THE ECONOMIC CONSEQUENCES OF COMPENSATING EMPLOYEES WITH TRADABLE SECURITIES AND ITS IMPLICATIONS FOR DISCLOSURE

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I hereby declare that the work presented in this thesis is my own.

Signed

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July 11th, 2007

Abstract

There is little economic theory that supports designing compensation packages to include a market-traded component. Any contract based on tradable securities can potentially be replicated with non-tradable securities that would give the employer tighter control on the incentives and trading activities of the employee. Indeed, it seems paradoxical to compensate employees with tradable securities only to impose restrictions that prohibit them from taking advantage of the tradability feature. This thesis provides insights into the role and economic consequences of disclosures aimed at reducing the ability of employees to gain from insider trading.

To analyze the impact of compensating employees with tradable securities I use a principal-agent framework where insider trading is captured by the notion of contract renegotiation. In the first analytical piece I show that in certain situations allowing the agent to trade anonymously on his private information increases production and, more importantly, is socially desirable compared to the case where the agent's trades are required to be publicly disclosed. The intuition for this result is that the bid-ask spread imposed by the market maker makes it costly for the agent to sell his shares and get full insurance if he shirks. The consequence of the positive incentive effects for the agent makes the overall economy better off.

In the second version of my model I attempt to capture the SEC notion of insider trading where a manager has material non-public information prior to trading his equity claims. In this piece I allow the agent to collect private information prior to his trading. I identify three information structures and compare the production in the economy where

the agent gathers private information prior to trading, to a scenario where private information acquisition is prohibited. I show that it is not at all clear-cut that private information collection by employees is always detrimental to the firm. Rather, situations may arise where private information collection and insider trading by employees results in higher production in the economy and can be socially desirable. Hence the thesis attempts to provide some potential economic reasons for employees to be compensated with tradable securities.

Acknowledgements

I would like to acknowledge the guidance, support and encouragement of my supervisor Thomas Hemmer who spent hours working with me; reading version after version of the thesis. I am also grateful to the other PhD students at the London School of Economics with whom I have spent hours discussing my research, frustrations and more importantly lots of laughter. I would also like to thank the professors and PhD students at the University of Houston for their generosity and kindness when I visited in the Fall of 2005. Lastly, I would like to acknowledge the support and constant encouragement of my parents, brother and husband who have stood by me through this journey.

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Chapter 1: Introduction

Although the potential for insider trading appears to be of significant concern to investors and regulators alike, it is an empirical fact that executives receive large fractions of their compensation in the form of tradable securities. Any contract based on tradable securities can in principle always be replicated with non-tradable securities that would give the employer tighