment fully resolves the information asymmetry problem in the separating equilibrium, and that all types but the worst have a residual over-investment problem which represents the cost of signalling.

All the papers we have reviewed so far concern conflicts between different groups of investors, either between shareholders and debtholders or between existing investors and potential ones. The main sources of conflict are information asymmetry about firm quality at the time of external financing and/or distorted investment incentives caused by existing debt.[1] In these models, the firm is essentially controlled by one of the investor groups or by someone who is a perfect agent for one investor group. The identity of the manager is not independently established in the sense that the utility function of the manager is not explicitly specified. Next, we turn to studies whose focus is on the conflict between managers and investors, usually shareholders. Possible sources of the conflict include differences in risk preference, perk consumption, managerial reputation-building, etc..

## 3.4 Capital Structure and Managerial Perk Consumption

In Jensen and Meckling [1976], the manager is a partial owner (with $\alpha$ fraction of equity) but is fully in charge of the firm's operating decisions. The owner-manager's utility is determined by monetary compensation and other benefits such as perquisites. For each dollar of perk

[1] Other studies with implications for capital structure include Harris and Raviv [1990] on the monitoring role of debt payment in improving liquidation decisions, Heinkel and Zechner [1991] on the role of debt payment in improving operating decisions through debt renegotiation, and Diamond [1989] on firms' concern for reputation in credit market and its effect on the project selection criterion.

consumption, the owner-manager enjoys the full benefit but bears only $\alpha$ fraction of the cost. This suggests that outside stock ownership potentially causes an excess amount of perquisites.

The portion of the cost of perk consumption borne by the owner-manager is positively related to $\alpha$. This suggests that the problem of excessive perk consumption can be mitigated by increasing the insider's proportional equity ownership. One way to achieve this is to issue external debt; given the size of insider's ownership in the firm, the proportion of inside equity ($\alpha$) increases as the firm is more highly levered. The cost of debt financing is the risk-shifting effect, as discussed earlier. The optimal debt-equity combination requires that the total agency cost of debt and external equity be minimized.

Jensen [1986] raises the problem of free cash flow. Namely, managers have incentives to build firms beyond optimal size because larger firms give managers more power and higher compensation. Therefore, if firms have excess internal funds, managers will over-invest. Jensen argues that debt is an effective way of forcing managers to pay out free cash flows. The advantage of debt is that its payments are mandatory. The optimal leverage balances the benefit of debt against its agency cost. Stulz [1990] also deals with the free cash flow problem. The manager's utility is assumed to be increasing in the investment level, which causes the manager to over-invest. Again, debt can be used to force the payment of free cash flows. However, debt payment reduces internal funds which may force the firm to forego profitable projects.

Haugen and Senbet [1981] demonstrate that it is possible to resolve the perk consumption problem by the use of stock options in managerial compensation. In their model, both the manager and investors are risk-neutral. It is assumed that the manager will not sell off the firm's securities provided for compensation purposes. However, the agency cost of perk consumption can be completely eliminated only under special situations, as shown by Narayanan [1987] and Haugen and Senbet [1987].

## 3.5 Capital Structure with Exogenous Managerial Compensation

Ross [1977] examines the relationship between firm value and managerial choice of capital structure in a context where the manager faces a given compensation contract. The technology is exogenously given and the manager privately knows the return distribution of the firm. The manager's compensation is assumed to be positively related to the market prices of the firm's securities. Furthermore, there is an exogenous penalty to the manager if the firm goes bankrupt. The manager signals the firm type through debt issuance; the higher the debt level chosen by the manager, the greater the perceived firm value, hence the greater the manager's compensation. However, a high debt level also increases the probability of bankruptcy. In equilibrium, the value of the firm is positively related to its leverage. However, since there is no deadweight cost of bankruptcy for shareholders, it is not clear in Ross [1977] why existing shareholders of a low type firm cannot bribe the manager to mimic high types by issuing a large debt, which would benefit the shareholders.

In Blazenko's [1987] model, debt is costly to the manager because (1) the manager is risk averse, (2) managerial compensation is linear in equity return, and (3) debt increases the risk of equity return. The firm has an existing asset, whose value is publicly known, and a new project whose success rate may or may not be common knowledge. External financing is required for the new project. With symmetric information, the manager strictly prefers equity to debt while all investors are indifferent with respect to the debt/equity ratio. If only the manager is informed about the success rate of the project, signalling may occur through the choice of financing. Good types attempt to separate themselves by choosing debt to reduce undervaluation. Bad types use equity financing since debt makes equity too risky. In equilibrium, firms sort themselves out into two groups. A sufficient condition for the existence of such an equilibrium is that the managers are sufficiently risk-averse, because risk-aversion makes debt a credible signal.

General Comments

The studies reviewed so far typically make two assumptions. First, investors are risk-neutral. An implicit justification for the assumption is that investors can diversify their portfolios. However, these models do not actually consider the ownership structure or whether investors are able to diversify completely within the framework. This is relevant because, in many of these models, shareholders control the firm's decision-making. It is well-known that a free-rider problem exists within the shareholder group when they fully diversify. On the other hand, if investors are intrinsically risk-neutral, then why do not investors hold all classes of securities of a firm proportionally to avoid conflicts between different groups?

Another common assumption is that managerial compensation is either exogenously given or the manager is a perfect agent for shareholders. The criticisms to this assumption have been raised by a number of studies, which are reviewed below.

## 3.6 Capital Structure with Endogenous Managerial Compensation

Brander and Poitvin [1991] point out that the capital structure decision is affected by the form of compensation. Their model contains a manager, a shareholder and a creditor, all assumed to be risk-neutral. The firm's return is a function of action and a random state which is realized after the action is taken. The variance of return increases with the action level. The existence of debt triggers opportunistic behavior on the part of the shareholders. The shareholders desire too much risk and the debtholders desire too little. A professional manager, who owns neither equity nor debt, does not necessarily act in accordance with the interest of either shareholders or debtholders. Rather, managerial action is dictated by the compensation rule. Two types of compensation contracts are analysed, one is the penalty contract which specifies a fixed wage with a penalty in case of bankruptcy, and the other is a bonus contract which consists of a fixed wage and an additional bonus if the firm reaches some revenue target. They show that (1) the form of managerial compensation affects the firm's optimal financial structure and (2) an optimal compensation contract leads to a local irrelevance of financial structure.

Dybvig and Zender [1991] contend that capital structure is irrelevant for a general class of problems when managerial compensation is endogenously chosen. In their model, the manager's utility function is explicitly specified, and the manager's actions are directed to maximize his own utility. The managerial compensation contract is endogenously determined. The main result is that there is a separation between financial structure and managerial incentive. This result challenges the validity of the "relevance" results in asymmetric information models where compensation is exogenously specified. The reason for the Dybvig and Zender's result can be roughly described as follows. The manager cares only about his compensation; therefore, the compensation rule completely determines managerial behavior. Under the condition that financial policies do not affect the set of available compensation rules, the same optimal rule will be chosen regardless of the firm's capital structure; hence, there exists a separation between financial and investment decisions.

There are others studies which have implications for capital structure. Since the focuses of these models are less directly related to the thesis, they are not included in this review.[2]

[2]These issues include allocation of cash flow privately observed by the insider, Townsend [1979], Diamond [1984], Gale and Hellwig [1985], Williams [1989a and 1989b]; allocation of control rights, Aghion and Bolton [1988], Zender [1989], Hart and Moore [1989]; allocation of voting rights, Grossman and Hart [1988], Harris and Raviv [1988a, 1988b and 1989], Blair, Golbe and Gerard [1989]; design of the optimal securities, Allen and Gale [1988, 1989]; and interaction between financial decision and product market competition, Brander and Lewis [1986], Gertner, Giggons and Sharfstein [1988], Maksimovic [1988], Maksimovic and Zechner [1991], and Maksimovic and Titman [1991].

# Bibliography


[1] Aghion, P., and P. Bolton, 1988, "An incomplete contract approach to bankruptcy and financial structure of the firm", Technical Report 536, IMSSS, Stanford University.

[2] Allen, F., 1990, "The changing nature of debt and equity: a financial perspective", in *Are the distinctions between debt and equity disappearing?*, R.W. Kopcke and E.S. Rosengren (eds.), Boston: Federal Reserve Bank of Boston), Conference Series No. 33,12–38

[3] Allen, F., and D. Gale, 1988, "Optimal security design", *Review of Financial Studies 1:* 229-263.

[4] Allen, F., and D. Gale, 1989, "Arbitrage, short sales and financial innovation", *Working Paper 10-89*, Rodney L. White Center, University of Pennsylvania.

[5] Baxter, N., 1967,"Leverage, risk of ruin and the cost of capital", *Journal of Finance 22*:395-403

[6] Blair, D., D. Golbe and J. Gerard, 1989, "Unbundling the voting rights and profit claims of the common shares", *Journal of Political Economy 97*:420-443.

[7] Blazenko, G., 1987, "Managerial preference, asymmetric information, and financial structure", *Journal of Finance 42*: 839-862

[8] Brander J., and T. Lewis, 1986, "Oligopoly and financial structure: the limited liability effect", *American Economic Review 76*: 956-970.

[9] Brander, J., and P. Michel, 1991, "Managerial compensation and the agency cost of debt finance", *Journal of Managerial Decision Making*, forthcoming.

[10] Brennan, M., and A. Kraus, 1987, "Efficient financing under asymmetric information", *Journal of Finance 42*: 1225-1243.

[11] Constantinides, G., and B. Grundy, 1989, "Optimal investment with stock repurchase and financing as signals", *Review of Financial Studies 2*:445-466.

[12] Darrough, M., and N. Stoughton, 1986, "Moral hazard and adverse selection: the question of financial structure", *Journal of Finance 41*: 501-513.

[13] DeAnglo, H., and R. Masulis, 1980, "Optimal capital structure under corporate and personal taxation", *Journal of Financial Economics 8*:3-30.

[14] Diamond, D., 1984, "Reputation acquisition in debt markets", *Journal of Political Economy 97*: 828-862.

[15] Dybvig, P., and S. Ross, 1986, "Tax clienteles and asset pricing", *Journal of Finance 41*

[16] Dybvig, P., and J. Zender, 1991, "Capital structure and dividend irrelevance with asymmetric information", *Review of Financial Studies 4:*

[17] Gale, D., and M. Hellwig, 1985, "Incentive-compatible debt contracts: the one-period problem", *Review of Economic Studies 52*:647-663.

[18] Gertner, R., R. Giggons and D. Sharfstein, 1988, "Simultaneous signalling to the capital and product markets", *Rand Journal of Economics 19*: 173-190.

[19] Green, R., 1984, "Investment incentives, debt, and warrants", *Journal of Financial Economics 13*: 115-136.

[20] Grossman, S., and O. Hart, 1982, "Corporate financial structure and managerial incentives", in *The Economics of Information of Uncertainty*, J. McCall (ed.), Chicago: University of Chicago Press.

[21] Grossman, S., and O. Hart, 1988, "One share/one vote and the market for corporate control", *Journal of Financial Economics 20*:175-202.

[22] Harris, M., and A. Raviv, 1988a, "Corporate control contests and capital structure", *Journal of Financial Economics 20*: 55-86.

[23] Harris, M., and A. Raviv, 1988b, "Corporate governance: voting rights and majority rule", *Journal of Financial Economics 20*:203-235.

[24] Harris, M., and A. Raviv, 1990a, "Capital structure and the information role of debt", *Journal of Finance 45*: 321-349

[25] Harris, M., and A. Raviv, 1990b, "Financial contracting theory", *working paper #82*, Kellogg School, Northwestern University.

[26] Harris, M., and A. Raviv, 1991, "The theory of capital structure", *Journal of Finance*

[27] Hart, O., and J. Moore, 1989, "Default and renegotiation: a dynamic model of debt", *Working Paper*, MIT, August.

[28] Haugen, R., and L. Senbet, 1987, "On the resolution of agency problems by complex financial instruments: a reply", *Journal of Finance 42*: 1091-1095.

[29] Heinkel, R., 1982, "A theory of capital structure relevance under imperfect information", *Journal of Finance 37*: 1141-1150.

[30] Heinkel, R., and J. Zechner, 1990, "The role of debt and preferred stock as a solution to adverse investment incentives", *Journal of Financial and Quantitative Analysis 25*: 1-24.

[31] Hirshleifer, D., and A. Thakor, 1989, "Managerial reputation, project choice and debt", *Working Paper #14-89*, Anderson Graduate School of Management at UCLA.

[32] Jensen, M., 1986, "Agency costs of free cash flow, corporate finance and takeovers", *American Economic Review 76*, 323-339.

[33] Jensen, M., and Meckling, 1976, "Theory of the firm: managerial behavior, agency costs, and capital structure", *Journal of Financial Economics 3*: 305-360.

[34] John, K., 1987, "Risk-shifting incentives and signalling through corporate capital structure", *Journal of Finance 42*:623-641.

[35] John, K., and C. Nachman, 1989, "Risky debt, investment incentives, and reputation in a sequential equilibrium", *Journal of Finance 40*:863-880

[36] John, K., and L. Senbet, 1988, "Limited liability, tax deductability of corporate debt, and public policy", *working paper*, Solomon Brothers Center for for the Study of Financial Institutions

[37] Kim, E., 1982, "Miller's equilibrium, shareholder leverage clienteles and optimal capital structure", *Journal of Finance 37*:301-318

[38] Kim, H., 1989, "Optimal capital structure in Miller's equilibrium", in *Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory, vol 2*, S. Bhattacharya and G. Constantinides (eds.), Totowa, N.J.: Rowman and Littlefield

[39] Kraus, A., and R. Litzenberger, 1973, "A state-preference model of optimal financial leverage", *Journal of Finance 28*:911-922

[40] Leland, H., and D. Pyle, 1977, "Information asymmetries, financial structure, and financial intermediation", *Journal of Finance 32*:371-388

[41] Maksimovic, V., 1988, "Capital structure in repeated oligopolies", *Rand Journal of Economics 19*:389-407

[42] Maksimovic, V., and S. Titman, 1991, "Financial policy and a firm's reputation for product quality", *Review of Financial Studies 4*

[43] Maksimovic, V., and J. Zechner, 1991, "Debt, agency costs and industry equilibrium", *Journal of Finance 46*

[44] Miller, M., 1977, "Debt and taxes", *Journal of Finance 32*: 261-275

[45] Miller, M., 1988, "The Modigliani-Miller Propositions after thirty years", *Journal of Economic Perspectives 2*: 99-120

[46] Modigliani, F., 1982, "Debt, dividend policy, taxes, inflation and market valuation", *Journal of Finance 37*:255-274

[47] Modigliani, F., 1988, "MM – past, present, and future", *Journal of Economic Perspectives 2*:149-158

[48] Modigliani F., and M. Miller, 1958, "The cost of capital, corporation finance, and the theory of investment", *American Economic Review 48*:261-297

[49] Modigliani, F., and M. Miller, 1963, "Corporate income taxes and the cost of capital: a correction", *American Economic Review 53*:433-443

[50] Myers, S., 1977, "Determinants of corporate borrowing", *Journal of Financial Economics 5*:147-175.

[51] Myers, S., 1984, "The capital structure puzzle", *Journal of Finance 39*:575-592

[52] Myers, S., and N. Majluf, 1984, "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics 13*: 187-221

[53] Narayanan, M., 1988, "On the resolution of agency problems by complex financial instructments: a comment", *Journal of Finance 42*:1083-1090

[54] Noe, T., 1988, "Capital structure and signalling game equilibria", *Review of Financial Studies 1*:331-356

[55] Ross, S.,1977, "The determination of financial structure: the incentive signalling approach", *Bell Journal of Economics 8*:23-40

[56] Ross, S., 1988, "Comments on Modigliani-Miller Propositions", *Journal of Economic Perspectives 2*: 127-134

[57] Stoughton, N., and E. Talmore, 1990, "Screening vs. signalling in managerial compensation and corporate investment", *working paper*, University of California at Irvine

[58] Scott, J., 1976, "A theory of optimal capital structure", *Bell Journal of Economics 7*:33-54

[59] Stulz, R., 1991, "Managerial discretion and optimal financial policies", *Journal of Financial Economics*

[60] Townsend, R., 1979, "Optimal contracts and competitive markets with costly state verification", *Journal of Economic Theories 22*:265-293.

[61] Warner, J.B., 1977, "bankruptcy costs: some evidence", *Journal of Finance 32*: 337-347

[62] Williams, J., 1989a, "Ex-ante monitoring, ex post asymmetry, and optimal securities", *Working Paper*, University of British Columbia

[63] Williams, J., 1989b, "Monitoring and optimal financial contracts", *working paper*, University of British Columbia

[64] Zender, J., 1989, "Optimal financial instruments", *Working Paper*, University of Utah

# Chapter 4

# Owner-Manager Conflict and the Disciplinary Role of Capital Rationing

## 4.1 Introduction

The purpose of this chapter is to demonstrate that the scale of investment financing has an important effect on managerial incentives.

Firms often face multiple investment opportunities across various divisions. As part of its overall investment and financing policy, a firm has to decide what projects should be financed and how. The first part of the decision determines the scale of financing, and the second the method of financing. Finance research has mainly focused on the latter but paid less attention to the former. The scale of financing is considered to be determined by investment opportunities available and is therefore largely exogenous to a firm. The implicit assumption is that the decision-maker acts to maximize the value of the firm; therefore, all profitable projects will be undertaken to enhance the firm's value.

What is ignored in the previous finance research is the managerial aspect of the firm. If managers are self-interested, they may undertake projects for their own benefit at the expense of investors. Managers are able to do so partly because they generally have superior information about investment opportunities relative to investors. The extent of potential managerial misconduct is directly related to the availability of investment funds. To control managerial behavior, investors may strategically set the size of financing which determines the scope of the firm's investment activities. In general, a tight investment policy provides better managerial discipline, but may also force the firm to pass up some good projects. The point to be demonstrated in this chapter is that the profitability of a particular project is affected by the level of managerial discipline asserted, which in turn is determined by the size of investment financing. Thus, there is a link between financing and investment decisions.

The model depicts a two-division firm whose ownership and control are separated. Initially, the owner (the principal) of the firm knows that there is a new project with a positive NPV available for each division, but only the managers (the agents) know the actual qualities of their respective projects. The return on a project depends on an exogenous state variable ("low" or "high") and the effort expended by the manager. In this model, the terms "state" and "project quality" are used synonymously.

The scope of the firm's investment is set initially by the amount of capital raised. Two options are available to the owner. One is to raise sufficient capital so that both divisions may be allowed to invest as the principal desires. The investment decisions for the two divisions are made independently. This is a case of no capital rationing. The other option is to acquire limited capital so that only one of the divisions actually gets a project. Then, the agents have to compete for the capital. This is a case of capital rationing.

According to the traditional capital budgeting theory, the firm should accept all positive NPV projects in the absence of capital constraints, known as the NPV rule. Suppose that the projects have positive NPVs in both the high and the low states. If the NPV rule is followed, the managers, having superior information about project quality, are able to obtain positive rents in the high state. The reason is that the managers, when observing the high state, always have the option to misrepresent the project quality in order to expend low effort and produce a low output. The information rents, however, may be reduced by adopting a more stringent investment policy. For example, the owner may threaten not to accept the project if the low state is reported. We show that, within a certain parameter region, it is desirable for the owner to forgo projects in the low state even though they are still profitable. The difficulty, however, is that the owner cannot credibly commit to such a policy in a sequential game: faced with the choices of accepting a profitable project or not investing at all, the principal always chooses the former.

One way for the owner to precommit to a restrictive policy is to impose capital rationing at the beginning, in which case the firm is forced to give up some of its projects subsequently. Rationing capital forces the managers to compete with each other for capital, hence reduces their incentive to shirk. Consequently, the managers' information rents diminish. We demonstrate that, if the projects are not highly profitable, capital rationing allows the owner to receive a greater expected profit.

The effect of imposing capital rationing on agent behavior is similar to that of rank-order tournament contracts.[1] In both cases, competition eases incentive problems and reduces shirk tendencies as each agent suffers a penalty if he is compared unfavorably with his counterpart. Notice that it is necessary to have multiple agents in order to apply both schemes. The differences between the two lie in the information structure and in how comparative information is used in making decisions. Rank-order tournament contracts are applied in moral hazard situations where agent effort is not observed by the principal. A tournament contract compares the outcomes of different agents and their rank is used to determine compensation. In contrast, capital rationing is useful in our problem because there is pre-decision information privately known by the agents. The use of capital rationing facilitates the revelation of private information which helps the principal to allocate investment funds better. The compensations are affected by the allocation of investment.

The analysis of the chapter provides an explanation for the use of self-imposed capital rationing. In finance textbooks, capital rationing broadly refers to situations where a firm places a limit on the total size of its capital investment during a specified time period. Surveys indicate that the practice of capital rationing is quite common among corporations. In the study by Gitman and Forrester, Jr. [1977], for example, "Respondents were asked to indicate 'yes' or 'no' on whether their firm made a competitive allocation of a *fixed* budget to competing projects. Of the 100 responses, 52 indicated 'yes'...". In the majority cases (70%), the cause of capital rationing was "a limit placed on borrowing by the internal management". In other words, the rationing in these cases is voluntarily imposed by the firm rather than involuntarily imposed by the financial market. Even higher incidents of capital rationing are reported by Ferreira and Brooks [1988], 60.3%, and Fremgen [1970], 73%.

[1] See Lazear and Rosen [1981] and Bhattacharya and Guasch [1988]. In addition, Demski and Sappington [1984] study optimal contracting with multiple agents whose production technologies are correlated. They show that the optimal compensation to each agent is related to the outcomes of other agents.

Although capital rationing is widely practised in corporate capital budgeting, there have been few attempts to address the issue in theory. Textbooks provide various ad hoc reasons. Brigham and Gapenski [1984] state "... the main reason for management knowingly to engage in capital rationing is that ... some firms are reluctant to engage in external financing". Brealey and Myers [1991] suggest that capital rationing is used to control excessive investment incentives because divisional managers habitually overstate their investment opportunity. In a recent paper by Holmstrom and Ricart i Costa [1986], the owner of a firm rejects the investment opportunity whenever the manager reports a bad state. The authors regard the owner's strategy as capital rationing. However, the concept implied in the model of Holmstrom and Ricart i Costa [1986] is different from the commonly used notion of capital rationing, i.e., firms limit investment to a fixed pool of capital before projects are evaluated. Also, in their setting, the manager can only report the state truthfully or withhold the information, but never misreport it.

The rest of the chapter is organized as follows: section 4.2 describes the model, section 4.3 analyses the principal's problem if no capital rationing is imposed, section 4.4 considers the problem after imposing capital rationing, and section 4.5 discusses empirical implications.

## 4.2 The Model

This is a one-period model. A firm has two divisions. There is one owner (the principal) and two divisional managers (the agents). Each manager is responsible for the operation of one of the divisions. At the beginning of the period, both the principal and the agents know that each division can invest independently in a project which requires a capital outlay of $I_o$. The cash flow from each project, say $i$, $i = 1, 2$, is $x^i = s^i e^i$ where $s^i$ is the state (or quality) of project $i$ and $e^i$ is the effort level of the agent operating project $i$. It is commonly known that $s^i \in S = \{s_l, s_h\}, s_l < s_h, i = 1, 2$, with $Prob(s^i = s_l) = p_l$ and $Prob(s^i = s_h) = p_h \equiv 1 - p_l$.

We make the following assumption about the projects: if the principal deals with each agent independently of the other, there exists an incentive compensation contract which allows the principal to receive a positive profit from each project in both $s_l$ and $s_h$. In other words, each project is always profitable on its own.[2] Under this assumption, capital rationing must force

[2]Sufficient conditions for this assumption to hold are: $I_o$ is not too large relative to both $s_l$ and $s_h$, and

the firm to give up some profitable project(s). This makes the issue of self-imposed rationing an interesting one.

To avoid contracting issues involving correlated states, we assume that state realizations of two divisions are uncorrelated,[3] i.e.,

$$cov(s^1, s^2) = 0.$$

For simplicity, we further assume that the firm's existing operation has a zero scale.

The events in the problem evolve in the following sequence:

- The principal raises an amount of capital in anticipation of new investment.
- The principal and the agents negotiate a contract. The contract specifies an investment policy and, for each agent, a compensation rule. It is possible that compensation to one agent is related to that of the other.
- Each agent privately observes his own state and submits a report to the principal about the state.
- The principal allocates the capital according to the investment policy.
- Each agent who receives capital installs a project and carries out production.
- Cash flow from each new project is publicly observed, and each agent is compensated.

The principal is risk-neutral. Her task is to design an investment policy and a compensation scheme in order to maximize the expected total profit.

The agents, on the other hand, are both risk- and effort-averse. Let $c$ be monetary compensation and $e$ be effort for production. The utility functions of the agents are defined as

$$u(c, e) = U(c) - V(e),$$

where $U'(c) > 0, U''(c) \leq 0, V'(e) > 0, V''(e) > 0, U(0) = V(0) = 0$. We normalize the base utility of each agent, i.e., the utility without new investment, to be zero.

managers are not too effort-averse.

[3] The results can be extended to problems with imperfectly correlated states. See Demski and Sappington [1984] for contracting in a production setting where divisional states are positively but imperfectly correlated.

Given that $x = se$, the utilities can be defined equivalently in terms of $(c, x)$ conditional on $s$,

$$u(c, x; s) = U(c) - V(\frac{x}{s}).$$

For each agent to be willing to accept a new project, his utility with the new project must be no less than the base utility in each state. This condition is referred to as the participation constraint.

If state realization is public information, then the principal's problem is to choose the optimal production and compensation in each state to maximize the profit subject to the participation constraint. In this case, the princiapl can deal with each agent independently. Let $x_i$ and $c_i$ be the production and compensation associated with state $s_i, i = l, h$. Then the principal's problem, denoted by **P0**, is

**P0**

$$\max_{\{x_i, c_i\}} \quad x_i - c_i,$$

subject to

$$U(c_i) - V(\frac{x_i}{s_i}) \geq 0$$

where $i = l, h$.

The first-best solution is characterized by

$$U(c_i) - V(\frac{x_i}{s_i}) = 0, \; i = l, h, \tag{4.1}$$

and

$$U'(c_i) - V'(\frac{x_i}{s_i})/s_i = 0, \; i = l, h. \tag{4.2}$$

In the first-best solution, each agent's utility is held just at the base level, as is shown by equation (4.1). Equation (4.2) means that, in each state, the marginal utility of compensation to each agent is equal to the marginal disutility of effort for production; therefore, production is always efficient.

However, in this model, the true states are observed only by the agents. Therefore, the first-best solution is not possible. Additional constraints are required in the princiapl's problem. Specifically, the principal has to design a contract so that reporting the true state is an equilibrium strategy for each agent. This is referred to as the incentive compatibility constraint.

Two options are available to the principal at the financing stage[4]: (i) raising $2I_o$ and dealing with each agent separately–a case of no capital rationing, and (ii) raising $I_o$ and allowing only one division to invest–a case of capital rationing. In the following, we analyse the principal's problem in each case.

## 4.3 The Principal's Decision without Capital Rationing

Without capital rationing, the principal initially raises $2I_o$ so that both agents may undertake a project. Since the two divisions operate independently, the principal essentially solves two single agent problems. It is sufficient to analyse the problem with one representative agent. As a result, we drop superscript $i$ in the rest of this section.

### 4.3.1 Accepting all positive NPV projects

If the principal follows the Net Present Value rule, the representative agent will accept the project in both states since, by assumption, the project is profitable in both states. Therefore, the investment decision becomes fixed, i.e., independent of the reported state. The principal simply needs to decide a production-compensation combination for each state.

#### 4.3.1a Standard formulation and the issue of renegotiation

According to the standard principal-agent formulation, the owner's problem is: maximizing the expected profit subject to both the participation constraint and the incentive compatibility constraint. Let $x_j$ be the specified outcome from the project if $s_j, j = l, h$, is reported, and let $c_j$ be the corresponding compensation. The principal's problem, denoted by **P1-a**, is represented by the following mathematical program.

[4]We consider only pure strategies in the principal's financing and investment decisions as this suffices to demonstrate our point.

**P1-a**

$$\text{MAX}_{\{x_l, x_h, c_l, c_h\}}\ p_l(x_l - c_l) + p_h(x_h - c_h) - I_o \tag{4.3}$$

subject to

$$U(c_i) - V(\frac{x_i}{s_i}) \geq 0,\ i = l, h, \tag{4.4}$$

$$U(c_i) - V(\frac{x_i}{s_i}) \geq U(c_j) - V(\frac{x_j}{s_i}),\ i, j = l, h,\ i \neq j. \tag{4.5}$$

In **P1-a**, equation (4.3) is the expected profit from the representative project, equation (4.4), the participation constraint, ensures that the agent is at least as well-off in each state by undertaking a new project should he report the true state, and equation (4.5), the incentive compatibility constraint, eliminates the agent's incentive to report the state falsely. This formulation relies on the Revelation Principle which states that the optimal incentive contract which is truth-revealing is also optimal within the class of all contracts. It should be pointed out that this formulation does not rule out the possibility of a pooling contract since the principal could offer identical production-compensation schedules for both states.

In this compensation mechanism, the principal specifies a production level based on the reported state, and the agent carries out the specified production. It is implicit that if the agent does not follow the principal's production instruction, he gets a sufficiently large penalty so that he is made worse off. Therefore, the agent will always obediently carry out the production plan after the state is reported.

**Lemma 1.** *The solution to* **P1-a** *has the following properties:*

1. *production in the high state is efficient, however production in the low state is below the efficient level,*
2. *the representative agent maintains the base utility in the low state, but receives a strictly positive rent in the high state.*

Proof: see Appendix 4A.

The intuition of Lemma 1 can be illustrated as follows. Let $\{x_{la}, x_{ha}, c_{la}, c_{ha}\}$ be the optimal solution to **P1-a**. In state $s_l$, the agent produces output $x_{la}$ and receives compensation $c_{la}$;

his utility is held just at the base level (zero). In state $s_h$, the agent has the option to misrepresent the state as $s_l$, in which case the production and compensation will be the same as in state $s_l$. However, with higher productivity in $s_h$, the agent can produce the same output with less effort. Therefore, the agent's utility will be strictly greater than that in $s_l$. This suggests that the asymmetric information allows the agent to extract a positive rent in $s_h$, which is represented by the following expression:

$$\text{Rent} = [U(c_{la}) - V(\frac{x_{la}}{s_h})] - [U(c_{la}) - V(\frac{x_{la}}{s_l})] = V(\frac{x_{la}}{s_l}) - V(\frac{x_{la}}{s_h}).$$

Clearly, the agent's informational rent increases in $x_{la}$. This is because a greater output in the low state allows the agent to save more effort by under-reporting the state in $s_h$. Given that the agent's utility is held at zero in $s_l$, a higher output $x_{la}$ gives the agent a stronger incentive to under-report his state; therefore, it requires a higher compensation to induce the agent to report the high state. As a result, the principal needs to set output $x_{la}$ below the efficient level in an attempt to limit the agent's rent. The optimal solution involves a trade off of the gain of net profit in the high state against the loss of production efficiency in the low state.

The degree of production inefficiency in $s_l$ depends on the likelihood of state $s_l$ relative to that of $s_h$. If $p_l$ is large relative to $p_h$, the principal will give more consideration to production in the low state, and she will be less willing to give up efficiency in $s_l$; therefore, $x_{la}$ will be more close to being efficient. However, as long as $p_h$ is strictly positive, $x_{la}$ will always be below the efficient level. (This is clear from the proof in Appendix 4A.) Only in an extreme case where state $s_h$ has a zero probability of occuring would production be perfectly efficient in $s_l$.

The standard principal-agent formulation implicitly assumes that the principal can commit to the ex ante optimal contract; and the possibility of renegotiation during the course of implementation is not considered. This assumption of implicit commitment is recognized as a major weakness in the standard approach. Recently, various models are proposed which allow contracting parties to renegotiate, i.e., to replace the old contract with a new one at a later point should this be beneficial to the parties. This approach is more appealing since it incorporates the possibility that interim or ex post inefficiency be reduced or removed in a rational way. In this sense, the notion of renegotiation is more consistent with the concept of sequential equilibrium used in game theory.

Different methods of renegotiation have been adopted in analysing problems with asymmetrically informed parties. In Maskin and Tirole [1988] and Nosal [1991], only the renegotiation of contract menu is considered. After the initial contracting, one party learns his true type and has the opportunity to propose a new menu of contracts. The other party revises his belief based on the newly proposed menu and then decides either to accept or reject it. Depending on the response of the uninformed party, either the old or the new menu will eventually be implemented. An implicit assumption is that once the menu is set, the parties can commit to the specific allocations within the menu even though there may still be inefficiency in the allocation actually chosen. Other studies allowing for renegotiation such as Hart and Tirole [1988] and Dewatripont [1989] also rely on some degrees of commitment. Although renegotiation in these models generally leads to an equilibrium different from that with full commitment, they do not fully avoid the kind of criticism to the standard formulation (see Beaudry and Poitevin [1991]).

Beaudry and Poitvin [1991] allow renegotiation to take place after a specific allocation in the contract menu is chosen. Furthermore, the assumption of commitment is avoided by allowing the possibility of infinite rounds of renegotiation. An important point which they make is that further renegotiation will always take place if, regardless of his beliefs, the uninformed party does not lose by renegotiating.

The analysis in this chapter incorporates renegotiation in the spirit of Beaudry and Poitvin [1991]. We adopt the following as a necessary condition for renegotiation to take place.

**Necessary Condition:** *The uninformed party will always accept a new contract which replaces the original one if he/she is at least as well off with the new contract regardless of the type of the informed party.*

This immediately leads to the next lemma.

**Lemma 2.** *The solution to* **P1-a** *is not a renegotiation-proof equilibrium.*

Proof. The specified production conditional on $s_l$ being reported is below the efficient level either when the true state is $s_l$ or when it is $s_h$. Therefore, no matter what the true state is, there is gain for both parties to increase the level of production. **QED**

In fact, Lemma 2 can be generalized as follows.

**Lemma 3.** *Any decision rule in which production in the low state is below the efficient level is not renegotiation-proof.*

### 4.3.1b The renegotiation-proof contract

From Lemma 3, the necessary condition for a decision rule to be renegotiation-proof is that production in the low state is not below the efficient level. Mathematically, this implies that

$$U'(c_l) \leq V'(\frac{x_l}{s_l})/s_l. \tag{4.6}$$

Adding condition (4.6) to the original program **P1-a** gives the new problem, denoted by **P1**. The solution properties of **P1** are described in Proposition 1.

**Proposition 1.** *The solution to* **P1***, denoted by* $\{x_{l1}, x_{h1}, c_{l1}, c_{h1}\}$*, has the following properties:*

1. $U(c_{l1}) - V(\frac{x_{l1}}{s_l}) = 0 > U(c_{h1}) - V(\frac{x_{h1}}{s_l})$; *the agent maintains the base utility in the low state if he reports truthfully and is strictly worse off if he falsely reports the high state.*
2. $U(c_{h1}) - V(\frac{x_{h1}}{s_h}) = U(c_{l1}) - V(\frac{x_{l1}}{s_h}) > 0$; *in the high state, the agent obtains a strictly positive rent from the project, and he is indifferent between truthfully reporting the high state and falsely reporting the low state.*
3. $V'(\frac{x_{l1}}{s_l})/s_{l1} = U'(c_{l1})$, *and* $V'(\frac{x_{h1}}{s_h})/s_{h1} = U'(c_{l1})$; *production is Pareto efficient in both the high and the low states.*
4. $x_{l1} < x_{h1}$; *the production level is higher in the high state than in the low state.*
5. $c_{l1} < c_{h1}$; *the equilibrium compensation is higher in the high state rather than in the low state.*
6. $x_{l1} - c_{l1} < x_{h1} - c_{h1}$; *the principal achieves a greater profit in the high state than in the low state.*

**Proof.** see Appendix 4A.

It is clear that, in **P1**, production is efficient in both states; hence, no party can increase his utility without hurting the other. Therefore, the possibility of renegotiations is ruled out.

**Lemma 4.** *The solution to* **P1** *is renegotiation-proof.*

The expected total profit of two divisions, denoted by $NPV(P1)$, is

$$NPV(P1) = 2p_l(x_{l1} - c_{l1}) + 2p_h(x_{h1} - x_{h1}) - 2I_o. \tag{4.7}$$

Proposition 1 shows that the agent obtains a strictly positive rent from his private information. If $s_l$ is realized and reported, the agent produces $x_{l1}$ and receives compensation $c_{l1}$ so that his utility is kept just at the base level (zero). If, however, $s_h$ is realized, the agent can always falsely report $s_l$ to produce $x_{l1}$ and receive $c_{l1}$ but now with a smaller effort. Therefore, his utility in $s_h$ must be positive. As long as the project is undertaken for certain in both states, a positive rent in $s_h$ is secured.

### 4.3.2 Accepting the project only in the high state

The agent receives an information rent only if the project is accepted. The ability of the agent to receive a positive rent lies in the condition that the project is accepted even if the state is low. Clearly, the shirking incentive will be weakened if the principal rejects the project when $s_l$ is reported. However, such a policy is also costly to the owner since it implies that positive NPV projects sometimes be rejected. It is important to examine whether the principal achieves a higher profit by a more stringent investment policy.

For the purpose of illustration, we temporarily set aside the issue of implementation and assume that the principal rejects the project when $s_l$ is reported and accepts it when $s_h$ is reported.[5] The principal's problem with respect to the representative agent, denoted **P2**, becomes:

**P2**

[5] Alternatively, one could take a more general approach by allowing the principal to randomize the investment decision when $s_l$ is reported. However, the analysis would not change qualitatively.

$$\text{MAX}_{\{x_h,c_h\}}\ p_h(x_h - c_h - I_o) \tag{4.8}$$

subject to

$$U(c_h) - V(\frac{x_h}{s_h}) \geq 0, \tag{4.9}$$

$$0 \geq U(c_h) - V(\frac{x_h}{s_l}). \tag{4.10}$$

In **P2**, both the participation constraint associated with $s_l$ and the incentive compatibility constraint associated with $s_h$ disappear due to the fact that all $s_l$-projects are rejected. Let $(x_{h2}, c_{h2})$ be the optimal solution to **P2**. It has the following properties.

**Proposition 2**. *The solution to programming problem* **P2** *has the following properties:*

1. $U(c_{h2}) - V(\frac{x_{h2}}{s_h}) = 0 = U(0) - V(0)$; *the agent maintains the base utility in both the high state and the low state.*

2. *the principal receives a positive profit in* $s_h$ *and zero profit in* $s_l$*.*

The expected total profit of the two divisions is

$$NPV(P2) = 2p_h(x_{h2} - c_{l2}) - 2p_h I_o. \tag{4.11}$$

### 4.3.3 Discussion

#### 4.3.3a Comparison of investment policies

The optimal production and compensation levels for **P1** and **P2** are illustrated in figure 1. Curves $OA$ and $OB$ represent the participation constraints for $s_l$ and $s_h$ respectively. Curve $EE'$ is the locus of efficient production levels in the high state, and curve $ee'$ is that in the low state. The intersection of $OA$ and $ee'$, $L$, gives the solution for $s_l$, $(c_{l1}, x_{l1})$. Let $II'$ be the indifference curve of the representative agent when the state is $s_h$ which passes through point $L$. The intersection of $II'$ and $EE'$, $H$, gives the optimal compensation and production in $s_h$, $(c_{h1}, x_{h1})$. For the project to have a positive NPV in both states, the two solution points must be above the 45-degree line, $OO'$. Curve $II'$ must not be above $OB$ as required by participation constraints (4.4).

The optimal solution to problem **P2** is determined by the intersection of $OB$ and $EE'$, $(c_{h2}, x_{h2})$.

Comparing the solutions to **P1** and **P2** leads to the following proposition.

**Proposition 3.** *(1) $x_{l1} - c_{l1} > 0$, and $0 < x_{h1} - c_{h1} < x_{h2} - c_{h2}$; the principal strictly prefers the contract of* **P1** *in $s_l$ and that of* **P2** *in $s_h$, and (2) the agents strictly prefer the contract of* **P1** .

In **P1**, the project is accepted in both states and the agent receives a positive rent. In **P2**, the project is accepted only in the high state and the agent has less incentive to shirk. The principal achieves a higher profit by following the NPV rule if $NPV(P1) > NPV(P2)$, or

$$I_o < (x_{l1} - c_{l1}) + (p_h/p_l)(x_{h1} - c_{h1}) - (p_h/p_l)(x_{h2} - c_{h2}). \tag{4.12}$$

Conversely, the principal achieves a higher expected profit by adopting a restrictive investment rule if $NPV(P2) > NPV(P1)$, or

$$I_o > (x_{l1} - c_{l1}) + (p_h/p_l)(x_{h1} - c_{h1}) - (p_h/p_l)(x_{h2} - c_{h2}). \tag{4.13}$$

These conditions have a straightforward meaning. For a given production function, the profitability of a project is inversely related to the required investment capital ($I_o$). When $I_o$ is small, the project is highly profitable, the cost of foregoing the project even in the low state is large relative to the benefit from the improved incentive. Hence, the owner prefers to accept the project in all states. On the other hand, when $I_o$ is large, the project is marginally profitable in $s_l$, and the benefit from the improved incentive outweighs the cost of foregoing the project in the low state. Therefore, the restrictive investment policy (**P2**) becomes more desirable from the principal's perspective.

The following numerical example provides an illustration.

**Example 1**

There are two divisions. The problem specification for each division is given by the following table.

| |
|---|
| $x = se,\ U(c) = c^{0.5},\ V(e) = e^2/50,$ |
| $s_l = 2^{0.5},\ s_h = 2.0,$ |
| $p_l = 0.5,\ p_h = 0.5.$ |

If there are no information asymmetries, the principal's net profit from each project (the first-best solution) is $10.17 - I_o$ in $s_l$ and $16.16 - I_o$ in $s_h$.

The solutions to **P1** and **P2**:

| **P1** | **P2** |
|---|---|
| $x_{l1} = 13.60,\ x_{h1} = 18.73$ | $x_{l2} = 0,\ x_{h2} = 21.54$ |
| $c_{l1} = 3.39,\ c_{h1} = 7.13$ | $c_{l2} = 0,\ c_{h2} = 5.39$ |
| $NPV(P1) = 21.81 - 2I_o$ | $NPV(P2) = 16.16 - I_o$ |

By comparing the NPVs, we see that

$$NPV(P1) > NPV(P2) \text{ if } I_o < 5.65$$

and

$$NPV(P1) < NPV(P2) \text{ if } I_o > 5.65.$$

So the principal prefers **P1** if $I_o < 5.65$ and **P2** if $I_o > 5.65$. This is illustrated in figure 2.

### 4.3.3b Implementability of investment policies

In this model, the actions of the principal and the agents take place sequentially. It is important to examine whether the investment and production decision rules specified in **P1** and **P2** can be rationally implemented.

In **P1**, the production and compensation rules are designed to be renegotiation-proof. Furthermore, it is rational for the principal to approve projects in both the high and the low states since, by assumption, the projects are always profitable. Therefore, it is sequentially rational for both the principal and the agents to follow the specified decision rules in **P1**.

In **P2**, the specified investment strategy requires the principal to reject the project if an agent reports $s_l$. However, the project will still generate a positive profit. Given that $s_l$ is reported, the principal can always be made better off by reneging on the original investment policy regardless of the actual state. In the absence of enforcement mechanisms, the rational principal would abandon the initial policy and accept the project upon being informed of $s_l$. Anticipating such a defection, the agents then have an incentive to report $s_l$ when observing $s_h$. This unravels the specified equilibrium. Therefore, the investment strategy in **P2** cannot be implemented by rational parties.

The analysis in this section points to a potential dilemma: the principal wishes to ease the incentive problem by adopting a stringent investment strategy but is unable to precommit to such a strategy. In the next section, we propose that capital rationing can be used as a solution to this dilemma.

## 4.4 The Principal's Decision with Capital Rationing

If the principal decides to impose capital rationing, she raises only $I_o$. This forces the agents to compete for investment capital.[6] Now, the agents are no longer dealt with independently since whether an agent is allowed to invest depends not only on his reported state but also on the reported state of the other agent.

### 4.4.1 Equilibrium concepts

For a given investment and compensation rule specified by the principal, a subgame is induced between the agents. It is essential that the initial contract directs the agents to follow the action rules intended by the principal. Two conditions are required to achieve this: first, the intended action rules must constitute an equilibrium in the subgame of the agents and, second, this equilibrium must not be Pareto dominated from the agents' perspective by another equilibrium.

As before, we focus on the class of truth-telling contracts in solving the principal's problem. There are three commonly known equilibrium concepts for formulating the problem: the Nash equilibrium, the dominant strategy equilibrium, and the subgame-undominated equilibrium. The Nash concept requires a minimal set of conditions on the contract and is the least

[6] We assume that there is a high cost of short-term financing. After the states are reported, it becomes too costly for the principal to raise additional capital immediately. On the other hand, if the projects are not undertaken immediately after the states are realized, their values decrease rapidly.

stringent. However, it is well known that the Nash formulation generally results in more than one equilibrium in the subgame and that the truth-telling equilibrium (the one desired by the principal) may be subgame dominated by a non-truth-telling equilibrium. Therefore, the implementation of the desired Nash equilibrium is not guaranteed. This problem arises because truth-telling is designed to be only a Nash strategy for each agent. That is, each agent has no incentive to lie about his state provided that the other agent also reports the true state, but it has no ability to direct each agent's behavior if the other agent does not tell the truth.

On the other hand, employing the concept of dominant strategy equilibrium solves the problem of multiple equilibria. In fact, with a slight modification to the contract so derived, the truth-telling equilibrium can be made a unique equilibrium in the subgame. Thus, the corresponding contract can be implemented. The disadvantage is that the dominant strategy formulation requires a stronger set of conditions in the contract with respect to all the agents. As a result, implementability comes with an additional cost to the principal.

Other methods have also emerged in the literature to achieve implementability. Demski and Sappington [1984] propose a concept called subgame-undominated equilibrium. Their basic idea is to formulate the problem in such a way that truth-telling is a dominant strategy for one agent and a Nash strategy for the other. This ensures that one agent always tells the true state no matter what strategy the other chooses. Given that one agent always tells the truth, the other agent also follows the truth-telling equilibrium strategy. Compared with the dominant strategy equilibrium, the subgame undominated equilibrium loosens the requirements on the contract for at least one agent. Fischer [1989] adopts a programming method which ensures that the truth-telling equilibrium is not Pareto dominated from the agents' perspective by another equilibrium in the subgame. This is done by explicitly incorporating constraints in such a way that no nontruth-telling strategy will be part of an equilibrium which is simultaneously strictly preferred by both agents.

To keep the analysis simple, but still adequately demonstrate the results, we adopt the dominant strategy equilibrium concept in the following analysis.

### 4.4.2 Formulation and analysis

We shall formulate the problem in such a way that truth-telling is a dominant strategy for both agents. After the states are reported, the capital is allocated by the following rule.[7] One of the agents, say agent 1, receives the capital in both $s_l$ and $s_h$ if the other agent (agent 2) reports $s_l$, but never receives the capital if the other reports $s_h$. Here, the principal no longer treats the agents symmetrically. Denote $x_i^j$ the project outcome required by the principal if agent $j, j = 1, 2$, reports $s_i, i \in \{l, h\}$, and receives the project. Compensation $c_i^j$ is similarly defined. The complete formulation of the problem, denoted **P3**, is given below.

**P3**

$$MAX_{\{x_i^j, c_i^j\}_{i=l,h;j=1,2}} \quad (p_l)^2(x_l^1 - c_l^1) + p_h p_l(x_h^1 - c_h^1) + p_h(x_h^2 - c_h^2) - I_o \tag{4.14}$$

subject to

$$U(c_l^1) - V(\frac{x_l^1}{s_l}) \geq 0, \tag{4.15}$$

$$U(c_h^1) - V(\frac{x_h^1}{s_h}) \geq 0, \tag{4.16}$$

$$p_l[U(c_l^1) - V(\frac{x_l^1}{s_l})] \geq p_l[U(c_h^1) - V(\frac{x_h^1}{s_l})], \tag{4.17}$$

$$p_l[U(c_h^1) - V(\frac{x_h^1}{s_h})] \geq p_l[U(c_l^1) - V(\frac{x_l^1}{s_h})], \tag{4.18}$$

$$U'(c_l^1) \leq V'(\frac{x_l^1}{s_l})/s_l, \tag{4.19}$$

$$U(c_h^2) - V(\frac{x_h^2}{s_h}) \geq 0, \tag{4.20}$$

$$0 \geq U(c_h^2) - V(\frac{x_h^2}{s_l}), \tag{4.21}$$

$$U(c_h^2) - V(\frac{x_h^2}{s_h}) \geq 0. \tag{4.22}$$

[7] This rule is specially chosen so that the result can be illustrated in a very simple way. Ideally, the optimal allocation rule should be derived endogenously.

In **P3**, the objective function, (4.14), represents the principal's expected profit, the participation constraints are given by equations (4.15) and (4.16) for agent 1 and by equation (4.20) for agent 2, and the incentive compatibility constraints are given by (4.17) and (4.18) for agent 1 and by (4.21) and (4.22) for agent 2. Since agent 2 never invests in $s_l$, i.e., $x_l^2 = c_l^2 = 0$, his participation constraint associated with $s_l$ disappears. Finally, equation (4.19) is required for production-compensation to be renegotiation-proof. This condition does not apply to agent 2 as he never produces in the low state.

It is interesting to see that **P3** can be decomposed into two parts so that the solution for agent 1 and agent 2 can be solved separately. Furthermore, the problem associated with agent 1 is identical to **P1** and that associated with agent 2 is identical to **P2**. As a result, the solution to **P3** is easily obtained by combining the solutions to **P1** and **P2**.

The relationship among **P1, P2** and **P3** clearly shows the benefit of capital rationing. Without capital rationing, the principal may prefer the contract of **P2** but can only implement the contract of **P1**. Capital rationing, as modelled in **P3**, effectively enables the principal to implement the contract of **P2** with probability $p_h$ and that of **P1** with probability $s_l$. Thus, it partially resolves the principal's dilemma described in section 4.3.

In **P3**, we can identify two sources of benefit from imposing capital rationing. First, capital rationing eases the agents' shirking problem, which is reflected by the fact that the incentive compatibility constraints become less stringent. Therefore, the set of feasible contracts expands. The reason is that with capital rationing agents are no longer guaranteed a project. Instead, they have to compete with each other for the investment capital. Each agent who observes $s_h$ is now less tempted to report $s_l$ since by doing so he may lose the opportunity to invest altogether. Hence, the principal does not have to pay as much to induce truth-telling. Second, the probability measure used in the objective function is revised. With capital rationing, the capital is always allocated to the more efficient division. Therefore, the probability that the project is operated in $s_h$ becomes $p_h + p_h p_l$, although the corresponding probability for each potential project is $p_h$.

The cost of imposing capital rationing is the loss of the profit of the foregone project.

Let $NPV(P3)$ be the principal's expected profit from **P3**,

$$NPV(P3) = p_l^2(x_l^1 - c_l^1) + p_h p_l(x_h^1 - c_h^1) + p_h(x_h^2 - c_h^2) - I_o \quad (4.23)$$

The principal rationally rations capital if and only if $NPV(P3) > NPV(P1)$, or

$$\begin{aligned} I_o &> [2p_l(x_{l1} - c_{l1}) + 2p_h(x_{h1} - c_{h1})] - [p_l^2(x_l^1 - c_l^1) + \\ &\quad p_h p_l(x_h^1 - c_h^1) + p_h(x_h^2 - c_h^2)] \\ &= p_l(2 - p_l)(x_{l1} - c_{l1}) + p_h(2 - p_l)(x_{h1} - c_{h1}) \\ &\quad - p_h(x_{h2} - c_{h2}). \end{aligned} \quad (4.24)$$

## Numerical example

The following numerical example is provided in order to examine the circumstances where capital rationing should be imposed.

### Example 2

This is a continuation of Example 1. That is, for each agent,

| |
|---|
| $x = se,\ U(c) = c^{0.5},\ V(e) = e^2/50,$ |
| $s_l = 2^{0.5},\ s_h = 2.0,$ |
| $p_l = 0.5,\ p_h = 0.5.$ |

The production and compensation levels without capital rationing (**P1**):

| |
|---|
| $x_{l1} = 13.60,\ x_{h1} = 18.73$ |
| $c_{l1} = 3.39,\ c_{h1} = 7.13$ |
| $NPV(P1) = 21.81 - 2I_o$ |

The production and compensation levels with capital rationing (**P3**):

| agent 1 | agent 2 |
|---|---|
| $x_l^1 = 13.60,\ x_h^1 = 18.73$ | $x_l^2 = 0.0,\ x_h^2 = 21.54$ |
| $c_l^1 = 3.39,\ c_h^1 = 7.13$ | $c_1^2 = 0.0,\ c_h^2 = 5.39$ |
| $NPV(P3) = 13.53 - I_o$ | |

By applying equation (4.24), we see that the expected profit is higher with capital rationing if $I_o > 8.28$. The example is illustrated in figure 2.

### 4.4.3 Implementability

We need to examine whether the contract derived from **P3** can be rationally implemented in the sequential game.

The first consideration is whether the owner has the incentive to renege on the capital allocation rule under any circumstance. The solution shows that $x_l^1 - c_l^1 > x_l^2 - c_l^2$, $x_h^1 - c_h^1 > x_l^2 - c_l^2$, $x_l^1 - c_l^1 < x_h^2 - c_h^2$, and $x_h^1 - c_h^1 < x_h^2 - c_h^2$. That is, the owner achieves a higher profit by allocating the capital to agent 1 if both report the low state, to agent 2 if both report the high state, and to whoever reports the high state if managers report different states. This is exactly the same as the rule in **P3**. Therefore, the owner is strictly better off by following the specified allocation rule.

A second question is whether renegotiation may take place between the owner and either one of the agents after capital is allocated. This question has two parts: renegotiation between the principal and the agent who receives the capital and that between the principal and the agent who does not. Clearly, the first kind of renegotiation is ruled out since production is always efficient in **P3**. The second kind of renegotiation is also ruled out since the non-investing agent, either agent 1 or agent 2, can never be better off by offering a production-compensation which also makes the principal strictly better off, and this holds in every situation.

Third, we need to examine the subgame between the agents induced by the overall decision rule.[8] Since reporting the true state is a dominant strategy for each agent, the intended equilibrium is a dominant strategy equilibrium. In fact, by reducing each agent's production level in $s_h$ by an arbitrarily small amount, truth-telling becomes a unique equilibrium in the subgame.

### 4.4.4 Comparative statics

The analysis above provides a rationale for multiple-division corporations to adopt a policy of capital rationing. The desirability of capital rationing is determined by the characteristics of potential projects.

[8] Explicit collusion between the managers is not considered in this model.

As is shown in figure 2, capital rationing is preferred by the owner if $I_o$ is high (the NPVs are low but positive). On the other hand, if $I_o$ is low (the NPVs are high), no rationing should be imposed. The reason is that capital rationing forces the firm to forgo some of the projects. The more profitable the projects, the higher the cost of capital rationing. When the projects are highly profitable, the owner would rather let the managers extract some rent than give up any of the projects.

A second factor influencing the decision to ration is the variation of project quality, $s_h - s_l$. Suppose that $s_l$ decreases while $s_h$ stays constant, i.e., the quality of each project varies more widely. If both projects are always accepted, the agents now are able to extract more rents because the potential to save effort by under-reporting the state has become greater. Therefore, rationing becomes more desirable. While a formal illustration is tedious, this point can be easily seen in Figure 1. As $s_l$ decreases, curve $OA$ rotates downward, which moves both $L$ and $H$ to the right along their respective efficient production curves. Therefore, both $x_{l1} - c_{l1}$ and $x_{h1} - c_{h1}$ become smaller. On the other hand, $x_{h2} - c_{h2}$ stays the same. Therefore, from equation (4.24), capital rationing becomes desirable over a greater region of $I_o$. Therefore, if the potential quality of the projects has a greater variation, capital rationing is more likely to take place.

Third, the probabilities, $p_l$ and $p_h$, also affect the decision to ration. From (4.24), rationing takes place whenever

$$I_o \geq \hat{I}_o \equiv p_l(2-p_l)(x_{l1} - c_{l1}) + (1-p_l)(2-p_l)(x_{h1} - c_{h1}) - (1-p_l)(x_{h2} - c_{h2}).$$

Differentiating $\hat{I}_o$ with respect to $p_l$,

$$\frac{d\hat{I}_o}{dp_l} = [(x_{h2} - c_{h2}) - (x_{h1} - c_{h1})] - 2p_h[(x_{h1} - c_{h1}) - (x_{l1} - c_{l1})].$$

Since the sign of the derivative depends on $p_h$, the effect of increasing $p_l$ relative to $p_h$ also depends on $s_h$. In generally, increasing $s_l$ (decreasing $s_h$) affects both the benefit and cost of capital rationing. Depending on specific parameters, capital rationing may become either more desirable or less desirable.

The correlation of state between the divisions is another factor influencing the rationing decision. In the analysis above, we assume that the divisions have uncorrelated states. In general, however, the states may be correlated. The benefit of capital rationing decreases as the correlation increases because the probability that the project is operated in $s_h$ becomes smaller. In an extreme case where the divisions have perfectly correlated states, there will be no benefit from rationing at all.

## 4.5 Implications

The analysis in this chapter provides a role of capital rationing in corporate capital investment decisions. Specifically, a tight capital constraint forces the alternative projects to compete for investment capital. This facilitates the revelation of project information and reduces managers' incentive to shirk. Capital rationing may help firms to achieve a higher profit when potential projects are marginally profitable. In this section, we discuss implications and empirical predictions from the above analysis.

Firm Characteristics and Capital Rationing

The purpose of internal capital rationing is to reduce managerial incentives to misrepresent their private information and their ability to extract rent. Managers are able to extract rent because they have more precise information about potential projects than the owner does. The more severe the information asymmetry between managers and the owner, the more costly it is for the owner to motivate managers, and therefore the more useful it is to impose capital rationing. This suggests that firms in which divisional managers have significant advantages in expertise and business information over their headquarters are more likely to practise capital rationing. In large corporations, it is difficult for top management to become well-informed of operations at the divisional level, so divisional managers may have large discretion in deciding how they report their local information. Information asymmetries become even more severe in firms which are engaged in multiple lines of business, as in a conglomerate, because of the difficulties for top management to possess specific information about many different industries. One implication is that capital rationing is more likely to be useful as a disciplinary device in large firms and firms with many lines of besiness.

The analysis also shows that capital rationing has a greater benefit if the qualities of projects in different divisions are less correlated. This is because if divisional states have low correlations, there is a higher probability that capital is allocated to divisions of high profitability.

Furthermore, incentive problems are more severe in those firms because with low state correlations it is more difficult to motivate each manager based on the performance of other managers. Therefore, capital rationing can play a more important role. This again leads to the prediction that firms with diverse business operations are more likely to impose capital rationing.

The desirability of capital rationing is inversely related to the profitability of investment opportunities; the more profitable investment opportunities are, the costly it is to forgo some projects. This suggests that capital rationing will be more commonly practised at times of high cost of capital or low credit availability.

## Managerial Adverse Investment Incentives

The analysis suggests a particular pattern of adverse incentives exhibited by managers. Divisional managers generally benefit from undertaking projects. (In the model here, the private benefit is information rent.) Since managerial benefit is conditional on projects being undertaken, managers have an incentive to over-report the profitability of potential projects at the capital budgeting phase. This implication is clear from the analysis even though the model has suppressed the incentive issue at the initial budgeting stage by assuming that parties have symmetric information regarding the ex ante profitability of the projects. The notion that managers have a tendency to over-represent project quality is generally accepted. For example, Brealey and Myers [1984] state "divisional managers habitually overstate investment opportunity". However, this recognizes only part of the story. The analysis shows that once projects are approved, managers have the incentive to shirk and, hence, under-report the state of productivity.

In brief, managerial adverse incentive is characterized by over-representation of project quality at the capital budgeting phase and under-representation at the implementation phase.

## Corporate Capital Budgeting Decisions

The analysis above points out limitations in traditional theories such as the value-additivity rule and the net present value rule. If the two divisions in the model belong to two different firms, the projects will be evaluated independently of each other and it is optimal for both firms to accept the potential project. Clearly, the value of an investment opportunity is dependent upon the organizational form of the firm. Projects within a firm should be evaluated collectively even if they are technologically and informationally independent. Therefore, it is generally incorrect in capital budgeting to apply the NPV rule for each individual project, and the value of the firm is not additive.

The analysis also provides implications for the decision-making delegation within an organization. Important capital investment decisions require the participation of different levels of management. To make informed decisions, divisional managers are needed to supply first-hand information. The task of the top management is to coordinate the overall investment based on the received information. This suggests that either a total centralization or a total decentralization is likely to be too extreme. In practice, the form of decision-making would reflect its related cost and be constrained by the scarcity of management resources. As Ferreira and Brooks [1988] show, the level of management involved in making investment decisions is related to the size of investment. Overall, all levels within large corporations, from the board of directors and CEOs, and divisions, to plant levels, are involved in different investment decisions, and many projects have joint participants.

# Bibliography


[1] Aron, D.J., 1988, "Ability, moral hazard, firm size, and diversification", *Rand Journal of Economics vol.19*

[2] Beaudry, P., and M. Poitevin, 1991, "Signalling and renegotiation in competitive contractual markets", *working paper*, Centre de recherche st developpement en economique

[3] Bhattacharya, S. and J.L. Guasch, 1988, "Heterogeneity, tournaments, and hierarchies", *Journal of Political Economy, vol. 96, no. 4*

[4] Brealey, R., and S. Myers, 1991, *Principles of Corporate Finance*, Fourth Edition, McGraw-Hill Inc.

[5] Campbell, T.S., Y.S. Chan and A.M. Marino, 1989, "When is it optimal to blow the whistle on yourself ?", *working paper 89-40*, University of Southern California

[6] Campbell, T.S., Y.S. Chan and A.M. Marino, 1989, "Incentive contracts for managers who discover and manage investment projects", *Journal of Economic Behavior and Organization*

[7] Demski, J. S. and D. Sappington, 1984, "Optimal contracts with multiple agents", *Journal of Economic Theory 33*

[8] Dewatripont, M., 1989, "Renegotiation and information revelation over time: the case of optimal labor contracts", *Quarterly Journal of Economics 104*, 589-619

[9] Ferreira, E.J. and L. Brooks, 1988, "Capital budgeting: a key management challenge", *Business, vol.38*

[10] Fischer, P., 1989, "A principal-agent-monitor model", *working paper*, the University of British Columbia

[11] Fremgen, J.M., 1973, "Capital budgeting practices", *Management Accounting*

[12] Giammarino, R.M. and T. Lewis, 1989,"A theory of negotiated equity financing", *The Review of Financial Studies, vol.1, no.3*

[13] Gitman, L., and J. Forrester, Jr., 1977,"A survey of capital budgeting techniques used by major U.S. firms", *Financial Management*, Fall

[14] Grossman, S.J. and O.D. Hart, 1983, "An analysis of the principal-agent problem", *Econometrica, vol.51, no.1*

[15] Hart, O., and J. Moore, 1988, "Incomplete contracts and renegotiation", *Economitrica 56*, 755-785

[16] Holmstrom, B., 1979, "Moral hazard and observability", *The Bell Journal of Economics*

[17] Holmstrom, B. and J. Ricart i Costa, 1986, "Managerial incentives and capital management", *The Quarterly Journal of Economics*

[18] Kreps, D.M. and R. Wilson, 1982,"Sequential equilibria", *Econometrica vol.50, no.4*

[19] Lambert, R.A., 1983, "Long-term contracts and moral hazard", *The Bell Journal of Economics 14*,

[20] Lambert, R.A., 1985, "Executive effort and selection of risky projects", *Rand Journal of Economics vol.17*

[21] Lazear, P. E. and S. Rosen, 1981, "Rank-order tournaments as optimal labor contracts", *Journal of Political Economy, vol. 89, no. 5*

[22] Maksimovic, V. and J. Zechner, 1989, "Debt, agency costs and industry equilibrium", *working paper, the University of British Columbia*

[23] Mao, J.C.T., 1970, "Survey of capital budgeting: theory and practice", *Journal of Finance vol 24*

[24] Maskin, E., and J. Tirole, 1988, "The principal-agent relationship with an informed principal, II: common values", *discussion paper no. 1412*, Harvard Institute of Economic Research

[25] Mookherjee, D., 1984, "Optimal incentive schemes in many agents", *Review of Economic Studies 51*

[26] Myers, S.C. and N.S. Majluf, 1984, "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics 13*

[27] Myerson, R.B., 1982, "Optimal coordination mechanisms in generalized principal-agent problems", *Journal of Mathematical Economics 10*

[28] Nosal, E., 1991, "Implementing ex ante contracts", *working paper*, University of Waterloo

[29] Nunamaker, T.R. and J.F. Truitt, 1987, "Rationing discretionary economic resources: a multiobjective approach", *Decision Science vol.18*

[30] Repullo, R, 1986, "On the revelation principal under complete and incomplete information", *Economic Organizations as Games*, ed. by K. Binmore and P. Dasgupta, Basil Blackwell: Oxford

[31] Repullo, R, 1985, "Implementation in dominant strategies under complete and incomplete information", *Review of Economic studies 52*

[32] Stoughton, N., and E. Talmore, 1990, "Screening vs. signalling in managerial compensation and corporate investment", *working paper*, University of California, Irvine, and Tel Aviv University

[33] Trivoli, W.G. and W.R. McDaniel, 1987, "Uncertainty, capital immobility and capital rationing in the investment decision", *Journal of Business Finance and Accounting 14(2)*

## Appendix 4A. Proofs of Propositions

### 4A.1. proof of lemma 1

Rewrite problem **P1-a**,

$$\mathrm{MAX}_{\{x_l, x_h, c_l, c_h\}}\ p_l(x_l - c_l) + p_h(x_h - c_h) - I_o \tag{4.25}$$

Subject to

$$U(c_l) - V(\frac{x_l}{s_l}) \geq 0, \tag{4.26}$$

$$U(c_h) - V(\frac{x_h}{s_h}) \geq 0, \tag{4.27}$$

$$U(c_l) - V(\frac{x_l}{s_l}) \geq U(c_h) - V(\frac{x_h}{s_l}), \tag{4.28}$$

$$U(c_h) - V(\frac{x_h}{s_h}) \geq U(c_l) - V(\frac{x_l}{s_h}). \tag{4.29}$$

The Lagrangian of programming problem **P1-a** is

$$\begin{aligned} L \;=\; & p_l(x_l - c_l) + p_h(x_h - c_h) + \\ & \lambda_1[U(c_l) - V(\frac{x_l}{s_l})] + \lambda_2[U(c_h) - V(\frac{x_h}{s_h})] + \\ & \mu_1[U(c_l) - V(\frac{x_l}{s_l}) - U(c_h) + V(\frac{x_h}{s_l})] + \\ & \mu_2[U(c_h) - V(\frac{x_h}{s_h}) - U(c_l) + V(\frac{x_l}{s_h})]. \end{aligned} \tag{4.30}$$

Let $\{x_{la}, x_{ha}, c_{la}, c_{ha}\}$ be the optimal solution. Taking the first order conditions, we get

$$\frac{\partial L}{\partial x_l} = p_l - \lambda_1 \frac{1}{s_l} V'(\frac{x_{la}}{s_l}) - \mu_1 \frac{1}{s_l} V'(\frac{x_{la}}{s_l}) + \mu_2 \frac{1}{s_h} V'(\frac{x_{la}}{s_h}) = 0, \tag{4.31}$$

$$\frac{\partial L}{\partial x_h} = p_h - \lambda_2 \frac{1}{s_h} V'(\frac{x_{ha}}{s_h}) + \mu_1 \frac{1}{s_l} V'(\frac{x_{ha}}{s_l}) - \mu_2 \frac{1}{s_h} V'(\frac{x_{ha}}{s_h}) = 0, \tag{4.32}$$

$$\frac{\partial L}{\partial c_l} = -p_l + [\lambda_1 + \mu_1 - \mu_2] U'(c_{la}) = 0, \tag{4.33}$$

and

$$\frac{\partial L}{\partial c_h} = -p_h + [\lambda_2 - \mu_1 + \mu_2] U'(c_{ha}) = 0. \tag{4.34}$$

Constraints (4.28) and (4.29) imply that

$$V(\frac{x_{ha}}{s_l}) - V(\frac{x_{la}}{s_l}) \geq V(\frac{x_{ha}}{s_h}) - V(\frac{x_{la}}{s_h})$$

which implies $x_{ha} \geq x_{la}$ since $V'' > 0$. Below, we rule out the possibility that $x_{ha} = x_{la}$.

Suppose $x_{la} = x_{ha}$, then it must be that $c_{la} = c_{ha}$ for the contract to be feasible. Then, all the constraints but (4.27) are binding. So $\lambda_1 > 0$, $\lambda_2 = 0$, $\mu_1 > 0$, $\mu_2 > 0$.

From first order conditions (4.31) and (4.33), we can show

$$U'(c_{la}) > \frac{1}{s_l} V'(\frac{x_{la}}{s_l}).$$

Similarly, from (4.32) and (4.34), we can show

$$U'(c_{ha}) < \frac{1}{s_h} V'(\frac{x_{ha}}{s_h}).$$

Therefore,

$$U'(c_{la}) > \frac{1}{s_l} V'(\frac{x_{la}}{s_l}) > \frac{1}{s_h} V'(\frac{x_{ha}}{s_h}) > U'(c_{ha}),$$

since $x_{la} = x_{ha}$ by supposition. This implies $c_{la} < c_{ha}$, contradicting the above. Therefore it must be that $x_{la} < x_{ha}$. Then, incentive compatible constraints (4.28) and (4.29) imply that $c_{la} < c_{ha}$. Since $x_{la} < x_{ha}$, at most one constraint is binding between (4.28) and (4.29). The optimal solution must make (4.29) binding. So $\mu_1 = 0$.

Then, the first order conditions imply that

$$U'(c_{la}) > \frac{1}{s_l} V'(\frac{x_{la}}{s_l}),$$

and

$$U'(c_{ha}) = \frac{1}{s_h} V'(\frac{x_{ha}}{s_h}).$$

This shows that production is efficient in $s_h$ but below the efficient level in $s_l$.

Since (4.29) is binding but not (4.30),

$$U(c_{la}) - V(\frac{x_{la}}{s_l}) > U(c_{ha}) - V(\frac{x_{ha}}{s_l})$$

and

$$U(c_{ha}) - V(\frac{x_{ha}}{s_h}) = U(c_{la}) - V(\frac{x_{la}}{s_h}) > U(c_{la}) - V(\frac{x_{la}}{s_l}).$$

Together with constraints (4.26) and (4.27), this suggests

$$U(c_{la}) - V(\frac{x_{la}}{s_l}) = 0$$

and

$$U(c_{ha}) - V(\frac{x_{ha}}{s_h}) > 0.$$

Therefore, the manager receives a positive rent in $s_h$.

### 4A.2. proof of proposition 1

Rewrite problem **P1**,

$$\text{MAX}_{\{x_l,x_h,c_l,c_h\}}\ p_l(x_l - c_l) + p_h(x_h - c_h) - I_o \tag{4.35}$$

Subject to

$$U(c_l) - V(\frac{x_l}{s_l}) \geq 0, \tag{4.36}$$

$$U(c_h) - V(\frac{x_h}{s_h}) \geq 0, \tag{4.37}$$

$$U(c_l) - V(\frac{x_l}{s_l}) \geq U(c_h) - V(\frac{x_h}{s_l}), \tag{4.38}$$

$$U(c_h) - V(\frac{x_h}{s_h}) \geq U(c_l) - V(\frac{x_l}{s_h}), \tag{4.39}$$

$$U'(c_l) \leq V'(\frac{x_l}{s_l})/s_l. \tag{4.40}$$

For the same reason as in **P1-a**, constraints (4.37) and (4.38) will be non-binding. The other three constraints, plus the efficient production condition in the high state uniquely determine the optimal solution. The proposition is proven by showing that, if any of these four equations are violated, the solution will not be optimal. The algebraic process is tedious but the intuition can be easily seen in Figure 1.

### 4A.3. proof of proposition 3

In program **P1**, the project generates a positive profit even in the low state. So, in $s_l$, the principal is strictly worse off in **P2** by forgoing the project.

The solution to **P2**, $(x_{h2}, c_{h2})$, is effectively the solution to the following problem:

$$MAX_{\{x,c\}}\quad x - c \tag{4.41}$$

S.t.

$$U(c) - V(\frac{x}{s_h}) \geq 0. \tag{4.42}$$

On the other hand, given $(x_{l1}, c_{l1})$, $(x_{h1}, c_{h1})$ is the solution to the following more restrictive problem.

$$MAX_{\{x,c\}} \quad x - c \tag{4.43}$$

S.t.

$$U(c) - V(\frac{x}{s_h}) \geq 0. \tag{4.44}$$

$$U(c) - V(\frac{x}{s_h}) \geq U(c_{l1}) - V(\frac{x_{l1}}{s_{l1}}). \tag{4.45}$$

From proposition 1, (4.45) is binding and (4.44) is not. Therefore, $x_{h1} - c_{h1} < x_{h2} - c_{h2}$; the profit in $s_h$ is higher in **P2** than **P1**.

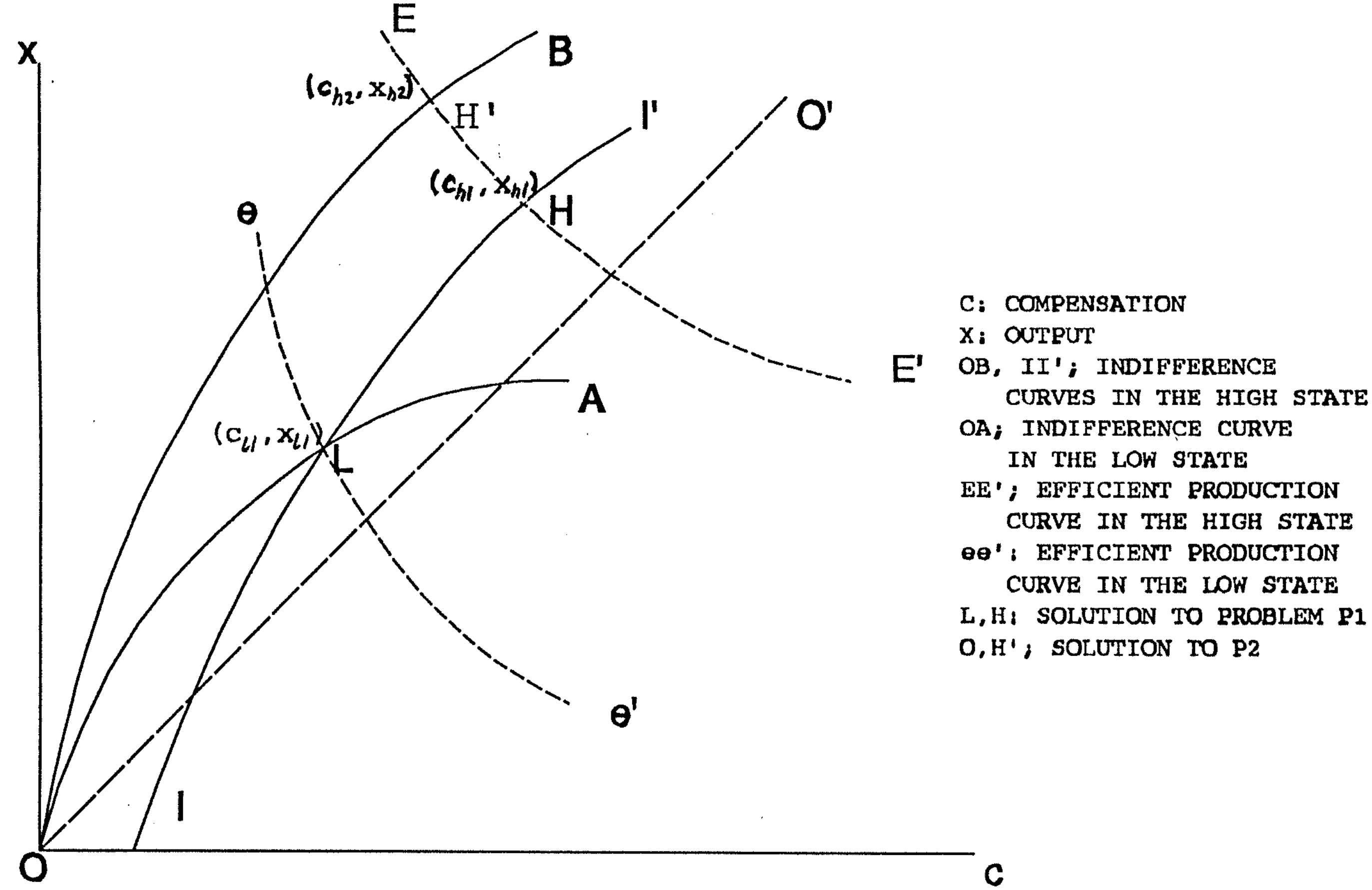


Figure 1: Illustration of Solutions to P1 and P2

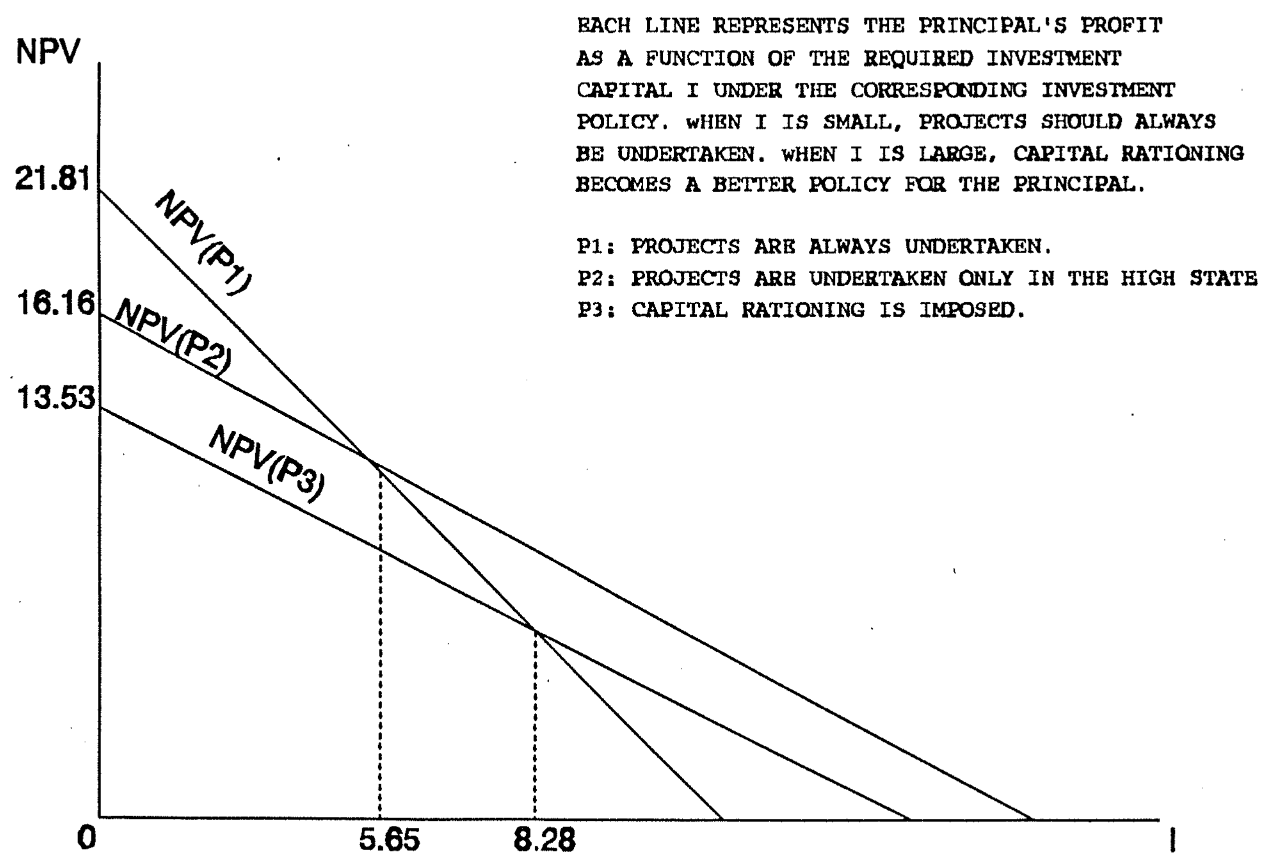


FIGURE TWO: Comparison of P1, P2 and P3

# Chapter 5

# The Role of Managerial Stock Acquisition in Resolving Shareholder-Manager Investment Conflicts

## 5.1 Introduction

The previous chapter has demonstrated that the scale of investment financing can affect managerial incentives. In this chapter, we analyse the role of managerial stock acquisition in resolving incentive problems in investment. Managerial investment decisions are in part determined by the private benefit they receive from an investment project which, in general, is not perfectly correlated with the monetary profit of the project. This potentially causes managers either to accept an unprofitable project or to reject a profitable one. Shareholders may then find it undesirable to rely on managers to make investment decisions.

One way to induce proper investment decisions is to provide managers with the opportunity of purchasing their own firms' shares. Presumably, a manager will buy stock only when he expects the investment project to be sufficiently profitable. Then, an action of stock purchase provides information which allows shareholders to make a more precise investment decision. The information revelation is made credible by the fact that the manager's interest is more closely related to that of the shareholders after stock acquisition.

In the principal-agent literature, mechanism design has traditionally been used to resolve the incentive problem. Specifically, the principal designs a direct compensation contract which induces the agent to reveal his private information and/or take a desirable action. In theory, a direct compensation contract based on all contractable variables can provide a flexible payoff schedule. On the other hand, in the corporate finance literature, mechanisms relying on financial policy have been proposed to resolve conflicts between various parties in a firm. Loosely speaking, the effect of a financial mechanism is to provide a proper allocation of cash flows among conflicting parties. An interesting question is whether the incentive and signalling roles of financial mechanisms are made redundant by the direct compensation mechanism. Holmstrom and Tirole [1989] point out, "The major shortcoming of these and other (financially based) incentive arguments is that they beg the question: Why should capital structure be used as an incentive instrument, when the manager could be offered explicit incentives that do not interfere with the choice of financing mode? ... This criticism applies equally to the signalling models...". Similar views are also expressed in other studies.[1]

It seems to be simple logic that the effect of any financial incentive mechanism could be achieved by an explicit incentive contract whose payoff function is equivalent to that of the former. Implicit in this argument, however, is the assumption that the equivalent payoff function is permissible in direct compensation. It is possible that this assumption can be violated by external conditions faced by firms. As proposed in this model, one such condition is limited liability.

In reality, limited liability is a universal constraint. Although the precise reasons for it are still open to debate, which this analysis does not intend to pursue, empirical observation suggests that ignoring limited liability is not realistic. In general, the personal wealth of an individual is small or negligible compared with the value of the firm; hence, there are obvious limits as to how much the manager can be penalized in monetary terms. Furthermore, as the precise knowledge of an individual's personal wealth is not available to others, wealthy managers may find ways to avoid making a payment, such as by transferring the legal ownership of assets to family members. As a result, it can be costly or impractical to enforce the settlement of managerial personal liabilities.

Typically, incentive compensation contracts are based on outcomes of managerial performance, which, therefore, can only be settled ex post. The effectiveness of direct compensation as an incentive device thus depends on the extent to which contracted ex post payments can

[1] see Dybvig and Zender [1991] and Hart and Holmstrom [1987].

be enforced. With limited liability, the set of possible payments is bounded from below. This implies that the manager cannot be required to make a large payment as a penalty when a bad outcome occurs. In situations where it would be desirable to impose a contingent penalty on the manager, the limited liability condition raises the overall cost of compensation and impairs its effectiveness.

In the analysis below, we suggest that managerial stock acquisition (before making real decisions) is a way of circumventing the limited liability condition. The key difference with stock acquisition is that managers precommit their personal wealth before an investment decision is made. This credibly conveys information to shareholders about the profitability of the investment. Notice that the manager's action is voluntary: only when the state is favorable would the manager be interested in stock acquisition.

To see why the net payoff schedule resulting from stock acquisition circumvents the condition of limited liability in direct compensation, notice that the manager faces an uncertain return on the acquired stock. The decision to purchase stock is based on the manager's beliefs about the project's return. An optimistic expectation ex ante does not guarantee a high return. Although there is a chance that the manager will gain from stock acquisition, it is also possible that the manager will suffer a loss. This all happens on a voluntary basis. In contrast, because of limited liability, a direct payment from the manager to shareholders could not have been enforced ex post.[2]

The detailed model is presented in the next section but here is a brief description. The firm faces a potential project, but only the manager has costless access to information about the project when the investment decision is made. If accepted, the project provides a monetary return and a private benefit which is exclusively enjoyed by the manager. The private benefit is a general representation of all the benefits, other than those specified by managerial ownership and the compensation contract, which the manager obtains by undertaking the project. The level of private benefit is determined by intrinsic characteristics of the manager and may be unrelated to the monetary return of the project. For example, the manager gains experience

[2]One may suggest the possibility of requiring the manager to put his personal wealth in a riskless asset ex ante and then writing a compensation contract. This way, the limited liability condition is also avoided. The theoretical framework here does not rule out this as an alternative to managerial stock acquisition. In practice, however, one can also be faced with the limited ability of writing and enforcing a complete contract. In this sense, managerial stock acquisition represents a more practical and convenient way of achieving a similar effect.

from undertaking the project which enhances his human capital, but the exact gain depends on how long the manager plans to continue working. Since monetary return and private benefit are not perfectly correlated, there is a divergence of investment criterion between the manager and the shareholders.

In the analysis, we first examine the role of direct compensation in resolving the conflict. Since limited liability bounds compensation from below, managerial incentive has to be provided through contingent rewards instead of contingent penalties. This, together with the uncertainty of both monetary return and private benefit, makes incentive compensation particularly costly to the shareholders. As we show, it is possible that the expected cost of compensation exceeds the expected profit of the potential project. Therefore, the shareholders are better off by rejecting the project unconditionally.

We then study a signalling mechanism in which the manager is allowed to purchase stock in the market. This is similar to the notion that insider trading is a means of transmitting private information to the market. The intention to purchase and the size of purchase convey information about project quality. Within this framework, a unique perfect sequential equilibrium is shown to exist where both the manager and shareholders receive a positive benefit from the potential project. The equilibrium is partially separating. Depending on model parameters, either over- or under-investment is possible.

In signalling, the manager makes the first move and the shareholders react to the manager's action. Due to the lack of coordination among shareholders in the stock market, the manager is able to appropriate part of the gain from the firm's investment. An alternative to signalling is the screening approach in which the shareholders set the terms of stock acquisition ex ante. A pre-determined contract for stock acquisition allows the course of the game to be set by the shareholders instead of the manager. Effectively, the contract serves as an instrument for coordinating the shareholders' actions. We show that a screening contract increases the expected profit to shareholders and improves the investment efficiency.

## 5.2 The Model

The model depicts an investment problem of a public firm which is operated by a manager and owned by shareholders. The manager initially owns no stock in the firm.

The problem starts at $t_0$, the time when a contractual relation between the manager and the shareholders is established. The manager then takes charge of an existing business on behalf of the shareholders.

At time $t_1$, a new project becomes available in addition to the existing business. The shareholders have the power to accept or reject the project. Both the existing business and the new project end at time $t_2$ and the firm is terminated at that time.

*Technology*

The existing business generates a cash flow $x_o$ at $t_1$. Since the focus of the analysis is on the shareholder-manager conflict surrounding the evaluation of the new project, we assume that the existing business has a zero scale from time $t_1$ onwards.

The new project requires an investment capital $I$. It generates a cash flow $x$ at $t_2$, which is normally distributed with mean $m$ and variance $V$; $x \sim N(m, V)$.

Whether the project is financed externally or internally does not make a difference in this problem, since it does not affect the manager's incentive nor the shareholders' investment decision. The reason is that information asymmetry is between the manager and investors but not between investors. Without loss of generality, we assume that the cash flow at $t_1$ from the existing business ($x_o$) is sufficient to finance the new project. For convenience, let $x_o = I$. If the project is rejected, $x_o$ is distributed as dividends.

*Preferences*

Shareholders are able to diversify all unsystematic risk of the firm. Therefore, the value of the firm is determined by the expected cash flow adjusted for its systematic risk. For convenience, we assume that the firm has a systematic risk (beta) of zero. Therefore, the shareholders' objective is equivalent to maximizing the expected cash flow of the firm. In this model, shareholders may either sell shares or hold them; the objective is unaffected.

The manager's utility is determined by the financial income and private benefit from undertaking the project. Let variable $i$ indicate the status of the project; $i = 1$ if the project is undertaken and $i = 0$ otherwise. Let $u^m$ be the manager's expected utility at $t_1$, $w$ his net income over the period from $t_0$ to $t_2$, and $q$ the private benefit of the project. Possible sources of income ($w$) include compensation and payoff from any security the manager buys before $t_2$. Clearly, $w$ can depend on all publicly observable variables such as $i$ and $x$.

The manager's utility at $t_1$ is defined as

$$u^m = E(w) - \gamma Var(w) + iq, \quad \gamma > 0,$$

where $E$ and $Var$ are the expectation and variance operators respectively. Notice that $u^m = 0$ if $w = 0$ and $i = 0$. The manager is strictly risk averse given that $\gamma$ is strictly positive. Furthermore, we assume that $E(w) - \gamma Var(w) \geq 0$ for any non-negative random variable $w$.

*Information Structure*

Time $t_0$: The shareholders and the manager have symmetric information at $t_0$. The following information is common knowledge:

- The mean return of the project, $m$, is drawn from the set[3] $\{m_1, m_2, m_3\}$, $0 < m_1 < m_2 < m_3$.
- The variance of return, $V$, is known for certain.
- The private benefit of the project, $q$, is drawn from the set $\{0, Q\}$, $Q > 0$.
- The state at $t_1$ is characterized by $(m, q) \in S$, where

  $$S \equiv \{(m_1, 0), (m_2, 0), (m_3, 0), (m_1, Q), (m_2, Q), (m_3, Q)\}.$$

  The probability of state $(m, q)$ is denoted by $p(m, q)$.

Time $t_1$: Cash flow from the existing business, $x_o$, is realized and publicly observed. State $(m, q)$ is realized and privately observed by the manager. We justify why the manager has better information than the shareholders about $m$ and $q$ as follows: the manager has first-hand knowledge about the technology that the firm possesses for operating the project and

[3]The project is assumed to have three possible types instead of two. A three-type model allows us to show the general result which is that the equilibrium is partially separating. On the other hand, a two-type model leads to a fully separating equilibrium which is not a general result in this problem.

has direct access to product-market information; therefore, he has better information about the anticipated cost and revenue associated with the project. Also, the manager knows how much the experience from managing the project is worth to him personally in future years, which is directly related to his career plan for the future, and how much he enjoys the challenge of managing the project, etc..

Time $t_2$: Cash flow from the project, $x$, is realized and publicly observed if the project is accepted at $t_1$.

*Assumptions about Parameters*

The model parameters include $m_1, m_2, m_3, Q$, $p(m,q)$, and $I$. There are many possible combinations of these parameters. For completeness, one may analyse the problem for each parameter region. However, it suffices to demonstrate our point by restricting the attention to the following set of assumptions:

**A1.** $m$ and $q$ are independently distributed. The marginal probabilities are $Prob(q=0)=0.5$, $Prob(q=Q)=0.5$, and $Prob(m=m_i)=p_i$, $i=1,2,3$. Then, the complete description of the probability distribution is:

| $(m,q)$ | $(m_1,0)$ | $(m_2,0)$ | $(m_3,0)$ | $(m_1,Q)$ | $(m_2,Q)$ | $(m_3,Q)$ |
|---|---|---|---|---|---|---|
| $Prob(m,q)$ | $0.5p_1$ | $0.5p_2$ | $0.5p_3$ | $0.5p_1$ | $0.5p_2$ | $0.5p_3$ |

**A2.** $0.5(p_1m_1+p_2m_2+p_3m_3-I)+0.5p_3(m_3-I)<0$; the average profit is negative if the project is accepted in states $(m_1,Q),(m_2,Q),(m_3,Q)$ and $(m_3,0)$ and rejected otherwise.

**A3.** $0.5(p_2(m_2-I)+p_3(m_3-I))+0.5p_3(m_3-I)\geq 0$; the average profit is positive if the project is accepted in states $(m_2,Q),(m_3,Q)$ and $(m_3,0)$ and rejected otherwise.

**A4.** $p_2(m_2-I)+p_3(m_3-I)<0$; the average profit is negative if the projected is accepted only in states $(m_2,Q)$ and $(m_3,Q)$.

**A5.** $p_3(m_3-I)-Q<0$; the unconditional expected profit is less than $Q$ if the project is accepted if and only if $m=m_3$.

**A6.** $m_2-I+Q<0$; the private benefit to the manager is not sufficient to compensation for the monetary loss associated with the project in state $(m_2,Q)$. Therefore, the socially optimal decision in state $(m_2,Q)$ is to reject the project.

**A7.** $0.5(m_1 + m_3) - m_2 \leq 0$.

Several implications are immediate from these assumptions. First, $m_2 < I < m_3$; therefore, the optimal decision rule for the shareholders is to accept the project in states $(m_3, 0)$ and $(m_3, Q)$, and reject it in all the other states. On the other hand, the manager prefers to accept the project whenever $q = Q$. Second, if $m < I$, then $m + Q < I$. In other words, if the project is unprofitable in monetary terms, it is also undesirable socially, hence the first-best decision is to reject it.

## 5.3 Direct Compensation

In this section, we examine the effectiveness of direct compensation in resolving the shareholder-manager investment conflict. An important assumption is that the manager has personal limited liability. Let compensation be represented by $c(i, x)$, which is a function of investment decision $i$ and cash flow $x$. The limited liability condition implies $c \geq c_0$. [4] Without loss of generality, we set $c_0 = 0$. In general, there may or may not be other externally imposed constraints on compensation. To keep the analysis simple, we only consider the limited liability condition. Doing this does not affect the essential result of this section.

At $t_1$, the expected utility of the manager, given state $(m, q)$, is

$$u^m(c(i, x) \mid m, q) = E(c(i, x)) - \gamma Var(c(i, x)) + iq.$$

The task is to find the optimal compensation function $c$ and the investment decision $i$ induced by $c$, which jointly maximize the expected profit of the firm. Since the investment decision $i$ is an integer (rather than a continuous) variable, the usual first-order-condition approach is not appropriate. As a result, we need to consider different investment possibilities in searching for the optimal solution.

<u>(a): the project is rejected in all states</u>

If the project is never accepted, there is no need to pay the manager any more than necessary. Therefore, $c = 0$. The expected profit of the investment opportunity, denoted by $\pi(a)$,

[4] Other external conditions, such as reservation wage, will result in the same form of constraint to the problem.

is

$$\pi(a) = 0.$$

(b): $c(i, x) = 0$ and the manager makes the investment decision

If the manager is paid a flat wage, $c = 0$, and delegated to make the investment decision, then the project is accepted when $q = Q$. Assume that the manager acts in the shareholders' interest when he is indifferent. Then, the project is also accepted in state $(m_3, 0)$, but rejected in $(m_1, 0)$ and $(m_2, 0)$.

The expected profit is

$$\pi(b) = 0.5(p_1 m_1 + p_2 m_2 + p_3 m_3 - I) + 0.5 p_3 (m_3 - I)$$

which is negative by A2.

(c): $c(i, x) = 0$ and the project is always undertaken

The manager is paid a flat wage, $c = 0$, and required to undertake the project in all states. The expected profit is

$$\pi(c) = p_1 m_1 + p_2 m_2 + p_3 m_3 - I < 0.$$

Notice that $\pi(c) < \pi(b)$ as $m_1 < m_2 < I$.

(d): contingent compensation

Based on the Revelation Principle, we can focus on a compensation contract which induces the manager to reveal the true state. The optimal investment decision requires that the project is accepted whenever $m = m_3$ and rejected otherwise.

To induce the manager to reject the project in $(m_1, Q)$, it requires that

$$[Ec(i = 0) - \gamma Var(c(i = 0))] - [E(c(i = 1, x) \mid m_1) - \gamma Var(c(i = 1, x) \mid m_1) + Q] \geq 0,$$

where $c(.) \geq 0$. Since the manager is strictly risk averse and the shareholders are (effectively) risk neutral, the optimal compensation must imply that $c(i = 0)$ be a constant, hence $Var(c(i = 0)) = 0$. Also, since $c \geq 0$, then, by assumption,

$$E(c(i = 1) \mid m_1) - \gamma Var(c(i = 1) \mid m_1) \geq 0.$$

Therefore, $c(i = 0) \geq Q$. In other words, the manager has to be paid at least $Q$ in order to induce him not to accept the project.

On the other hand, to induce the manager to accept the project in state $(m_3, 0)$, it requires that

$$\begin{aligned} u^m(c(i=1,x) \mid m_3, 0) &= E(c(i=1,x) \mid m_3) - \gamma Var(c(i=1,x) \mid m_3) \\ &\geq c(i=0) \geq Q. \end{aligned}$$

Therefore, $E(c(i = 1, x) \mid m_3) \geq Q$; i.e., the expected compensation conditional on $m = m_3$ is no less than $Q$. Together with $c(i = 0) \geq Q$, this means that the expected cost of compensation is greater than or equal to $Q$ in all states. The expected profit resulting from this policy is

$$\pi(d) \leq p_3(m_3 - I) - Q,$$

which is negative by A5.

The following proposition summarizes the analysis in this section.

**Proposition 1.** *Given assumptions A1 to A6 and the limited liability condition, there does not exist a compensation contract which allows the shareholders to obtain a positive profit from the investment opportunity.*

The condition of limited liability is crucial in the above result. To provide the manager with proper investment incentives, compensation has to be sensitively related to investment decisions and final performance. The monetary reward from correctly rejecting a bad project has to be at least as great as the non-monetary benefit which the project would provide to the manager. To keep the overall compensation cost low, the manager should be rewarded for good outcomes but penalized for bad ones. However, the limited liability condition essentially limits the shareholders' ability to penalize the manager. This raises the overall cost of compensation for achieving the same incentive effect. In some cases, as in this model, the cost becomes so high that shareholders are better off by giving up the project entirely.

## 5.4 Signalling: Stock Acquisition in the Market

We have shown that, with limited liability, direct compensation cannot resolve the investment conflict in this problem, and that the firm would have to forgo the new project. Hence, neither the manager nor shareholders benefit from the investment opportunity.

In this section, we examine the possibility of allowing the manager to purchase stock in the stock market. As suggested in the insider trading literature, managerial trading potentially conveys inside information to the market. This may help shareholders to make more precise investment decisions. Two questions are of interest here: is managerial stock purchase in the stock market a credible way of conveying information, and does the equilibrium reveal information perfectly?

the manager's strategy: Let $\alpha \in [0,1]$ be the fraction of equity the manager intends to purchase. The manager's strategy is a mapping $\sigma_m$: $S \rightarrow [0,1]$, where $S$ is the set of possible states.

the shareholders' strategy: Let $D$ be the $\sigma$-algebra of $S$. The shareholders' response to the manager's action is a mapping $r$: $[0,1] \rightarrow D$. Let $p'(m,q \mid \alpha)$ be the posterior belief. Then, the perceived mean return of the project, conditional on $\alpha$, is

$$m_\alpha = \sum_{(m,q)\in r(\alpha)} p'(m,q \mid \alpha)m,$$

where $r(\alpha) \in D$. In other words, the shareholders narrow down the state to a subset of $S$ after they observe an $\alpha$. Then, they form posterior beliefs and calculate the conditional mean return of the project.

The shareholders' investment strategy is

$$i = \begin{cases} 1 & \text{if } m_\alpha \geq I \\ 0 & \text{if } m_\alpha < I. \end{cases} \tag{5.1}$$

That is, the project is approved if and only if its perceived mean return is no less than the required investment.

Define the following subsets of $S$:

$$S_1 \equiv \{(m_3, Q)\},$$

$$
\begin{aligned}
S_2 &\equiv \{(m_2, Q), (m_3, 0), (m_3, Q)\}, \\
S_3 &\equiv \{(m_3, 0)\}, \\
S_4 &\equiv \{(m_3, 0), (m_3, Q)\}, \text{ and} \\
S_5 &\equiv \{(m_2, 0), (m_3, 0), (m_3, Q)\}.
\end{aligned}
$$

The previous assumptions imply that $m_\alpha \geq I$ if and only if $r(\alpha) \in \{S_1, S_2, S_3, S_4, S_5\}$.

Suppose that the firm's shares are diversely held and the shareholders act competitively in the stock market. Then, the stock price is set equal to the perceived mean return. Therefore, the price of stock in acquisition, denoted by $P$, is

$$P = \max\{m_\alpha, I\}. \tag{5.2}$$

The stock price never falls below $I$ as shareholders can always reject the project.

The expected utility of the manager is determined by investment decision $i$, terms of trade $(\alpha, P)$, and true state $(m, q)$. Assume that the manager bears a very small cost $\epsilon$ if $\alpha > 0$; $\epsilon$ represents the cost associated with making an attempt of stock acquisition. Therefore, the manager's utility is

$$u^m(\alpha, P, i \mid m, q) = \begin{cases} \alpha(m - P) - \gamma V \alpha^2 + q - \epsilon & \text{if } i = 1, \\ -\epsilon & \text{if } i = 0 \text{ and } \alpha > 0, \\ 0 & \text{if } i = 0 \text{ and } \alpha = 0. \end{cases} \tag{5.3}$$

When the project is undertaken subsequent to managerial stock acquisition, $\epsilon$ will be negligible in the manager's overall utility and, therefore, can be omitted without affecting the analysis. But $\epsilon$ cannot be omitted if stock acquisition results in no investment.

The expected profit to shareholders is

$$\pi = \max\{0, m_\alpha - I\}.$$

**Definition of Equilibrium:** An equilibrium is a combination $(\sigma_m, r)$ where $\sigma_m$ maximizes the manager's expected utility in every state given shareholders' response function $r$, investment rule (5.1) and pricing function (5.2).

**Lemma 1.** *$r(\alpha) \in \{S_3, S_4, S_5\}$ is not admissible in equilibrium for any $\alpha > 0$.*

**Proof.** Consider $r(\alpha) = S_3 \equiv \{(m_3, 0)\}$ in equilibrium. Since $m_\alpha = m_3 \geq I$, the project is approved by the shareholders.

Trading price is $P = m_3$. The manager's utility is

$$u^m(\alpha(m_3, 0), m_3, i = 1 \mid m_3, 0) = -\gamma\alpha(m_3, 0)^2 V < 0.$$

However, if the manager chooses $\alpha = 0$ and pretends $m < m_3$, then $i = 0$ and his utility would be 0. This is because, in $(m_3, 0)$, the manager gets a zero private benefit from the project but has to acquire equity at a fair price if he is to signal truthfully. Since the manager is risk averse, he is better off not to reveal the true state. This rules out $r(\alpha) = S_3$ in equilibrium.

The other two cases are ruled out in a similar way. **QED**

Lemma 1 suggests that for a positive $\alpha$ which results in $i = 1$, $r(\alpha)$ must either be $S_1$ or $S_2$.

Next, we shall search for various equilibria of the signalling game.

### 5.4.1 Classes of equilibria

First, we can rule out the existence of a separating equilibrium.

**Proposition 2.** *There is no separating equilibrium in the signalling game.*

**Proof:** By lemma 1, $r(\alpha) = \{(m_3, 0)\}$ is not admissible in equilibrium for any $\alpha > 0$. Therefore, there is no separating equilibrium. **QED**

Proposition 2 implies that any equilibrium of the game is either partially separating or pooling. Furthermore, as lemma 1 implies that $S_1$ and $S_2$ are the only consistent responses for any $\alpha > 0$, there are only two possible types of partially separating equilibria. Therefore, there are at most three types of equilibria.

In the pooling equilibrium (PE), the manager adopts an identical strategy in all the states. As the unconditional mean return of the project is less than $I$, the project is never accepted.

**Pooling Equilibrium (PE):**
*The manager's strategy:* $\alpha = 0$ *in all the states.*
*Posterior belief: the same as the prior belief.*

*Investment Decision:* $i = 0$ *in all the states.*
*Expected profit:* $\pi = 0$.
*The manager's expected utility:* $Eu^m = 0$.

A second class of equilibria is partially separating in which trading and investment take place only in state $(m_3, Q)$. We define them as partially separating equilibria 1 (PSE1). To prevent mimicking by $(m_2, Q)$, $\alpha$ must satisfy the following condition:

$$\alpha(m_2 - m_3) - \gamma\alpha^2 V + Q \leq 0. \text{ solution: } \alpha \geq \alpha_1. \tag{5.4}$$

**Partially Separating Equilibrium 1 (PSE1):**
*The manager's strategy: acquires* $\alpha_1$ *fraction of equity in state* $(m_3, Q)$*, and zero equity in any other state, where* $\alpha_1$ *is the smallest* $\alpha$ *satisfying inequality (5.4).*
*Posterior belief:* $m_\alpha = m_3$ *if* $\alpha \geq \alpha_1$ *and* $m_\alpha < I$ *if* $\alpha < \alpha_1$.
*Trading price:* $P_1 = m_3$.
*Investment decision:* $i = 1$ *if* $\alpha \geq \alpha_1$ *and* $i = 0$ *if* $\alpha < \alpha_1$.
*Expected profit:*

$$\pi(PSE1) = 0.5p_3(m_3 - I).$$

*The manager's expected utility:*

$$Eu^m(PSE1) = 0.5p_3[-\gamma\alpha_1^2 V + Q] > 0.$$

There may exist another class of partially separating equilibria (PSE2) related to consistent response $S_2$, $S_2 \equiv \{(m_2, Q), (m_3, Q), (m_3, 0)\}$. Specifically, for some positive value $\alpha_2$, $r(\alpha_2) = S_2$ and $i = 1$; and for $\alpha = 0$, $r(0) = S_2^c$ and $i = 0$, where $S_2^c$ is the complement of $S_2$ with respect to set $S$.

The posterior mean return, conditional on $\alpha_2$, is

$$m_{\alpha_2} = \frac{0.5p_2m_2 + p_3m_3}{0.5p_2 + p_3}.$$

By assumption, $m_{\alpha_2}$ is greater than $I$. Therefore, the trading price is

$$P_2 = m_{\alpha_2} = \frac{0.5p_2m_2 + p_3m_3}{0.5p_2 + p_3}. \tag{5.5}$$

Clearly, $m_2 < P_2 < m_3$.

In order to validate response $r(\alpha_2) = S_2$, $\alpha_2$ must be such that the manager prefers $\alpha_2$ to $\alpha = 0$ when $(m, q) \in S_2$ and prefers $\alpha = 0$ to $\alpha_2$ otherwise. That is,

$$\alpha_2(m_1 - P_2) - \gamma\alpha_2^2 + Q \leq 0, \text{ solution: } \alpha \geq \alpha_a, \tag{5.6}$$

$$\alpha_2(m_2 - P_2) - \gamma\alpha_2^2 + Q \geq 0, \text{ solution: } \alpha \leq \alpha_b, \tag{5.7}$$

and

$$\alpha_2(m_3 - P_2) - \gamma\alpha_2^2 \geq 0, \text{ solution: } \alpha \leq \alpha_c. \tag{5.8}$$

Therefore, $\alpha_2$ is a valid choice for PSE2 if

$$\alpha_2 \in A_2 \equiv [\alpha_a, \min\{\alpha_b, \alpha_c\}]. \tag{5.9}$$

From (5.6) and (5.7), it is obvious that $\alpha_a < \alpha_b$. In order for set $A_2$ to be non-empty, $\alpha_c$ must be greater than or equal to $\alpha_a$. The necessary and sufficient condition for $\alpha_a \leq \alpha_c$ is

$$(m_3 - m_1)(m_3 - m_2) \geq \gamma VQ(1 + \frac{2p_2}{p_3}). \tag{5.10}$$

**Partially Separating Equilibrium 2 (PSE2):**
*The manager's strategy: acquires $\alpha_2$ fraction of equity in state $(m_3, 0)$, $(m_2, Q)$ or $(m_3, Q)$, and zero equity in any other state, where $\alpha_2$ satisfies equation (5.9).*
*Posterior belief: $r(\alpha) = S_2$ if $\alpha = \alpha_2 \in A_2$, and $r(\alpha) = S_2^c$ if $\alpha \notin A_2$.*
*Trading price:*

$$P_2 = \frac{0.5p_2m_2 + p_3m_3}{0.5p_2 + p_3}.$$

*Investment decision: $i = 1$ if $\alpha = \alpha_2$ and $i = 0$ if $\alpha \notin A_2$.*
*Expected profit:*

$$\pi(PSE2) = 0.5p_2(m_2 - I) + p_3(m_3 - I).$$

*The manager's expected utility:*

$$Eu^m(PSE2) = -(0.5p_2 + p_3)\gamma\alpha_2^2V + 0.5(p_2 + p_3)Q.$$

Proposition 3 establishes the existence of equilibria.

**Proposition 3: Existence of Equilibria**

- *PE exists.*
- *PSE1 exists.*
- *The class of PSE2 exists if and only if (5.10) is satisfied.*

**Proof:** The proposition is verified by applying the definition of equilibrium.

### 5.4.2 Refinement of equilibria

Given the multiplicity of equilibria, we need to examine whether each class of equilibria is sensible.

First, we are able to eliminate the pooling equilibrium (PE) with the CK-intuitive criterion by Cho-Kreps [1987].

**Proposition 4.** *PE fails the CK-intuitive criterion.*

**Proof.** In PE, $\alpha = 0$ in all the states, and the project is never undertaken. The proof utilizes the existence of PSE1 which makes both the manager and the shareholders strictly better off than in PE.

Consider the out-of-equilibrium move, $\alpha = \alpha_1$, by the manager, where $\alpha_1$ is defined in PSE1.

If $i = 0$ when $\alpha = \alpha_1$, the manager is worse off in every state by defecting. Then, the only way to rationalize the move is to believe that, in choosing $\alpha_1$, the manager is sending the message that $m_{\alpha_1} \geq I$. Given lemma 1, the shareholders ought to think that the state belongs to either $S_1$ or $S_2$. Therefore, the trading price is either $P = m_3$ or $P = P_2$.

To validate the posterior belief, we first need to rule out states $(m_1, 0)$, $(m_2, 0)$ and $(m_1, Q)$. Clearly, with a trading price $P \geq P_2 > m_2$, no mimicking happens in either $(m_1, 0)$ or $(m_2, 0)$. Furthermore, if the manager in state $(m_1, Q)$ mimics, the utility is

$$u^m(\alpha_1, P, i = 1 \mid m_1, Q) = \alpha_1(m_1 - P) - \gamma\alpha_1^2 V + Q.$$

By definition,

$$\alpha_1(m_2 - m_3) - \gamma\alpha_1^2 V + Q = 0.$$

Therefore,

$$\begin{aligned} u^m(\alpha_1, P_2, i = 1 \mid m_1, Q) &= \alpha_1(m_1 - P) + \alpha_1(m_3 - m_2) \\ &< \alpha_1(m_1 - P_2) + \alpha_1(m_3 - m_2) \\ &= -\frac{\alpha_1}{0.5p_2 + p_3}[p_2(m_2 - 0.5(m_1 + m_3)) + p_3(m_2 + m_1)] \\ &< 0. \end{aligned}$$

The inequality follows from A7. Therefore, states $(m_1, 0)$, $(m_2, 0)$ and $(m_1, Q)$ are ruled out. This is sufficient to induce the shareholders to approve the project.

The CK-criterion asks whether there exists at least one state in which the manager is strictly better off by defecting to $\alpha_1$ even if the shareholders' response is most unfavorable to the manager.

Consider state $(m_3, Q)$. The expected utility of the manager, given trading price $P \leq m_3$, would be

$$\begin{aligned} u^m(\alpha_1, m_3 \mid m_3, Q) &= \alpha_1(m_3 - P) - \gamma\alpha_1^2 V + Q \\ &\geq -\gamma\alpha_1^2 V + Q \end{aligned}$$

which is positive by the definition of $\alpha_1$.

Therefore, the manager in state $(m_3, Q)$ is strictly better off by defecting to $\alpha_1$ even if $P = m_3$. The pooling equilibrium then fails the CK-stability criterion. **QED**

Since the pooling equilibrium does not satisfy the CK-criterion, a reasonable choice of equilibrium must be between PSE1 and PSE2. This further depends on whether or not condition (5.10) is satisfied.

**Proposition 5:** *PSE1 is the unique equilibrium satisfying the CK-intuitive criterion if condition (5.10) is not satisfied.*

**Proof:** If equation (5.10) is not satisfied, PSE2 does not exist. Then, PSE1 is the only equilibrium which remains to be examined.

Consider a defection $\alpha$ with $\alpha < \alpha_1$.

Given that the trading price never falls below $I$, states $(m_1, 0)$ and $(m_2, 0)$ are ruled out as the manager is strictly worse off with any positive $\alpha$ in these states.

Observe that, conditional on $i = 1$, (i) the manager in state $(m_2, Q)$ is always better off by defecting, and (ii) the manager in $(m_1, Q)$ also defects if defection occurs in states $(m_3, 0)$, $(m_2, Q)$ and $(m_3, Q)$, given that (5.10) is violated. It follows that neither $S_1$ nor $S_2$ is a consistent response. This rules out all consistent responses for which the project is profitable. Consequently, the shareholders would always reject the project. Therefore, the manager never defects to $\alpha < \alpha_1$.

Consider a defection $\alpha$ with $\alpha > \alpha_1$. $S_2$ is ruled out as a consistent response for the same reason as before. The only consistent response which supports the acceptance of the project is $S_1$. Therefore, in no state other than $(m_3, Q)$ might the manager have an incentive to defect. However, given $r(\alpha) = m_3$, $P = m_3$ and the manager is strictly worse off with $\alpha$ than with $\alpha_1$, as $\alpha > \alpha_1$. Again, the manager will never defect.

Therefore, PSE1 satisfies the CK-intuitive criterion. **QED**

When condition (5.10) is satisfied, both PSE1 and PSE2 exist. Comparing the outcomes of PSE1 and PSE2, we see that the manager strictly prefers PSE2 to PSE1 in states $(m_2, Q)$, $(m_3, Q)$ and $(m_3, 0)$, and is indifferent in all the other states. Since the manager makes the first move, he rationally chooses to play PSE2 rather than PSE1.

However, unlike PSE1 which is uniquely defined, there are many possible choices of $\alpha_2$ for PSE2. The feasible set of $\alpha_2$ is $A_2 = [\alpha_a, \min\{\alpha_b, \alpha_c\}]$, see the definition of PSE2. Our task is to search for a particular $\alpha_2$ which is most likely to prevail.

In state $(m_2, Q)$, the manager's utility given $P = P_2$ is

$$u^m(\alpha, P_2, i = 1 \mid m_2, Q) = \alpha(m_2 - P_2) - \gamma\alpha^2 V + Q.$$

Differentiating with respect to $\alpha$, we get

$$\frac{du^m(\alpha, P_2, i = 1 \mid m_2, Q)}{d\alpha} = (m_2 - P_2) - 2\gamma\alpha V < 0.$$

Therefore, the optimal choice in state $(m_2, Q)$ is

$$\alpha_2 = \min_{\alpha \in A_2} \alpha = \alpha_a,$$

where $\alpha_a$ is defined by equation (5.6).

In state $(m_3, Q)$,

$$u^m(\alpha, P_2, i = 1 \mid m_3, Q) = \alpha(m_3 - P_2) - \gamma\alpha^2 V + Q,$$

and

$$\frac{du^m(\alpha, P_2 \mid m_3, Q)}{d\alpha} = (m_3 - P_2) - 2\gamma\alpha V.$$

$u^m(\alpha, P_2 \mid m_3, Q)$ is maximized at $\alpha = \frac{m_3 - P_2}{2\gamma V} \equiv \frac{1}{2}\alpha_c$. The optimal choice of $\alpha_2$ in state $(m_3, Q)$ is

$$\alpha_2 = \begin{cases} \alpha_a & \text{if } \frac{1}{2}\alpha_c \leq \alpha_a, \\ min\{\alpha_b, \frac{1}{2}\alpha_c\} & \text{otherwise.} \end{cases}$$

The optimal $\alpha_2$ in state $(m_3, 0)$ is the same as in $(m_3, Q)$.

(i). $\frac{1}{2}\alpha_c \leq \alpha_a$.

If $\frac{1}{2}\alpha_c \leq \alpha_a$, the optimal choice of $\alpha_2$ is $\alpha_a$ in all three states. Therefore, $\alpha_2 = \alpha_a$ in PSE2. The next proposition states that PSE2 is a perfect sequential equilibrium, a concept proposed by Grossman and Perry [1986], but PSE1 is not.

**Proposition 6:** *If condition (5.10) holds and $\frac{1}{2}\alpha_c \leq \alpha_a$, then $\alpha_2 = \alpha_a$ in PSE2. Furthermore, PSE2 is the unique perfect sequential equilibrium.*

**Proof.** First, we prove that PSE1 is not perfect sequential.

Suppose that PSE1 is the equilibrium to be played, in which case the project is accepted if and only if the manager chooses $\alpha_1$ at price $P = m_3$.

Consider a defection $\alpha_a$. ($\alpha_a < \alpha_1$ by definition.) Notice, the manager is strictly better off by defecting to $\alpha_a$ given $i = 1$. This rules out $S_1$ as a consistent response. The only consistent response which leads to $i = 1$ remains to be $S_2$. If the shareholders conjecture that the state belongs to $S_2$ and construct the posterior probabilities proportional to the priors, i.e.,

$$p'(m_2, Q) = \frac{0.5p_2}{0.5p_2 + p_3}, \; p'(m_3, Q) = \frac{0.5p_3}{0.5p_2 + p_3}, \; p'(m_3, 0) = \frac{0.5p_3}{0.5p_2 + p_3},$$

then the optimal investment decision is $i = 1$ and the manager is strictly better off by defecting whenever $(m, q) \in S_2$. In other words, the shareholders' belief is fulfilled. Hence, PSE1 is not perfect sequential.

Next, we prove that PSE2 is a perfect sequential equilibrium.

Consider a defection $\alpha, \alpha < \alpha_a$. Then, $S_2$ is no longer a consistent response, as at price $P_2$ the manager in state $(m_1, Q)$ will also choose $\alpha$. (This is clear from the definition of $\alpha_a$.) Since $S_1$ cannot be a consistent response either, the project is rejected. Therefore, the manager will not defect.

Consider a defection $\alpha, \alpha > \alpha_a$. It is easy to check that such a defection is strictly dominated by the equilibrium strategy from the manager's perspective. Therefore, the equilibrium sustains.

Therefore, PSE2 is a perfect sequential equilibrium. **QED**

(ii) $\frac{1}{2}\alpha_c > \alpha_a$.

In this case, the manager wishes to choose $\min\{\frac{1}{2}\alpha_c, \alpha_b\}$ in states $(m_3, 0)$ and $(m_3, Q)$, but $\alpha_a$ in state $(m_2, Q)$; there is no ex post consensus among different states although they all wish to pool. This particular situation generally does not arise in the existing signalling models. The reason for such an "uneasy" pooling is explained below.

In the current model, the manager wishes to signal that the project is profitable, but does not wish to reveal his private information fully. As the shareholders act competitively in the stock market, the acquisition price equals the perceived mean return of the project. When $(m_2, Q)$, $(m_3, Q)$ and $(m_3, 0)$ are pooled, the manager buys under-priced stock if $m = m_3$; hence, he wishes to buy a large amount. On the other hand, the manager in state $(m_2, Q)$ has to buy over-priced stock; therefore, he wishes to buy as little stock as possible. But, he also benefits from pooling if the private benefit of the project outweighs the loss in stock acquisition. In all the three states contained in $S_2$, the manager gains by pooling, but for different reasons. The optimal choices of $\alpha_2$ are different in different states.

The existing equilibrium concepts do not lead us to a unique choice of $\alpha_2$ within set $A_2$. In the following, we propose the concept of efficient equilibrium (EE).

In a signalling game, the uninformed shareholders do not impose any constraint on the manager's action. They simply react to whatever action is taken by the manager. Since the manager wishes to pool all the investing states, he has to commit to a single choice of $\alpha_2$ in all these states. Otherwise, $\alpha_2$ conveys information about the true $m$; hence, PSE2 unravels. Given that the ex post decision is not unanimous across the states, the implicit commitment has to be made ex ante. The choice of $\alpha_2$ we propose here is the one which maximizes the expected utility before the state is realized. We refer to the PSE2 with the ex-ante optimal $\alpha_2$ an efficient equilibrium (EE).

**Definition (EE):** A PSE2 equilibrium is efficient if

$$\alpha_2 = \operatorname{Arg} \max_{\alpha \in A_2} Eu^m(PSE2).$$

Comments: (1) the concept applies only when there is pooling or partial pooling, and (2) the concept is non-trivial only when there is a two-way mimicking within the pooled types; good and bad types mutually benefit from pooling.

**Proposition 7:** *If condition (5.10) holds and $\frac{1}{2}\alpha_c > \alpha_a$. Then,*

- *PSE2 is efficient if and only if $\alpha_2 = \alpha_a$.*
- *The efficient PSE2 is the unique perfectly sequential equilibrium.*

**Proof.** It is easy to show that the ex ante utility of the manager is maximized at the lower bound of the feasible set of $\alpha_2$, i.e., $\alpha_a$. The reason is simple. Trading price always equals the posterior expected mean return of the project. Therefore, on average, the manager is not compensated for the risk of the acquired stock. As the manager is risk-averse, he wishes to take as little stock as possible.

The proof for the rest of the proposition is the same as for proposition 6. **QED**

The analysis in this section shows that managerial stock acquisition in the market provides a signal about the quality of the project which facilitates the investment decision. Signalling by managerial stock acquisition strictly dominates direct compensation in this model. The advantage of the signalling mechanism is that the manager commits personal wealth to the firm when stock is purchased but before the investment decision is made. This sends a credible signal to shareholders that the project is profitable since, otherwise, the manager suffers an overall loss from the investment just as shareholders do.

In contrast, in the case of direct compensation, no ex ante commitment of personal wealth is made; all payments are settled ex post when final performance is realized. Given the restriction of limited ability in settling ex post payments, direct compensation may be too costly to induce proper managerial actions.

## 5.5 Screening: Stock Acquisition through a Pre-designed Contract

Although managerial stock purchase in the stock market allows shareholders to profit from the potential project, shareholders have an obvious disadvantage in trading with the manager in the market because of the free-rider problem. Instead of acting on the collective interest, individual shareholders behave competitively among themselves. For example, shareholders as a group may benefit by charging the manager a price higher than the perceived value. But competition among shareholders will lower the price to equal the perceived value. This puts the manager into a strategically advantageous position and allows him to extract rent from trading.

In this section, we propose a way of strengthening the bargaining power of shareholders by restricting the manager's freedom in stock acquisition. This is done by specifying, ex ante, the terms at which the manager can purchase stock.

Let the mechanism be represented by a quantity-price schedule, denoted by $\{(\alpha_{(m,q)}, P_{(m,q)}), \forall (m,q)\}$. After observing the state realization, the manager picks a particular choice, $(\alpha, P)$, from the menu. The manager's choice reveals information about the state. The shareholders then make an investment decision based on the revealed information. Clearly, $(\alpha, P) = (0, 0)$ for those states where the project is rejected.

The following lemma simplifies the task of mechanism design. It states that we only need to look for a single quantity-price combination, $(\alpha, P)$, for all the states in which the project is undertaken.

**Lemma 2:** *Let $(\alpha_o P_o)$ be the terms of stock acquisition designed for state $(m_o, q)$ and the project is accepted if $(\alpha_o, P_o)$ is chosen by the manager, then it is optimal that stock acquisition also follows $(\alpha_o, P_o)$ for any state with $m > m_o$.*

**Proof.** Let $m'$ be an arbitrary mean return with $m' > m_o$. Suppose that $m'$ and $m_o$ are the only two possible values of $m$ when the project is undertaken. Given that the manager chooses $(\alpha_o, P_o)$ when $m = m_o$, the terms of acquisition for $m = m'$ is determined by the following programming problem.

$$\max_{(\alpha,P)} \ \alpha P + (1-\alpha)m', \tag{5.11}$$

subject to

$$\alpha(m' - P) - \gamma V \alpha^2 \geq \alpha_o(m' - P_o) - \gamma V \alpha_o^2, \tag{5.12}$$

$$\alpha_o(m_o - P_o) - \gamma V \alpha_o^2 \geq \alpha(m_o - P) - \gamma V \alpha^2. \tag{5.13}$$

Constraints (5.12) and (5.13) are the usual incentive compatibility conditions. Together, they imply that $\alpha \geq \alpha_o$ given that $m' > m_o$.

There are three possibilities regarding the constraints: only constraint (5.12) is binding, only (5.13) is binding, and both are binding.

First, suppose that constraint (5.12) is binding but not (5.13). Then, the problem becomes

$$\max_{\alpha \geq \alpha_o} \ L = -\gamma V \alpha^2 - \alpha_o(m' - P_o) + \gamma V \alpha_o^2 + m'. \tag{5.14}$$

The first- and second-order conditions are

$$\frac{dL}{d\alpha} = -2\gamma V \alpha < 0,$$

and

$$\frac{d^2L}{d\alpha^2} = -2\gamma V < 0.$$

Therefore, the optimal solution is $\alpha = \alpha_o$ By assumption that (5.12) is binding, we get $P = P_o$

Now suppose that constraint (5.13) is binding but not (5.12). Then, by the same approach, we obtain $(\alpha_o, P_o)$ as the optimal solution.

Finally, if both constraints are binding, the optimal solution is determined by the two equations. Again, $(\alpha_o, P_o)$ is the solution. **QED**

Lemma 2 suggests that, once the lowest acceptable value of $m$ is determined, it suffices to find a single $(\alpha, P)$ combination for all states in which the project is accepted. The reason is that shareholders do not want the manager to buy any more stock than $\alpha_o$ in better states and the manager will always choose to buy less than $\alpha_o$ in the lowest acceptable state if any lower $\alpha$ is allowed.

However, we need to search for the optimal cut-off point of $m$. Although shareholders do not observe the true state, they can set a specific $(\alpha, P)$ which will determine the states in which the manager will undertake the project. For the current problem, three alternative policies need to be considered.

(P1). The project is accepted in $(m_3, Q)$ and rejected in all other states.

We first consider the case in which the project is undertaken only in state $(m_3, Q)$ where both $m$ and $q$ reach their maximum values. It can be easily shown that the optimal contract requires the manager to make a payment of $Q$ to shareholders if the project is undertaken.[5] As a result, the manager is indifferent about whether or not the project is accepted when $q = Q$, and strictly prefers not to invest when $q = 0$.

As the manager acts in the shareholders' interest when he is indifferent, the project is undertaken only in state $(m_3, Q)$. The expected profit is

$$\pi(P1) = 0.5p_3(m_3 - I + Q).$$

(P2). The project is accepted in $(m_3, Q)$ or $(m_3, 0)$, and rejected otherwise.

The investment decision is efficient as the project is accepted if and only if $m \geq I$.

The shareholders' optimization problem is

$$\max_{(\alpha,P)} \; p_3[\alpha P + (1-\alpha)m_3], \tag{5.15}$$

subject to

$$\alpha(m_3 - P) - \gamma V\alpha^2 \geq 0, \tag{5.16}$$

$$\alpha(m_2 - P) - \gamma V\alpha^2 + Q \leq 0. \tag{5.17}$$

Constraints (5.16) and (5.17) ensure that the manager has the incentive to acquire stock in state $(m_3, 0)$ but not in state $(m_2, Q)$. If these constraints are satisfied, the manager's action conforms to the investment policy in all other states.

The solution is

$$\alpha = \frac{Q}{m_3 - m_2},$$

[5]This effectively means that the manager acquires zero fraction of equity at an infinite price.

and

$$P = m_3 - \frac{\gamma V Q}{m_3 - m_2}.$$

The expected profit is

$$\pi(P2) = p_3[m_3 - I - \frac{\gamma V Q^2}{(m_3 - m_2)^2}].$$

(P3). The project is accepted in $(m_2, Q)$, $(m_3, Q)$ and $(m_3, 0)$, and rejected otherwise.

The shareholders' problem under this investment policy is

$$\max_{(\alpha,P)} \; (0.5p_2 + p_3)\alpha P + (1-\alpha)(0.5p_2 m_2 + p_3 m_3), \tag{5.18}$$

subject to

$$\alpha(m_3 - P) - \gamma V \alpha^2 \geq 0, \tag{5.19}$$

$$\alpha(m_1 - P) - \gamma V \alpha^2 + Q \leq 0, \tag{5.20}$$

$$\alpha(m_2 - P) - \gamma V \alpha^2 + Q \geq 0. \tag{5.21}$$

Clearly, between (5.20) and (5.21), at most one constraint is binding in the solution.

To satisfy all three constraints requires

$$\frac{Q}{m_3 - m_1} \leq \alpha \leq \frac{Q}{m_3 - m_2}.$$

The solution depends on the region in which the parameters lie.

(P3.a) $(m_3 - m_1)(m_3 - m_2) \leq 2\gamma V Q(1 + 2p_3/p_2)$

In this region, only constraints (5.19) and (5.20) are binding. The solution is

$$\alpha = \frac{Q}{m_3 - m_1},$$

and

$$P = m_3 - \frac{\gamma V Q}{m_3 - m_1}.$$

The expected profit is

$$\pi(P3) = 0.5p_2(m_2 - I) + p_3(m_3 - I) + 0.5p_2 Q\frac{m_3 - m_2}{m_3 - m_1} - (0.5p_2 + p_3)\frac{\gamma V Q^2}{(m_3 - m_1)^2}.$$

(P3.b) $(m_3 - m_2)^2 < 2\gamma VQ(1 + 2p_3/p_2) < (m_3 - m_1)(m_3 - m_2)$

In this case, only (5.19) is binding. The optimal solution is

$$\alpha = \frac{0.5p_2(m_3 - m_2)}{\gamma V(0.5p_2 + p_3)},$$

and

$$P = \frac{0.25p_2(m_2 + m_3) + m_3p_3}{0.5p_2 + p_3}.$$

The expected profit is

$$\pi(P3) = 0.5p_2(m_2 - I) + p_3(m_3 - I) + \frac{p_2^2(m_3 - m_2)^2}{16\gamma V(0.5p_2 + p_3)}.$$

(P3.c) $(m_3 - m_2)^2 \geq 2\gamma VQ(1 + 2p_3/p_2)$

In this region, constraints (5.19) and (5.21) are binding. The optimal solution is:

$$\alpha = \frac{Q}{m_3 - m_2},$$

$$P = m_3 - \frac{\gamma VQ}{m_3 - m_2}.$$

The expected profit is

$$\pi(P3) = 0.5p_2(m_2 - I) + p_3(m_3 - I) + 0.5p_2Q - (0.5p_2 + p_3)\frac{\gamma VQ^2}{(m_3 - m_2)^2}.$$

Which policy among (P1), (P2) and (P3) prevails depends on the specific parameters of the problem. In equilibrium, there may be either first-best investment (as in (P2)), over-investment (as in (P3)), or under-investment (as in (P1)).

The expected equilibrium profit is

$$\pi = \max\{\pi(P1), \pi(P2), \pi(P3)\}. \tag{5.22}$$

Typically, in mechanism design, it is assumed that the uninformed is able to commit to the ex ante contract. However, such a precommitment may not be in the contracting parties' interests ex post. A more appealing approach is to allow for the possibility of renegotiation after the initial contract is set. What we show next is that the ex ante optimal screening contract is also renegotiation-proof.

**Proposition 7.** *The ex ante contract defining the terms of stock acquisition which maximize the expected profit is renegotiation-proof.*

**Proof.** Suppose that the manager makes an offer, say $(\alpha, P)$, which is different from that specified by the contract. The shareholders update their beliefs in the following way: the manager chooses the out-of-equilibrium move if and only if it conveys credible information that the project is profitable and the manager's utility conditional on the acceptance of the project is greater with his own offer than in the specified equilibrium. The shareholders need to determine whether the project should be approved and, if so, whether the out-of-equilibrium offer should replace the original contract.

Independent of the manager's offer, the optimal investment decision is to accept the project if the posterior mean return is greater than $I$ and reject it otherwise.

If the project is rejected, the out-of-equilibrium offer is obviously rejected. However, even if the project is accepted, the shareholders will still reject the out-of-equilibrium option plan. The reason is that there is no gain from trading itself. Any move which benefits the manager must harm the shareholders. **QED**

Comparing screening (stock acquisition through a pre-designed contract) with signalling (acquisition in the stock market) yields the next proposition.

**Proposition 8.** *The expected profit is always higher under the screening mechanism than under the signalling mechanism.*

**Proof.** The proposition is proved by comparing the levels of expected profit under the two mechanisms. Observe that, mathematically, the problem in signalling is equivalent to that in screening plus the additional constraint $P = m_\alpha$. **QED**

An implication of Proposition 8 is that the shareholders will optimally prohibit the manager from purchasing stock in the market. Instead, they will require the manager to buy stock through a pre-designed contract.

In the following, we offer a numerical example to illustrate the three alternative mechanisms.

**EXAMPLE**

The problem parameters are:

$$m_1 = 40,\ m_2 = 80,\ m_3 = 120,\ V = 400,\ I = 101,$$
$$Q = 10,\ \gamma = 0.05,\ p_i = \frac{1}{3},\ i = 1, 2, 3.$$

The result with each incentive mechanism is given below.

<u>direct compensation</u>

never invest

0 profit and 0 utility

<u>stock acquisition in the market (signalling)</u>

PSE2 prevails: invest when $(m, q) \in \{(80, 10), (120, 10), (120, 0)\}$

terms of trade: $\alpha = 15\%, P = 106.7$

expected profit: 2.83

expected utility: 3.56

<u>stock acquisition through a contract (screening)</u>

optimal policy (P2): invest when $(m, q) \in \{(120, 0), (120, Q)\}$

optimal terms of stock acquisition: $\alpha = 25\%, P = 115$

expected profit: 5.92

expected utility: 1.67

Thus, the example confirms the analytical results.

## 5.6 Summary and Discussion

In this chapter, we analyse different mechanisms for resolving shareholder-manager conflict surrounding investment decisions. Our main results are the following.

- With limited liability, direct compensation may be ineffective in resolving the shareholder-manager conflict.

- Signalling through managerial stock acquisition can improve the investment efficiency and increases the utilities of both shareholders and the manager. This implies that the previously mentioned criticism to financial signalling models is not always valid when limited liability is taken into account. The reason that direct compensation may not be able to replace managerial stock acquisition is that the latter forces the manager to commit personal wealth before the investment takes place, while it is not possible to do so in the former case.

- It is possible that trading by an informed manager transmits information to the market, but it is not in the manager's personal interest to reveal his private information fully. In contrast to the result in Leland and Pyle [1977], full revelation of firm quality is not possible if the insider is not the original owner of the firm.

- In trading with the manager, shareholders can coordinate their actions and increase their bargaining power by setting the terms of managerial stock acquisition ex ante. Here, a pre-designed contract resolves the free-rider problem caused by a diverse ownership structure.

Surveys shows that stock ownership constitutes a substantial proportion of total managerial income. Table One provides data on CEO stock ownership.[6] The percentage of insider ownership is small, with an average of 2.42%. However, the dollar value is of a great magnitude (mean $41.0 millions). The distribution of insider ownership is skewed; the median CEO holding is only 0.25% while the mean holding is 2.42%.

In practice, direct compensation and insider stock ownership are quite different from each other. Conceptually, however, it is difficult to distinguish the two as the payoff to the manager in either case can be represented as a function of the same set of financial and/or accounting variables. This poses the following question: can stock ownership be replaced by a direct compensation function? Existing models of optimal contracting have offered little explanation for a distinct incentive role of insider ownership.

[6]Source: Jensen and Murphy [1989].

**Table One**: Ownership of Common Stock from Studies of Various Samples within the Interval 1980–1985

| Percentage of Common Stock held by: | Mean (%) | Median (%) |
|---|---|---|
| Largest Shareholder [Shleifer and Vishny (1986)] | 15.4 | NA |
| Five Largest Shareholders [Demsetz and Lehn (1985)] | 24.8 | NA |
| Board of Directors [Morck,Shleifer and Vishny (1988)] | 10.6 | 3.4 |
| Board of Directors plus Officers | 10.1 | 4.4 |
| Brickley, Lease and Smith (1988) | | |
| Chairman and President [Weisbach (1988)] | 3.7 | NA |
| CEO [Jensen and Murphy (1988)] | 2.4 | 0.2 |
| All Institutions: | | |
| Brickley, Lease and Smith (1988) | 32.9 | 33.9 |
| Pound (1988) | 19.1 | NA |
| Investment Counsel Firms [Brickley, Lease and Smith (1988)] | 6.2 | 4.7 |
| Banks [Brickley, Lease and Smith (1988)] | 5.9 | 4.5 |
| Mutual Funds [Brickley, Lease and Smith (1988)] | 3.4 | 1.9 |
| Identity of Largest Shareholders [Shleifer and Vishny (1986)] | % of Firms | |
| family represented on board | 32.7 | |
| pension and profit-sharing plans | 19.7 | |
| Institution | 25.7 | |
| firm or family holding company not represented on board | 19.7 | |

The analysis in this chapter shows that managerial stock acquisition and ownership play a unique incentive role which direct compensation cannot duplicate under the condition of limited liability. Stock acquisition requires managers to precommit personal wealth to their firms which better connects the managerial interest with those of investors. A manager's action to buy stock provides certain degree of assurance to shareholders about the profitability of the project. That is, stock acquisition has a signalling role.

The analysis distinguishes two forms of stock acquisition: one in the stock market and the other through a pre-designed contract. In both cases, information is revealed through managerial acquisition. However, shareholders may be placed in a disadvantaged position in trading directly in the stock market. The reason is that individual shareholders act competitively rather than cooperatively in the market due to the free-rider problem. This disadvantage can be overcome by allowing the manager to buy stock only according to pre-determined terms. In this sense, an ex ante contract served as a device to coordinate shareholders' actions in trading with managers.

However, it may be premature to generalize that shareholders should always limit managerial acquisition to a pre-designed contract. An implicit assumption in our model is that shareholders have precise prior beliefs and it is cost-justified to design a contract ex ante based on the prior. If valuable inside information is a rare event which is unpredictable by shareholders, it would be too costly or impossible to design such a contract. In this case, allowing the manager to purchase stock provides an opportunity for revealing inside information.

# Bibliography


[1] Akerlof, G., 1970, "The market for lemons: quality uncertainty and the market mechanisms", *Quarterly Journal of Economics 80, no. 3, pp. 488-500*

[2] Banks, J. and J. Sobel, 1987, "Equilibrium selection in signalling games", *Econometrica, vol. 55, no. 3, pp. 647-661*

[3] Beaudry, P. and M. Poitevin, 1991, "Signalling and renegotiation in competitive contractual markets", *working paper,* C.R.D.E.

[4] Brennan, M. and A. Kraus, 1987,"Efficient financing under asymmetric information", *Journal of Finance, vol 42, pp. 1225-1243*

[5] Cho, I. and D. Kreps, 1987, "Signalling games and stable equilibria", *Quarterly Journal of Economics, 102*

[6] Demsetz, H., 1988, "Corporate control, insider trading, and rates of return", *American Economic Review*

[7] Demsetz, H. and K. Lehn, 1985, "The structure of corporate ownership: causes and consequences", *Journal of Political Economy, vol. 93, no. 6*

[8] Dybvig, P., and J. Zender, 1991, "Capital structure and dividend irrelevance with asymmetric information", *Review of Financial Studies*

[9] Dye, R., 1984, "Inside trading and incentives", *Journal of Business, vol. 57, no. 3*

[10] Easterbrook, F., 1985, Insider Trading as an Agency Problem, in *Principals and Agents: The Structure of Business*, ch. 4, ed. by J. W. Pratt and R. J. Zeckhauser, Harvard Business Press

[11] Fischer, P., 1990, "Optimal contracting and insider trading restrictions", *working paper,* University of British Columbia

[12] Fudenberg, D. and J. Tirole, 1990, "Moral hazard and renegotiation in agency contracts", *Econometrica, vol. 58, no. 6, pp. 1279-1319*

[13] Giammarino, R., R. Heinkel and B. Hollifield, 1992, "Corporate decisions and anonymous trading", *working paper* University of British Columbia

[14] Grossman, S. and M. Perry, 1986, "Perfect Sequential Equilibrium", *Journal of Economic Theory 39, pp. 97-119*

[15] O. Hart, and B. Holmstrom, 1985,"The theory of contracts", in T. F. Bewley, ed., *Advances in Economic Theory: Fifth World Congress*

[16] Haugen, R. and L. Senbet, 1981, "Resolving the agency problems of external capital through options", *Journal of Finance, vol. 36, no. 3*

[17] Heinkel, R., 1982, "A theory of capital structure relevance under imperfect information", *Journal of Finance 37, pp. 1141-1150*

[18] Jensen, M., and K. Murphy, 1989,"Performance pay and top management incentives", *Journal of Political Economy vol.98, no.2:225-264*

[19] Kaplan, R., 1982, *Advanced Management Accounting*, Prentice-Hall, Inc.,Englewood Cliffs, New Jersey

[20] Murphy, K., 1985,"Corporate performance and managerial remuneration: an empirical analysis", *Journal of Accounting and Economics 7:11-42*

[21] Kreps, D. and R. Wilson, 1982, "Sequential equilibria", *Econometrica, 50, pp. 863-894*

[22] Laffont, J. and E. Maskin, 1990, "The efficient market hypothesis and insider trading on the stock market", *Journal of Political Economy, vol. 98, no. 1*

[23] Leland, H., 1990, "Insider trading: should it be prohibited?", *working paper,* University of California, Berkeley

[24] Leland, H. and D. Pyle, 1977, "Information asymmetries, financial structure and financial intermediation", *Journal of Finance 32, pp. 371-387*

[25] Manove, M., 1989, "The harm from insider trading and informed speculation", *Quarterly Journal of Economics*

[26] Maskin, E. and J. Tirole, 1988, "The principal-agent relationship with an informed principal, II: common values", *working paper*, Harvard University

[27] Myers, S. and N. Majluf, 1984, "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics 13, pp. 187-221*

[28] Ross, S., 1977, "The determination of financial structure: the incentive-signalling approach", *Bell Journal of Economics 8, pp. 23-40*

[29] Stoughton, N. and E. Talmor, 1990, "Screening and signalling in managerial compensation and corporate investment", *working paper*, University of California, Irvine

[30] Thakor, A., 1991, "Game Theory in Finance", *discussion paper*, Indiana University

[31] Wilson, P., 1990, "Public ownership, delegated project selection and financial policy", *working paper*, Indiana University

# Chapter 6

# Improving Investment Efficiency with Risky Debt

## 6.1 Introduction

Unlike the two previous chapters where agency conflicts are resolved by aligning the monetary interest of the manager with that of investors, we consider in this chapter the possibility of disciplining managers through direct monitoring by external investors.

In general, monetary income is only one of many factors determining a manager's utility. Managerial decisions can also be affected by other considerations, such as personal power and prestige. In situations where these non-monetary factors are important to managers, external monitoring by investors may become a more effective way of protecting investors' interest. Empirical studies suggest that large shareholders can influence corporate decisions and that external monitoring can be a substitute for direct incentive compensation.[1] The purpose in this chapter is not to investigate when and how external monitoring should be employed, issues which are beyond the scope of this thesis. Rather, the central question here is: given the need for external monitoring, how does the nature of agency conflict within a firm change, and what role do ownership and capital structure play in resolving the conflict?[2]

The basic model is similar to that in Chapter 5. It depicts a firm which is operated by a

[1] see, for example, Argrawal and Mandelker [1990] and Douglas and Santerre [1990].

[2] We restrict the attention to monitoring by external investors of the firm. Monitoring by an independent third party is not considered here.

manager and owned by external investors. The manager's task is to initiate investment proposals and implement investment and production decisions. Conflicts exist between the manager and investors because the two groups bear different costs and obtain different benefits associated with an investment project. Consequently, investors need to screen investment proposals submitted by the manager. To improve the quality of investment decisions, investors may expend resources to engage in monitoring activities, such as investigating the profitability of a proposed project.

Because individual investors are risk-averse, they desire to hold diversified portfolios. This implies that the stock of the firm should be spread over a large number of individuals and each of them hold only a tiny fraction of the stock. Complete diversification, however, poses problems for monitoring because of the free-rider problem. To overcome this, there needs to be one investor holding a sufficiently large claim so that the benefit to that claimant of monitoring is at least as great as the monitoring cost. Therefore, a substantial fraction of the firm's ownership must be concentrated on one (controlling) investor, with the rest being held by atomistic investors.

A partially concentrated ownership structure moderates the agency problem caused by the separation of ownership and control. At the same time, however, it creates a new layer of agency problem: the conflict between the controlling investor and the atomistic investors. Potentially, there are various factors contributing to the conflict between the two groups of investors. In this analysis, we focus on the fact that the investor groups have different degrees of risk diversification. Within this context, the effect of capital structure is examined.

We first consider the firm's investment behavior when the firm is fully equity-financed. The atomistic investors diversify all the unsystematic risk of the firm. For them, only the systematic risk is relevant in project evaluation. On the other hand, since the controlling investor holds a large fraction of equity, his utility is affected by the total risk of the project, not just its systematic risk. Therefore, the controlling investor does not wish to take as much risk as other investors, thus creating an under-investment problem.

We then show that the under-investment incentive can be partially corrected if the firm's initial financing involves risky debt as well as equity. Due to the limited liability condition, the holders of levered equity are able to unload the downside risk of the firm while still reaping the upside gain. That is, the levered equity is equivalent to a call option on the firm's value. It is well known that risky debt can create a risk-shifting effect which makes shareholders more risk-seeking. Suppose the controlling investor is a holder of the levered equity. Then, the debt makes him more willing to accept risky projects. In our particular context, this mitigates the under-investment problem described above. As the level of risky debt increases, the controlling investor will accept more risky projects. However, there is a limit to the firm's optimal leverage since too much debt may induce an excessively risk-taking behavior which causes an over-investment problem.

Within this framework, we show the following results: optimal capital structure involves interior risky debt; equilibrium investment efficiency is strictly improved with debt-equity financing compared with full-equity financing; and equilibrium permits some residual under-investment but no over-investment.

Existing models have demonstrated that capital structure can affect investment decisions under the condition of information asymmetry and moral hazard.[3] In particular, it is shown that the existence of debt can cause shareholders to undertake excessively risky projects at the expense of debt-holders. This risk-shifting effect is viewed as part of the agency cost of debt. It is assumed in these models that the firm's decisions are controlled by a particular group of investors, usually the existing shareholders, and that all investors are risk-neutral. Without debt, shareholders as a group make first-best investment decisions. With debt, shareholders are more willing to undertake risky projects. This results in the problem of over-investment. Clearly then, the risk-shifting effect of debt is socially harmful and is part of the agency cost. The justification for the risk-neutrality assumption in these models is that investors can diversify their portfolios in the financial market. This, however, leads to the question: If all shareholders fully diversify, who monitors managerial corporate decision-making and what ensures that investment will be directed towards maximizing shareholders' wealth? On the other hand, if investors are intrinsically risk-neutral, then it is not clear why investors do not hold a firm's securities proportionally to avoid conflicts between investor groups. Risk-neutrality makes ownership irrelevant in many situations.

However, these results are challenged by Dybvig and Zender [1991] and others on the basis that the managerial compensation rule in these models is specified exogenously rather

[3] Examples include Jensen and Meckling [1976], Myers [1977] and Myers and Majluf [1984].

than derived optimally. Dybvig and Zender argue that if the compensation rule is optimally chosen, captial structure becomes irrelevant for a large class of problems. One limitation in the Dybvig and Zender [1991] model, as well as in other studies, is that it focuses exclusively on the use of monetary compensation to influence corporate decision-making. Their analyses are valid only insofar as managers are best motivated by monetary compensation alone. The question is whether the incentive role of direct compensation needs to be supplemented by other mechanisms, such as external monitoring, in order to provide better protections for investors.

In practice, active participation by shareholders in major corporate decisions are not uncommon. Typical examples include proxy contests and antitakeover charter amendments. Less dramatically, annual shareholder meetings also provide a forum for shareholders to exercise their rights. Empirical data on ownership structure are generally consistent with some degree of external monitoring. Typically, a significant fraction of a firm's stock is concentrated on a small number of holders.[4] Presumably, if there is no controlling power associated with stock ownership, these large shareholders can benefit by engaging in further portfolio diversification.

A main distinction of our model is that it explicitly recognizes the need for external monitoring in protecting investors' interests. In other words, we assume that compensation alone does not optimally motivate the manager. Here, the fundamental source of the agency problem is the conflict between the manager and investors, i.e., the separation of ownership and control. All other types of conflicts are rooted in the separation. In contrast, in most of existing models conflicts between different groups of investors are exogenously given. Second, we assume that investors are intrinsically risk-averse. The effective risk preferences of investors emerge within the model structure endogenously, which are consistent with investors' abilities to diversify. The assumption of risk-aversion allows us to derive a precise ownership structure.

The particular set of assumptions adopted in this model leads to an important implication which is in contrast to that in existing models; that is, the risk-shifting effect can be beneficial to the overall efficiency of the investment decision, even though it is harmful to debtholders just as in the other models. Here, the debtholders are always opposed to undertaking the risky project in favor of a riskless investment even if the project is profitable. This suggests that it would be suboptimal to let debtholders control the firm's investment decisions.

[4]See, for example, Shleifer and Vishny [1986] and Demsetz and Lehn's [1985].

The rest of the chapter is organized as follows. Section 6.2 presents the model. The firm's investment behavior under full-equity financing is analysed in section 6.3. The analysis shows that full-equity financing leads to under-investment. Section 6.4 examines the role of debt in correcting the under-investment problem. The equilibrium properties of capital structure and investment decision are discussed. Section 6.5 discusses alternative assumptions related to project financing. And section 6.6 discusses impirical implications.

## 6.2 The Model

This is a three-date (two-period) model. The dates are denoted by $t_0$, $t_1$ and $t_2$ respectively. At the outset, $t_0$, a firm is established by an individual (the owner). The owner sets an initial capital structure, represented by a mixture of debt and equity, and hires a manager to operate the firm.

*Technology*

At time $t_0$, production takes place on the initial technology.

At time $t_1$, a cash flow, denoted by $x_o$, is realized from the initial technology; $x_o$ is publicly observable. At the same time, a new project becomes available which requires investment capital $I$. If the project is accepted at $t_1$, it produces a cash flow $X$ at time $t_2$, $X \in \{I+x, I-x\}$; the probabilities are $\text{Prob}(X = I + x) = p$ and $\text{Prob}(X = I - x) = 1 - p$ respectively. It is assumed that $I \geq x$. If the project is not accepted at $t_1$, the cash flow $x_o$ may either be reinvested in a riskless asset with a zero interest rate or distributed to security holders.[5]

To focus on the effect of existing capital structure on the firm's investment incentive, we avoid the complexity caused by $t_1$-financing by assuming that the firm has adequate internal funds to finance the project. For simplicity, set $x_o = I$.[6] Alternative scenarios are discussed later in the chapter.

At time $t_2$, the firm is terminated and all remaining cash is allocated to relevant parties.

[5]Since the project is always available, the role of the manager in project initiation becomes trivial.

[6]This is not a restrictive assumption. According to Masulis [1988], for non-farm, non-financial firms as a group, internal funds constituted 40% of the total investment over the period from 1946—1986.

*Preferences*

The owner has a negative exponential utility function,

$$u(w) = -\frac{1}{\gamma} exp[-\gamma w], \tag{6.1}$$

where $w$ represents the owner's total income over the period from $t_0$ to $t_2$ inclusive, and $\gamma$ is a positive constant. We assume that the owner's endowment is represented by his exclusive ownership of the firm. Then, the owner's total income consists of the proceeds from selling securities at $t_0$ and the payoffs at $t_1$ and $t_2$ of his retained ownership.

The manager's utility is determined by wage compensation, private cost and benefit associated with the job and, possibly, other considerations. We assume that the manager's preference is different from those of the owner and other investors and that the use of direct incentive compensation is too costly for the firm's investors to make the project worthy of exploiting. This implies that the investors would rather make an investment decision based on their own information than delegate the investment decision to the manager. [7] For our present model, with this assumption, it becomes unnecessary to specify the form of the manager's preference.

All external investors are risk-averse.

*Information Structure*

At time $t_0$, all individuals have identical beliefs about the distribution of probability $p$. Without limiting the generality of the analysis, we assume that $p$ is uniformly distributed over the interval $[0, 1]$. The systematic risk of the project is known for certain and, for notational simplicity, is assumed to be zero.

At $t_1$, the manager observes the realization of $p$. The owner and other investors, on the other hand, have no direct access to the information. However, any individual investor may learn the realization of $p$ through a costly monitoring action (e.g., analysing product market information). The information is only revealed to those investors who monitor.

[7] The model in Chapter 5 of this thesis provides such an example. This assumption is not necessary for deriving our result, but it significantly simplifies the analysis since it avoids the need to derive an optimal compensation contract. What we really need is the assumption that shareholder monitoring can strictly improve the firm's value given that compensation is optimally chosen.

### 6.2.1 Investor-manager conflicts

Since the manager's preference is different from those of the owner and other investors, he may be motivated either to accept an unprofitable project or to reject a profitable one. The usual approach in the literature to resolving the principal-agent conflict is to design an incentive compensation contract. This essentially ties the manager's financial reward to the return of the firm. While the incentive compensation approach is intuitively appealing and widely applied in practice, it also has many limitations. First, a performance-related compensation contract may impose a substantial risk on the risk-averse manager. It may also be very costly to the investors if the compensation contract requires that a significant share of the return be allocated to the manager. Second, financial income is only one aspect of the manager's overall preference. There are situations where managerial decisions are driven by non-monetary considerations such as power and prestige. In these cases, monetary compensation may become ineffective in correcting the manager's adverse incentives (see Chapter 5 of the thesis as an example). As a result, other disciplinary measures, such as external monitoring, may have to be taken to protect the investors' interest.

In this model, we assume that external monitoring is required at $t_1$ when the project becomes available in order to make a proper investment decision.

### 6.2.2 Diversification versus monitoring

Because of risk aversion, the owner wishes to diversify the firm's risk to the greatest extent possible. Complete diversification requires that the firm's securities be held by a large number of investors and each hold just a tiny claim to the firm. The dispersion of ownership, however, makes it difficult for investors to carry out the monitoring task, known as the free-rider problem. With each investor holding a small claim, the personal benefit from monitoring is small compared with the cost of monitoring; therefore, no investor monitors. To overcome the free-rider problem, ownership has to be allocated in such a way that a significant fraction of the security is held by one (controlling) investor while the rest is spread over a large number of atomistic investors. Then, the controlling investor becomes self-motivated to carry out the monitoring task.

A partially concentrated ownership structure, although resolving the investor-manager conflict, creates another kind of agency problem, that between the controlling investor and atomistic ones. Since the two groups enjoy different degrees of risk diversification, their investment incentives are different. After monitoring, the controlling investor learns the realization of $p$ but atomistic investors do not. In other words, monitoring creates an information asymmetry between the two investor groups. This gives the controlling investor the opportunity to advocate an investment decision in his own interest rather than in the interest of investors as a whole.

In the analysis below, we do not make an attempt to examine which investor emerges to become the controlling investor. Instead, we simply assume that the original owner becomes the controlling investor after the initial financing.[8] From now on, the terms "controlling investor" and "owner" are used interchangeably.

Since it is common knowledge that a project is always available at $t_1$, the role of the manager is suppressed in this model. Below, we analyse the impact of financial structure on investment behavior.

## 6.3 The Case of Full-Equity Financing

We first examine the investment decision when the firm is fully equity-financed. The sequence of actions is as follows: at $t_0$, the owner chooses an ownership structure by selling off a fraction of the equity to external investors and retaining the rest; at $t_1$, the owner decides whether or not to monitor the profitability of the project, and the project is then either accepted or rejected; and finally at $t_2$, the cash flow of the firm is distributed among the shareholders.

Definition of the notation:

| | |
|---|---|
| $\alpha$ | fraction of equity retained by the owner, |
| $y$ | security sold to atomistic investors, |

[8]This can be justified by assuming that the owner is no more risk averse than other investors or that the owner has the necessary wealth base to be the controlling investor while others may not.

| | |
|---|---|
| $P_y$ | total proceeds raised from selling $y$, |
| $X$ | gross return on the project, $X \in \{I - x, I + x\}$, |
| $c$ | cost of monitoring, |
| $i$ | variable indicating that the project is accepted, |
| $ni$ | variable indicating that the project is rejected, |
| $m$ | variable indicating that the owner monitors, |
| $nm$ | variable indicating that the owner does not monitor. |

As usual, we proceed by working through the problem backwards, in the order of the investment decision, the monitoring decision and finally the financing decision.

### 6.3.1 Investment decision

At $t_1$, the owner makes an investment decision based on his information about the project. And the information available to the owner depends on whether or not he monitors.

*i. the owner does not monitor (nm)*

Suppose that the owner decides not to monitor. Then, the owner's posterior belief is the same as his prior. In this case, the owner may either delegate the investment decision to the manager or make an unconditional decision himself based on his prior. By assumption, the owner prefers to make an investment decision by himself.

Given that $p$ is uniformly distributed over $[0, 1]$, the unconditional expected net return on the project is zero. The risky project is compared with the riskless investment of a zero interest rate. Since the owner is risk-averse and always receives $\alpha$ fraction of the total return, he strictly prefers to reject the project.[9] Then, his total income equals the proceeds from initial financing ($P_y$) plus $\alpha$ fraction of the riskless asset $I$. The expected utility, conditional on $nm$, is

$$E(u \mid nm) = u(P_y + \alpha I). \tag{6.2}$$

*ii. the owner monitors (m)*

[9] Given that the project has a systematic risk of zero, the atomistic investors, not knowing the true value of $p$, are indifferent about whether or not the project is accepted.

If the owner chooses to monitor, the investment decision will be based on the realization of $p$. The owner may either approve the project ($i$) or reject it ($ni$). The expected utility, conditional on decision $ni$, is

$$E(u \mid m, ni) = u(P_y - c + \alpha I), \quad \forall p \in [0, 1], \tag{6.3}$$

which is independent of $p$. On the other hand, the expected utility, given $i$ and $p$, is

$$\begin{aligned} E(u \mid m, i, p) &= pu(P_y - c + \alpha(I + x)) + (1 - p)u(P_y - c + \alpha(I - x)) \\ &= u(P_y - c + \alpha(I - x)) \\ &\quad + p[u(P_y - c + \alpha(I + x)) - u(P_y - c + \alpha(I - x))]. \end{aligned} \tag{6.4}$$

The necessary and sufficient condition for the owner to approve the project is

$$E(u \mid m, i, p) \geq E(u \mid m, ni). \tag{6.5}$$

From equation (6.4), we see that the expected utility is strictly increasing in $p$. Therefore, there exists a cutoff probability, denoted by $\hat{p}$, such that the project is accepted if and only if $p \geq \hat{p}$.

Given the assumption that $u(w) = -\frac{1}{\gamma}e^{-\gamma w}$, we obtain the following expression for $\hat{p}$:

$$\hat{p} = \frac{e^{\gamma \alpha x}}{e^{\gamma \alpha x} + 1}. \tag{6.6}$$

### 6.3.2 Monitoring decision

As given in (6.2), the owner's expected utility conditional on no-monitoring ($nm$) is

$$E(u \mid nm) = u(P_y + \alpha I).$$

Alternatively, if the owner monitors, the expected utility is

$$\begin{aligned} E(u \mid m) &= Prob(p < \hat{p})E(u \mid m, ni) + \int_{\hat{p}}^{1} E(u \mid m, i, p)dp \\ &= \frac{(1 - \hat{p})^2}{2}u(P_y - c + \alpha(I - x)) + \hat{p}u(P_y - c + \alpha I) + \\ &\quad \frac{(1 - \hat{p}^2)}{2}u(P_y - c + \alpha(I + x)) \end{aligned}$$

The necessary and sufficient condition for the owner to monitor is

$$E(u \mid m) \geq E(u \mid nm). \tag{6.7}$$

It is clear that both the monitoring and investment decisions are affected by the initial financing decision, $\alpha$.

The cost of monitoring, $c$, is a key factor determining whether equation (6.7) can hold, a point to be discussed later. But whenever (6.7) holds, monitoring is optimal for the owner.

### 6.3.3 Financing decision at $t_0$

With full-equity financing, the financing decision (represented by $\alpha$) merely concerns the division of equity ownership between the owner and external investors.

The proceeds from initial financing ($P_y$) equals the expected cash flow that external investors will receive. When $p < \hat{p}$, the project is rejected, and external investors receive $1 - \alpha$ fraction of the $t_1$-cash flow. On the other hand, if $p \geq \hat{p}$, the project is accepted, and the external equity is worth $1 - \alpha$ fraction of the expected cash flow from the project. Therefore,

$$\begin{aligned} P_y &= (1-\alpha)\int_0^{\hat{p}} I\,dp + (1-\alpha)\int_{\hat{p}}^{1} [(1-p)(I-x) + p(I+x)]dp \\ &= (1-\alpha)[I + \hat{p}(1-\hat{p})x]. \end{aligned}$$

There are three possible values of the final cash flow: $I - x$, $I$, and $I + x$. The owner's contingent incomes corresponding to these cash flows are denoted by $W_1$, $W_2$ and $W_3$, respectively.

The contingent incomes of the owner, taking into account the cost of monitoring ($c$), are

$$\begin{aligned} W_1 &= P_y + \alpha(I - x) - c = I + \hat{p}(1-\hat{p})x - \alpha(1 + \hat{p} - \hat{p}^{\,2})x - c, \\ W_2 &= P_y + \alpha I - c = I + \hat{p}(1-\hat{p})x - \alpha(\hat{p} - \hat{p}^{\,2})x - c, \\ W_3 &= P_y + \alpha(I + x) - c = I + \hat{p}(1-\hat{p})x + \alpha(1 - \hat{p} + \hat{p}^{\,2})x - c. \end{aligned}$$

The choice of $\alpha$ affects the owner's utility in three ways: (a) investment behavior, $\hat{p}$, (b) proceeds, $P_y$, through both the size of external equity offering $(1-\alpha)$ and the induced investment behavior ($\hat{p}$), and (c) extent to which the owner diversifies.

The owner's objective is to choose an $\alpha$ which maximizes the expected utility subject to the incentive-to-monitor constraint:

$$\max_{\alpha} \ \hat{p}E(u \mid m, ni) + (1-\hat{p})E(u \mid m, i, p \geq \hat{p}),$$

subject to

$$E(u \mid m) \geq E(u \mid nm).$$

Given the assumptions about the utility function and probability distribution, the program can be rewritten as:

$$\begin{aligned} \max_{\alpha} \ Eu \ \equiv \ & \hat{p}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha I)}] + \frac{(1-\hat{p})^2}{2}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha(I-x))}] \\ & + \frac{1-\hat{p}^2}{2}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha(I+x))}], \end{aligned} \tag{6.8}$$

subject to

$$\begin{aligned} & \hat{p}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha I)}] + \frac{(1-\hat{p})^2}{2}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha(I-x))}] \\ + \ & \frac{1-\hat{p}^2}{2}[-\frac{1}{\gamma}e^{-\gamma(P_y - c + \alpha(I+x))}] \\ \geq \ & -\frac{1}{\gamma}e^{-\gamma(P_y + \alpha I)}, \end{aligned} \tag{6.9}$$

where

$$\hat{p} = \frac{e^{\gamma\alpha x}}{e^{\gamma\alpha x} + 1}$$

and

$$P_y = (1-\alpha)[I + \hat{p}(1-\hat{p})x].$$

Define the following function,

$$G(\alpha) \equiv \hat{p}e^{-\gamma\alpha I} + \frac{(1-\hat{p})^2}{2}e^{-\gamma\alpha(I-x)} + \frac{1-\hat{p}^2}{2}e^{-\gamma\alpha(I+x)}.$$

Then, constraint (6.9) can equivalently be written as

$$G(\alpha) \leq e^{-\gamma c}. \tag{6.10}$$

Before searching for the optimal solution, we first examine the impact of $\alpha$ on investment decision and expected utility.

**Lemma 1.** (i) $\frac{d\hat{p}}{d\alpha} > 0$; (ii) $\frac{dEu}{d\alpha} < 0$.

Proof. see Appendix 6A.

As $\alpha$ increases, the owner bears a larger portion of the firm's total risk. Constant absolute risk aversion implies increasing relative risk aversion. This means that, as $\alpha$ increases, the owner behaves as if he were becoming more risk averse in project evaluation. Consequently, the project is accepted in fewer states. An increase in $\alpha$ hurts the expected utility in two ways: the project is accepted less frequently and the risk is less diversified.

From lemma 1, it becomes clear that the owner wishes to hold as little equity as possible given that the incentive-to-monitor constraint is satisfied. However, to satisfy the constraint, $\alpha$ cannot be arbitrarily small. For example, if $\alpha$ is close to zero, the constraint becomes violated because the benefit from an improved investment would not be great enough to compensate for the cost of monitoring. It is easy to see that, for any positive $c$, the optimal solution, denoted by $\alpha^*$, must be positive and bounded away from zero. In other words, the controlling investor must hold a non-negligible fraction of equity. Since $G(\alpha)$ is a continuous function of $\alpha$, the need for diversification ensures that the constraint is binding at the optimal solution. This leads to the following characterization of $\alpha^*$.

**Lemma 2.** *The optimal financing decision ($\alpha^*$) is characterized by the smallest $\alpha$ which satisfies the incentive-to-monitor constraint.*

### 6.3.4 Conflict among investors

In order to resolve the investor-manager conflict, two distinct groups of investors come into existence, one performing the monitoring task and controlling the firm's investment decision while the other diversifies the firm's risk. However, since the two groups do not enjoy the same degree of diversification, their investment incentives differ as well. This creates a conflict between the investor groups.

The cutoff probability adopted by the controlling investor is

$$\hat{p} = \frac{e^{\gamma\alpha^* x}}{e^{\gamma\alpha^* x} + 1}.$$

Because $\alpha^* > 0$, then $e^{\gamma\alpha^* x} > 1$; therefore, $\hat{p} > 0.5$.

On the other hand, the atomistic investors can fully diversify their portfolios. They behave as though they were risk-neutral. For them, the project is acceptable whenever its expected (net) return is positive, given that the systematic risk is zero. The expected net return of the project, given $p$, is

$$E(X) - I = px + (1 - p)(-x) = (2p - 1)x,$$

which is positive whenever $p > 0.5$. Thus, the cutoff probability that the atomistic investors would use is 0.5.

Therefore, as long as the monitoring cost is strictly positive which requires a strictly positive $\alpha^*$, the controlling investor will invest less frequently than the atomistic investors.

A key factor in determining $\alpha^*$ is the size of the monitoring cost. When $c$ is close to zero, the controlling investor needs to hold only a small fraction of equity, and monitoring is always optimal. As $c$ increases, the constraint becomes more difficult to satisfy. When $c$ reaches a certain value, the constraint can never be satisfied; and monitoring should never take place in such circumstances. Because the objective function is strictly decreasing in $\alpha$ and the constraint is always binding, then, by Lemma 2, $\alpha^*$ must be increasing in $c$. Furthermore, the under-investment problem becomes more severe,

$$\frac{d\hat{p}}{dc} = \frac{d\hat{p}}{d\alpha^*}\frac{d\alpha^*}{dc} > 0.$$

**Lemma 3.** $\frac{d\alpha^*}{dc} > 0$; $\frac{d\hat{p}}{dc} > 0$.

An increase in $c$ adversely affects the owner's utility in three ways. First, as $c$ increases, the direct out-of-pocket expense becomes greater. Second, since the cutoff probability is increasing in $\alpha^*$, the investment efficiency deteriorates. Third, the loss from under-diversification also becomes greater due to a larger $\alpha^*$.

The analysis in this section is summarized below.

**Summary One:** *With full-equity financing, (a) the controlling investor under-invests from the view point of atomistic investors, and (b) the under-investment problem becomes more severe when the monitoring cost increases.*

## 6.4 Impact of Risky Debt on Investment Decisions

We have shown that an under-investment problem would result if the firm were fully equity-financed. In this section, we show that including risky debt in initial financing can moderate the under-investment problem. Due to the limited liability condition, the holders of levered equity are able to unload the downside risk of the firm while still reaping the upside benefit. That is, the levered equity is equivalent to a call option on the firm's value. It is well known that risky debt may create a risk-shifting effect which makes shareholders more risk-seeking. As a result, risky debt encourages the controlling investor, who holds part of the levered equity, to accept the risky project more frequently. The risk-shifting effect of debt then offsets the under-investment incentive caused by under-diversification in the controlling investor's portfolio. As the level of debt increases, the controlling investor becomes more willing to accept the risky project. However, there is a limit to the firm's optimal leverage since too much debt may induce an excessively risk-taking behavior which causes an over-investment problem. The task here is to search for the optimal debt level.

In the analysis, we shall keep the controlling investor a holder of the levered equity. All the debt and the remaining part of the equity are held by atomistic investors whose portfolios are fully diversified. The following structure of debt contract is employed: (a) the debt is issued at time $t_0$ and matures at time $t_2$, and (b) the firm is prohibited from paying any dividends at $t_1$, i.e., if the project is rejected, the time $t_1$ cash flow is reinvested in a riskless asset. Condition (a) is necessary for debt to produce the desired risk-shifting effect; and condition (b) is to protect the interest of debtholders as, otherwise, they may be left with a worthless security.

Let $F$ be the face value of debt to be paid off at $t_2$, and $\alpha$ the fraction of the levered equity retained by the owner (the controlling investor). Now, the $t_0$-financing decision is represented by $(\alpha, F)$.

The market sets security prices according to expected return. Let $P_B$ and $P_E$ be the prices of the debt and equity, respectively. Then, the total proceeds are

$$P_y = P_B + (1 - \alpha)P_E.$$

Define the contingent incomes $W_1$, $W_2$ and $W_3$ similarly to the above. The owner's expected utility is

$$Eu(\alpha, F) = \frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{(1-\hat{p}^2)}{2}u(W_3),$$

where

$W_1 = P_y + \alpha \max\{0, I - x - F\} - c,$
$W_2 = P_y + \alpha \max\{0, I - F\} - c,$
$W_3 = P_y + \alpha \max\{0, I + x - F\} - c$, and
$u(w) = -\frac{1}{\gamma}exp(-\gamma w).$

The incentive-to-monitor constraint is

$$\frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{(1-\hat{p}^2)}{2}u(W_3) \geq u(W_2 + c).$$

In the remaining part of this section, we present the properties of the optimal capital structure and investment decision by deriving a series of lemmas.

### (a). Riskless debt has no effect

First, we show that if the debt is riskless, implying $F \leq I - x$, then the problem is identical to the case of full-equity financing; the owner makes the same investment decision and achieves the same expected utility as if there were no debt.

**Lemma 4.** *Within the range $F \in [0, F - x]$, debt has no effect on the investment decision or expected utility of the owner.*

Proof: trivial. The claim is confirmed by examining the owner's income schedule and the investment criterion. **QED**

Lemma 4 is obvious since riskless debt does not trigger risk-taking incentives. It follows that only risky debt can have an impact on the firm's investment behavior. Therefore, we only need to consider $F > I - x$ in the analysis below.

### (b). Over-investment is never optimal

As face value ($F$) increases, debt becomes more risky. The owner's investment decision is described by the cutoff probability, $\hat{p}$, determined by

$$(1-\hat{p})e^{-\gamma(P_y-c)} + \hat{p}e^{-\gamma(P_y+\alpha(I+x-F)-c)} = \hat{p}e^{-\gamma(P_y+\alpha\max\{0,I-F\}-c)}.$$

The left-hand side of the equation is the expected utility of the owner if the project is accepted, and the right-hand side is the utility if the project is rejected. When $F \geq I, \hat{p} = 0$. In other words, the owner approves the project in all states when $F$ is greater than or equal to $I$. Clearly, the investment policy is inefficient in this case. To make the analysis interesting, we must rule out that $F \geq I$ in equilibrium. Notice that if $F > I$ is optimal, there will be no need for monitoring; the manager can simply be instructed to accept the project all the time. As a result, we can further restrict the analysis to $F < I$.

Given that $I - x \leq F < I$, the cutoff probability has the following expression:

$$\hat{p} = \frac{1-e^{-\gamma\alpha(I-F)}}{1-e^{-\gamma\alpha(I+x-F)}}. \tag{6.11}$$

Differentiating $\hat{p}$ with respect to $F$ yields

$$\frac{d\hat{p}}{dF} = -\frac{\gamma\alpha e^{-\gamma\alpha(I-F)}(1-e^{\gamma\alpha x})}{(1-e^{-\gamma\alpha(I+x-F)})^2} < 0. \tag{6.12}$$

As the level of debt increases, the owner accepts more projects, i.e., a higher debt level creates a stronger risk-taking incentive. Because of limited liability, the owner is protected on the downside, which effectively provides a put option when the risky project is undertaken. Since $I \geq F$, the put option is worthless if the project is rejected. As the level of debt increases, the put option becomes more valuable if the project is accepted; therefore, the risky project becomes more attractive to the owner relative to the riskless investment.

When debt increases, $\hat{p}$ moves closer to 0.5; that is, the under-investment incentive diminishes. At some point, $\hat{p}$ reaches 0.5 and the investment decision becomes first-best, (but risk-sharing may not be optimal). Further increases in the debt level create over-investment inefficiencies. However, as we show below, over-investment never occurs in equilibrium.

**Lemma 5.** *Under debt-equity financing, the equilibrium investment decision implies that* $\hat{p} > 0.5$.

Proof: see Appendix 6A.

This result seems intuitive. The under-investment inefficiency in the case of fully equity-financing is caused by risk-aversion of the controlling investor. Risky debt is introduced in order to encourage the controlling shareholder to accept the project more frequently. It is the risk-shifting effect of debt that corrects the under-investment incentive. However, Lemma 5 states that an over-correction by risky debt is never optimal.

### (c). Optimal capital structure must involve risky debt

So far, we have shown that riskless debt is equivalent to full-equity financing, and that the optimal debt level (denoted by $F^*$) must be less than $I$. Below, we prove that the equilibrium capital structure must involve an interior risky debt.

**Lemma 6.** *In equilibrium,* $I - x < F^* < I$.

By Lemma 5, $p^* > 0.5$, implying $F^* < I$; therefore, we have ruled out a corner solution with respect to $F$ at the upper end. What needs to be shown is that risky debt is strictly better than riskless debt. This is proven in Appendix 6A. In the proof, we treat $F = I - x$ (the point dividing riskless debt from risky debt) as a reference point. As $F$ increases slightly, both $\hat{p}$ and $P_y$ change. The overall impact increases the owner's expected utility. At the same time, the monitoring constraint continues to hold. Therefore, riskless debt is also ruled out in equilibrium.

### (d). Investment is more efficient under debt-equity financing

Up to this point, we have shown that the equilibrium capital structure must involve an interior risky debt. Since fully equity-financing is a special case of debt-equity financing, it seems natural to conjecture that investment is more efficient in the debt-equity equilibrium than in the full equity equilibrium. Formally, we need to compare the cutoff probabilities in the two scenarios.

The cutoff probability with fully equity financing is given by equation (6.6). For the case of debt-equity financing, the cutoff probability ($\hat{p}$) depends on $\alpha$ as well as $F$. However, we have not shown the behavior of $\alpha^*$ in equilibrium. Due to mathematical complexity, we are unable to solve for the optimal $\alpha^*$ in closed form. This makes it difficult to calculate $\hat{p}$. Nonetheless, we can still compare investment efficiency for the two cases.

**Lemma 7.** *Let $\alpha_1^*$ and $(\alpha_2^*, F^*)$ be the optimal financial structures with full-equity financing and debt-equity financing respectively. Then,* $0.5 < \hat{p}(\alpha_2^*, F^*) < \hat{p}(\alpha_1^*)$.

Proof. see Appendix 6A.

Due to the divergence of investment incentive between the controlling investor and atomistic ones, unanimity among all investors cannot be reached; an investment decision which makes one group of investors better off may hurt the interest of another. Then, how do we conclude that investment is more efficient with risky debt than without risky debt based on Lemma 7?

If investors can observe the state as the manager does, they can completely diversify the firm's risk, and the project will be accepted if and only if $p \geq 0.5$. However, with information asymmetry, this is not possible. Lemma 7 states that the firm invests less frequently in the cases of both full-equity financing and debt-equity financing compared with the first-best solution, but investment is more close to being first best in the latter case.

It is important to note that, in each case, the cutoff probability ($\hat{p}$) is determined by the controlling investor's problem endogenously. Whatever investment policy adopted in equilibrium must serve the personal interest of the controlling investor. Since full-equity financing is a special case of debt-equity financing, the controlling investor is strictly better off in the latter case. Furthermore, given the assumption that the financial market is competitive, external investors break-even regardless of the method of financing.

Because financing with a combination of debt and equity (1) makes investment more close to being first best, (2) improves the owner's expected utility, and (3) does not hurt the interest of external investors, we conclude that risky debt strictly improves the firm's investment efficiency relative to full-equity financing.

The result of in this section is summarized below.

**Summary Two** *The optimal capital structure implies interior risky debt. Debt-equity financing strictly improves investment efficiency compared with full equity financing. However, there still exists residual under-investment in equilibrium.*

## 6.5 Alternative Assumptions Related to Financing

Now, we consider alternative scenarios to the assumptions (1) that $x_o = I$, and (2) that the debt contract prohibits the firm from making any dividend payment at $t_1$.

Suppose that $x_o < I$, i.e., internal cash flow is not adequate to finance the project. In this case, the firm may secure the $t_1$-investment by creating a financial slack at $t_0$ to fill any shortfall at $t_1$. With this change, the problem essentially becomes the same as above where $x_o = I$.

Alternatively, the firm may rely on additional financing at time $t_1$ for the shortfall. Two possibilities exist. One is to have the existing shareholders provide the needed capital. The other is to raise funds externally. However, there are problems associated with either case. In the former case, there exists a debt-related under-investment problem as in Myers [1977]. In the latter, there may also be an under-investment problem due to adverse selection as in Myers and Majluf [1984]. Therefore, the original under-investment due to risk-aversion is compounded in either case, making the investment inefficiency worse. However, the under-investment incentive from $t_1$-financing can be eliminated by building financial slack prior to the arrival of the project.

Suppose that $x_o > I$, that is, there is a financial surplus of $x_o - I$ after the project is accepted. In this case, it does not matter whether or not the firm pays out the surplus as dividends at $t_1$. If the surplus is paid out as dividends, then the optimal capital structure, say $(\alpha^*, F^*)$, is the same as in the case $x_o = I$. Alternatively, if the surplus is reinvested in a riskless security, it becomes part of the source to pay off the debt at $t_2$. ($x_o - I$ may be viewed as a sinking fund for the debt.) Then, the firm's optimal financing decision would simply be $(\alpha^*, F^* + x_o - I)$. Clearly, both the investment efficiency and Pareto-efficiency are unchanged from the case of $x_o = I$ with the financing decision being $(\alpha^*, F^*)$.

## 6.6 Empirical Implications

The analysis of this chapter shows that simultaneous consideration of monitoring and diversification leads to two different groups of investors, one with monitoring and controlling responsibilities and the other enjoying risk diversifications. A major implication of external monitoring is that investors cannot fully diversify: ownership should be partly concentrated and partly diversified. On the other hand, if direct compensation is sufficient to provide all proper managerial incentives, there will be no external investors holding undiversified portfolios.

Empirical data on ownership structure are generally consistent with some degree of external monitoring. Typically, a firm's stock is owned by numerous investors, a small number of whom control a large percentage of the stock. In Shleifer and Vishny [1986], the largest shareholder owns 15.4% of total stock on average. In Demsetz and Lehn's [1985] sample, the five largest shareholders hold 24.8% of total stock. In Canada, the concentration is even higher. For instance in 1983, of 283 companies in the TSE 300 Composite Index, 137 companies had more than half of their voting stock held by one or a small group of shareholders. Presumably, if there is no controlling power associated with stock ownership, these large shareholders can benefit by engaging in further diversification.

A more direct test of the monitoring hypothesis is to examine the effect of shareholding concentration on corporate decision-making. Studies based on statistical tests lend empirical support to the monitoring hypothesis. Brickley, Lease and Smith [1988] present evidence that large stockholders vote more actively on antitakeover amendments than non-blockholders. Argrawal and Mandelker [1990] suggest that the presence of large shareholders has a positive wealth effect in antitakeover charter amendments. Douglas and Santerre [1990] find an inverse relationship between stockholder concentration and executive compensation, which reflects the reduced asymmetry of information that accompanies greater ownership concentration. Similar evidence is also reported by Dyl [1988]. These findings generally imply that stockholder monitoring can be a substitute for incentive compensation.

The creation of different investor groups, although mitigating the conflict between the manager and investors, brings conflicts between shareholder groups. In this model the controlling shareholder tend to reject projects which may be desirable to other shareholders. This is because the controlling investor, holding an under-diversified portfolio, exhibits more riskaverion than atomistic investors. The underinvestment incentive of the controlling shareholder is partly offset by the risk-shifting effect caused by debt. A major factor determining the size of the controlling shareholder's ownership is the cost of monitoring. A higher minotoring cost requires a larger fraction of stock to be held by the controlling shareholder; therefore, his portfolio becomes more underdiversified, resulting in a more severe under-investment problem. As a result, more debt is required to produce a greater risk-shifting effect. Similarly, for a given level of monitoring cost, the more risk-averse the controlling shareholder, the higher the debt level will be. A major implication from this is that the size of stock ownership by the controlling shareholder will be positively correlated to the level of debt.

# Bibliography


[1] Agrawal, A. and G. Mandelker, 1990, "Large shareholders and the monitoring of managers: the case of antitakeover charter amendments", *Journal of Financial and Quantitative Analysis, vol. 25, no. 2*

[2] Allen, F., 1989, "The changing nature of debt and equity: a financial perspective", Proceedings of a Conference held at Melvin Village, New Hampshire, Oct. 1989, Edited by R. K. Kopcke and E. S. Rosengren.

[3] Brennan, M. and A. Kraus, 1987,"Efficient financing under asymmetric information", *Journal of Finance, vol 42, pp. 1225-1243*

[4] Brickley, J., R. Lease and C. Smith, Jr., 1988,"Ownership structure and voting on antitakeover amendments", *Journal of Financial Economics 20:267-291*

[5] Demsetz, H.,1986,"Corporate control, insider trading, and the rate of return", *American Economic Review vol.76, no.2:313-316 Business, vol.38*

[6] Demsetz, H., and K. Lehn, 1985,"The structure of corporate ownership: causes and consequences", *Journal of Political Economy vol 93 no 6:1155-1177*

[7] Douglas, E., and R. Santerre, 1990,"Incentive contracts and stockholder monitoring: substitute sources for executive compliance", *Quarterly Review of Economics and Business vol.30, no.2:24-31*

[8] Dybvig, P., and J. Zender, 1991, "Capital structure and dividend irrelevance with asymmetric information", *Review of Financial Studies*

[9] Dyl, E., 1988,"Corporate control and management compensation: evidence on the agency problem", *Mnangement and Decision Economics :21-25*

[10] Grossman, S. and O. Hart, 1984, "Takeover bids, the free rider problem and the theory of the corporation", *The Bell Journal of Economics*

[11] Harris, M. and A. Raviv, 1990, "Capital structure and the information role of debt", *Journal of Finance*

[12] Harris, M. and A. Raviv, 1991, "The theory of capital structure", *The Journal of Finance*

[13] O. Hart, and B. Holmstrom, 1985,"The theory of contracts", in T. F. Bewley, ed., *Advances in Economic Theory: Fifth World Congress*

[14] Heinkel, R. and J. Zechner, 1990, "The role of debt and preferred stock as a solution to adverse investment incentives", *Journal of Financial and Quantitative Analysis vol.25, no. 1*

[15] Holmstrom, B. and P. Milgrom, 1987, "Aggregation and linearity in the provision of intertemporal incentives", *Econometrica vol 55, no.2, pp. 303-328*

[16] Huddart, S.,1990, "The effect of a large shareholder on corporate value", *working paper,* Yale University

[17] Jensen, M., and W. Meckling, 1976, "The theory of firm: managerial behavior, agency cost and ownership structure", *Journal of Financial Economics, vol. 3, pp. 305-360*

[18] Jensen, M., and J. Warner, 1988, "The distribution of power among corporate managers, shareholders and directors", *Journal of Financial Economics 20:3-24*

[19] John, K., 1987, "Risk-shifting incentives and signalling through corporate capital structure", *Journal of Finance 42*, no.3:623-641

[20] Lambert, R., 1986, "Executive effort and selection of risky projects", *Rand Journal of Economics 17*, no.1

[21] Maksimovic, V. and J. Zechner, 1991, "Debt, agency costs and industry equilibrium", *Journal of Finance*

[22] Mintz, B. and M. Schwartz, 1985, *The Power Structure of American Business*, the University of Chicago Press

[23] Modigliani, F., and M. Miller, 1958, "The cost of capital, corporation finance and the theory of investment", *The American Economic Review, vol. 48, pp. 261-297*

[24] Myers, S., 1977, "Determinants of corporate borrowing", *Journal of Financial Economics, vol.5, pp. 147-175*

[25] Myers, S. and N. Majluf, 1984, "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics 13, pp. 187-221*

[26] Pratt, J. W., 1964, "Risk-aversion in the small and in the large", *Econometrica*, vol 32, no. 1-2

[27] Verma, S., 1990, "Ownership structure and corporate dividend policy", PHD thesis, University of British Columbia

[28] Williams, J., 1989a, "Ex-ante monitoring, ex-post asymmetry, and optimal securities", *working paper 1989*, the University of British Columbia

[29] Williams, J., 1989b, "Monitoring and Optimal Financial Contracts", *working paper 1989*, the University of British Columbia

[30] Winton, A., 1991, "Limitation of liability and corporate form", *working paper,* University of Pennylvania

## Appendix 6A: Proofs of Lemmas

**Proof of lemma 1.**

1.a. Differenting $\hat{p}$ with respect to $\alpha$ yields the result. Since,

$$\hat{p} = \frac{e^{\gamma\alpha x}}{e^{\gamma\alpha x}+1},$$

then

$$\frac{d\hat{p}}{d\alpha} = \frac{\gamma x e^{\gamma\alpha x}}{(e^{\gamma\alpha x}+1)^2} > 0.$$

1.b. The owner's total income has three possible values:

$$\begin{aligned}
W_1 &\equiv I + \hat{p}(1-\hat{p})x - \alpha(1+\hat{p}-\hat{p}^{\,2})x - c, \\
W_2 &\equiv I + \hat{p}(1-\hat{p})x - \alpha(\hat{p}-\hat{p}^{\,2})x - c, \text{ and} \\
W_3 &\equiv I + \hat{p}(1-\hat{p})x + \alpha(1-\hat{p}+\hat{p}^{\,2})x - c,
\end{aligned}$$

where $W_1 < W_2 < W_3$. The expected utility is

$$Eu = \frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{1-\hat{p}^2}{2}u(W_3).$$

$$\begin{aligned}
\frac{dEu}{d\alpha} = {} & \frac{(1-\hat{p})^2}{2}u'(W_1)[(1-2\hat{p})x\frac{d\hat{p}}{d\alpha} - (1+\hat{p}-\hat{p}^{\,2})x - \alpha x(1-2\hat{p})\frac{d\hat{p}}{d\alpha}] \\
& + \hat{p}u'(W_2)[(1-2\hat{p})x\frac{d\hat{p}}{d\alpha} - (\hat{p}-\hat{p}^{\,2})x - \alpha x(1-2\hat{p})\frac{d\hat{p}}{d\alpha}] \\
& + \frac{1-\hat{p}^2}{2}u'(W_3)[(1-2\hat{p})x\frac{d\hat{p}}{d\alpha} + (1-\hat{p}+\hat{p}^{\,2})x - \alpha x(1-2\hat{p})\frac{d\hat{p}}{d\alpha}] \\
& - (1-\hat{p})u(W_1) + u(W_2) - \hat{p}u(W_3)
\end{aligned}$$

By definition,

$$(1-\hat{p})u(W_1) + \hat{p}u(W_3) = u(W_2).$$

Therefore,

$$\begin{aligned}
\frac{dEu}{d\alpha} = {} & \frac{(1-\hat{p})^2}{2}u'(W_1)[(1-2\hat{p})(1-\alpha)x\frac{d\hat{p}}{d\alpha} - (1+\hat{p}-\hat{p}^{\,2})x] \\
& + \hat{p}u'(W_2)[(1-2\hat{p})(1-\alpha)x\frac{d\hat{p}}{d\alpha} - (\hat{p}-\hat{p}^{\,2})x] \\
& + \frac{1-\hat{p}^2}{2}u'(W_3)[(1-2\hat{p})(1-\alpha)x\frac{d\hat{p}}{d\alpha} + (1-\hat{p}+\hat{p}^{\,2})x]
\end{aligned}$$

$$
\begin{aligned}
&< \frac{(1-\hat{p})^2}{2}u'(W_1)[-1-\hat{p}+\hat{p}^2]x + \hat{p}u'(W_2)[-\hat{p}+\hat{p}^2]x + \frac{1-\hat{p}^2}{2}u'(W_3)[1-\hat{p}+\hat{p}^2]x \\
&< u'(W_3)x[\frac{(1-\hat{p})^2}{2}(-1-\hat{p}+\hat{p}^2) + p(-\hat{p}+\hat{p}^2) + \frac{1-\hat{p}^2}{2}(1-\hat{p}+\hat{p}^2) \\
&= 0,
\end{aligned}
$$

where the first inequality follows since $\hat{p} > 0.5$, $\alpha < 1$ and $d\hat{p}/d\alpha > 0$, and the second inequality follows because $u'(W_1) > u'(W_2) > u'(W_3)$ given that $W_1 < W_2 < W_3$. **QED**

**Proof of lemma 5**

The cutoff probability, given financing $(\alpha, F)$, is

$$\hat{p} = \frac{1 - e^{-\gamma\alpha(I-F)}}{1 - e^{-\gamma\alpha(I+x-F)}}.$$

The owner's contingent income levels are

$$
\begin{aligned}
W_1 &= P_y - c = I - \frac{1+2\hat{p}-\hat{p}^2}{2}(I-F)\alpha + \frac{1}{2}[2\hat{p}(1-\hat{p}) - \alpha(1-\hat{p}^2)]x - c, \\
W_2 &= W_1 + \alpha(I-F) - c, \text{ and} \\
W_3 &= W_1 + \alpha(I-F+x) - c.
\end{aligned}
$$

Let $t$ be a control variable which alters decision variables $\alpha$ and $F$ in the following way: $\alpha'(t) > 0$, $F'(t) > 0$, and $\alpha(t)(I - F(t))$ independent of $t$.

Suppose that, contrary to lemma 5, $\hat{p} \leq 0.5$ in equilibrium. What we will show is that we can increase the expected utility and preserve the incentive-to-monitor constraint by decreasing $t$, i.e., by decreasing $\alpha$ and $F$ simultaneously while keeping $\alpha(I - F)$ unchanged.

Differentiating $\hat{p}$ and $W_1$ with respect to $t$ yields

$$\frac{d\hat{p}}{dt} = -\frac{\hat{p}\gamma x e^{-\gamma\alpha(I-F)}\alpha'(t)}{1 - e^{-\gamma\alpha(I-F+x)}} < 0,$$

and

$$
\begin{aligned}
\frac{dW_1}{dt} &= (-1+\hat{p})(I-F)\alpha\frac{d\hat{p}}{dt} + (1 - 2\hat{p} + \alpha\hat{p})x\frac{d\hat{p}}{dt} - \frac{1}{2}(1-\hat{p}^2)x\frac{d\alpha}{dt} \\
&= (1-2\hat{p})x\frac{d\hat{p}}{dt} + (\hat{p}(I-F+x) - (I-F))\alpha\frac{d\hat{p}}{dt} - \frac{1}{2}(1-\hat{p}^2)x\frac{d\alpha}{dt}.
\end{aligned}
$$

Then,

$$
\begin{aligned}
\frac{dEu}{dt} &= \frac{(1-\hat{p})^2}{2}u'(W_1)\frac{dW_1}{dt} + pu'(W_2)\frac{dW_1}{dt} + \frac{1-\hat{p}^2}{2}u'(W_3)[\frac{dW_1}{dt} + x\frac{d\alpha}{dt}] \\
&\quad +[-(1-\hat{p})u(W_1) + u(W_2) - \hat{p}u(W_3)]\frac{d\hat{p}}{dt} \\
&= \{[\frac{(1-\hat{p})^2}{2}u'(W_1) + pu'(W_2) + \frac{1-\hat{p}^2}{2}u'(W_3)] \\
&\quad [(1-2\hat{p})x + \alpha\hat{p}(I-F+x) - \alpha(I-F))]\}\ \frac{d\hat{p}}{dt} \\
&\quad +\{-[\frac{(1-\hat{p})^2}{2}u'(W_1) + pu'(W_2) + \frac{1-\hat{p}^2}{2}u'(W_3)] + u'(W_3)\}\frac{(1-\hat{p}^2)}{2}x\frac{d\alpha}{dt}].
\end{aligned}
$$

By supposition, $\hat{p} \leq 0.5$. Given that the owner is risk averse, the definition of $\hat{p}$ implies $\hat{p}(I+x-F) > I-F$. Also $d\hat{p}/dt < 0$. Therefore, the first term is negative. The second term is also negative given that $u'(W_1) > u'(W_2) > u'(W_3)$. Therefore,

$$\frac{dEu}{dt} < 0.$$

The remaining part of the proof is to show that the incentive-to-monitor constraint is not violated as $t$ decreases.

First, we need to decide what the owner's optimal investment decision is given that he does not monitor.

If the owner does not monitor, the investment decision is independent of $p$; the project is either always accepted or always rejected. The expected utilities under the alternative decisions are:

$$
\begin{aligned}
E(u \mid nm, i) &= E[(1-p)u(W_1+c) + pu(W_3+c)] \\
&= \frac{1}{2}(u(W_1+c) + u(W_3+c)),
\end{aligned}
$$

and

$$E(u \mid nm, ni) = u(W_2 + c).$$

The supposition $\hat{p} \leq 0.5$ implies,

$$E(u \mid nm, i) \geq E(u \mid nm, ni).$$

Therefore, the owner accepts the project given that he does not monitor.

If the owner monitors, the expected utility becomes

$$E(u \mid m) = \frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{1-\hat{p}^2}{2}u(W_3).$$

Monitoring takes place if and only if

$$E(u \mid m) \geq E(u \mid nm, i),$$

or,

$$\frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{1-\hat{p}^2}{2}u(W_3) \geq \frac{1}{2}u(W_1 + c) + \frac{1}{2}u(W_3 + c).$$

Substituting the expressions for $\hat{p}$ and $u(.)$ then simplifying, we get

$$\frac{(2k-1)e^{2\gamma\alpha x} - 1}{k^2 e^{2\gamma\alpha x} - 1} \leq e^{\gamma c},$$

where $k = e^{\gamma\alpha(I-F)}$, independent of $t$. It is easy to show that $k^2 > 2k - 1$. Define the left-hand side of the constraint as

$$LHS(t) \equiv \frac{(2k-1)e^{2\gamma\alpha(t)x} - 1}{k^2 e^{2\gamma\alpha(t)x} - 1}.$$

Then,

$$LHS'(t) = \frac{2\gamma x\alpha'(t)e^{2\gamma\alpha x}(k^2 - 2k + 1)}{(k^2 e^{2\gamma\alpha x} - 1)^2} > 0.$$

This shows that the constraint is preserved as $t$ decreases.

Therefore, the supposition that $\hat{p} \leq 0.5$ in equilibrium must be false. **QED**

**Proof of lemma 6**

The way to prove that $F > I - x$ is by showing that, at $F = I - x$, the owner can increase expected utility by increasing the amount of debt.

The owner's expected utility is

$$Eu = \frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{1-\hat{p}^2}{2}u(W_3).$$

Differentiating $\hat{p}$, $W_1$, $W_2$, and $W_3$ with respect to $F$, we get

$$\frac{d\hat{p}}{dF} = -\frac{\gamma\alpha e^{-\gamma\alpha(I-F)}(1 - e^{\gamma\alpha x})}{(1 - e^{-\gamma\alpha(I+x-F)})^2} < 0,$$

$$
\begin{aligned}
\frac{dW_1}{dF} &= [(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p}]\,\frac{d\hat{p}}{dF} + \alpha(\hat{p} + \frac{1-\hat{p}^2}{2}),\\
\frac{dW_2}{dF} &= [(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p}]\,\frac{d\hat{p}}{dF} - \alpha(1-\hat{p} + \frac{1-\hat{p}^2}{2}),
\end{aligned}
$$

and

$$
\frac{dW_3}{dF} = [(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p}]\,\frac{d\hat{p}}{dF} + \alpha(\hat{p} - \frac{1+\hat{p}^2}{2}).
$$

Differentiating $Eu$ with respect to $F$,

$$
\begin{aligned}
\frac{dEu}{dF} &= \frac{(1-\hat{p})^2}{2}u'(W_1)\frac{dW_1}{dF} + \hat{p}u(W_2)\frac{dW_2}{dF} + \frac{1-\hat{p}^2}{2}u(W_3)\frac{dW_3}{dF}\\
&\quad -(1-\hat{p})u(W_1) + u(W_2) - \hat{p}u(W_3)\\
&= [(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p}]\\
&\quad \frac{d\hat{p}}{dF}[\frac{(1-\hat{p})^2}{2}u'(W_1) + \hat{p}u'(W_2) + \frac{1-\hat{p}^2}{2}u'(W_3)]\\
&\quad +u'(W_1)[\frac{(1-\hat{p})^2}{2}(\hat{p} + \frac{1-\hat{p}^2}{2})] - u'(W_2)\frac{\hat{p}(1-\hat{p})}{2} - u'(W_3)\frac{(1-\hat{p})^2}{2}(\hat{p} + \frac{1-\hat{p}^2}{2})\\
&> [(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p}]\\
&\quad \frac{d\hat{p}}{dF}[\frac{(1-\hat{p})^2}{2}u'(W_1) + \hat{p}u'(W_2) + \frac{1-\hat{p}^2}{2}u'(W_3)].
\end{aligned}
$$

The inequality follows since $u'(W_1) > u'(W_2) > u'(W_3)$.

Let $F = I - x + \epsilon$, $\epsilon \geq 0$. Then,

$$
(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p} = (1-2\hat{p})(1-\alpha)x + \alpha(1-\hat{p})\epsilon.
$$

Since $\hat{p} > 0.5$ and $\alpha < 1$, then,

$$
(1-2\hat{p})x - \alpha(I-F) + \alpha(I-F+x)\hat{p} < 0
$$

if $\epsilon$ is sufficiently small; then, $\frac{dEu}{dF} > 0$. This means that when the amount of risky debt is small, the expected utility is increasing in $F$. The remaining issue is whether the constraint is still satisfied as $F$ increases.

It is easy to show that, given $\hat{p} > 0.5$ in equilibrium, the owner would reject the project if he does not monitor. Then, the incentive-to-monitor constraint is

$$
\frac{(1-\hat{p})^2}{2}u(W_1) + \hat{p}u(W_2) + \frac{1-\hat{p}^2}{2}u(W_3) \geq u(W_2 + c).
$$

Substituting the expressions for $\hat{p}$ and $u(.)$ and simplifying, we get

$$\frac{e^{\gamma\alpha(I+x-F)} - \frac{e^{\gamma\alpha x}+e^{-\gamma\alpha x}}{2}}{e^{\gamma\alpha(I+x-F)} - 1} \leq e^{\gamma c}.$$

Denote $L(F)$ to be the left-hand side of the equation above, $L(F) < 1$. Then

$$L'(F) = -\frac{\gamma\alpha(1 - L(F))e^{\gamma\alpha(I+x-F)}}{e^{\gamma\alpha(I+x-F)} - 1} < 0.$$

Therefore, for a given $\alpha$, an increase in $F$ does not violate the constraint. This completes the proof. **QED**

**Proof of lemma 7**

We first present the following lemma.

**Lemma 7a.** For any two financing choices, one with debt and one without, which result in the same investment criterion, the one without debt dominates the other.

*Proof of lemma 7a*

Consider the following two financing strategies, $\alpha_1$ and $(\alpha_2, F)$, which result in the same cutoff probability for investment. That is

$$\hat{p}(\alpha_1) = \frac{e^{\gamma\alpha_1 x}}{e^{\gamma\alpha_1 x} + 1} = \hat{p}(\alpha_2, F) = \frac{e^{\gamma\alpha_2(I+x-F)} - e^{\gamma\alpha_2 x}}{e^{\gamma\alpha_2(I+x-F)} - 1}. \tag{6.13}$$

Since $\partial\hat{p}(\alpha_2, F)/\partial F < 0$, and $\partial\hat{p}(\alpha_2, F)/\partial\alpha > 0$, condition (6.13) implies that

$$\alpha_1 < \alpha_2. \tag{6.14}$$

By rearranging (6.13), we can also show that

$$\alpha_1 x < \alpha_2(I - F). \tag{6.15}$$

The owner's expected utility under each alternative financing choice:

$$\begin{aligned} Eu(\alpha_1) &= \frac{(1-\hat{p})^2}{2}u(W_1(\alpha_1)) + \hat{p}u(W_2(\alpha_1)) + \frac{1-\hat{p}^2}{2}u(W_3(\alpha_1)); \\ Eu(\alpha_2, F) &= \frac{(1-\hat{p})^2}{2}u(W_1(\alpha_2, F)) + \hat{p}u(W_2(\alpha_2, F)) + \frac{1-\hat{p}^2}{2}u(W_3(\alpha_2, F)). \end{aligned}$$

Under financing $\alpha_1$, the owner's income schedule is

$$\begin{aligned} W_1(\alpha_1) &= I+\hat{p}(1-\hat{p})x-\alpha_1(1+\hat{p}-\hat{p}^2)x, \\ W_2(\alpha_1) &= I+\hat{p}(1-\hat{p})x-\alpha_1(\hat{p}-\hat{p}^2)x, \text{ and} \\ W_3(\alpha_1) &= I+\hat{p}(1-\hat{p})x+\alpha_1(1-\hat{p}+\hat{p}^2)x. \end{aligned}$$

Similarly, the income schedule under $(\alpha_2, F)$ is

$$\begin{aligned} W_1(\alpha_2,F) &= I+\hat{p}(1-\hat{p})x-\alpha_2(I-F)(\hat{p}+\frac{1-\hat{p}^2}{2})-\alpha_2\frac{1-\hat{p}^2}{2}x, \\ W_2(\alpha_2,F) &= I+\hat{p}(1-\hat{p})x+\alpha_2(I-F)(1-\hat{p}-\frac{1-\hat{p}^2}{2})-\alpha_2 x\frac{1-\hat{p}^2}{2}, \\ W_3(\alpha_2,F) &= I+\hat{p}(1-\hat{p})x+\alpha_2(I-F)(\frac{1-\hat{p}^2}{2}-\hat{p})+\alpha_2 x\frac{1+\hat{p}^2}{2}. \end{aligned}$$

Using the fact that $\alpha_1 < \alpha_2$ and $\alpha_1 x < \alpha_2(I-F)$, we can show that

$$W_1(\alpha) > W_1(\alpha_2,F),\ W_2(\alpha) > W_2(\alpha_2,F),\ \text{and } W_3(\alpha) < W_3(\alpha_2,F).$$

Furthermore, the expected incomes under the two financing choices are the same:

$$\begin{aligned} EW(\alpha_1) &= \frac{(1-\hat{p})^2}{2}W_1(\alpha_1)+\hat{p}W_2(\alpha_1)+\frac{1-\hat{p}^2}{2}W_3(\alpha_1) \\ &= I+\hat{p}(1-\hat{p})x \\ &= \frac{(1-\hat{p})^2}{2}W_1(\alpha_2,F)+\hat{p}W_2(\alpha_2,F)+\frac{1-\hat{p}^2}{2}W_3(\alpha_2,F) \\ &= EW(\alpha_2,F). \end{aligned}$$

This implies that $\alpha_1$ second-order stochastically dominates $(\alpha_2, F)$. This completes the proof of lemma 7a.

Next, we prove lemma 7 based on lemma 7a.

Let $\hat{p}(\alpha_1^*)$ be the optimal cutoff probability under full-equity financing. By lemma 1, for any $\alpha_1$ greater than $\alpha^*, \hat{p}(\alpha_1) > \hat{p}(\alpha_1^*)$ and $Eu(\alpha_1) < Eu(\alpha_1^*)$.

Let $(\alpha_2^*, F^*)$ be the optimal policy under debt-equity financing, with the cutoff probability $\hat{p}(\alpha_2^*, F^*)$. Suppose that $\hat{p}(\alpha_2^*, F^*) \geq \hat{p}(\alpha_1^*)$. Then, there exists an $\alpha_1'$, with $\alpha_1' > \alpha^*$, such that

$$\hat{p}(\alpha_1') = \hat{p}(\alpha_2^*, F^*).$$

Then, lemmas 1 and 7a together imply that

$$Eu(\alpha_2^*, F^*) < Eu(\alpha_1') < Eu(\alpha_1^*).$$

However, this contradicts lemma 6. Therefore, it must be that

$$\hat{p}(\alpha_2^*, F^*) < \hat{p}(\alpha_1^*).$$

According to lemma 5, $\hat{p}(\alpha_2^*, F^*) > 0.5$. Therefore,

$$0.5 < \hat{p}(\alpha_2^*, F^*) < \hat{p}(\alpha_1^*).$$

**QED**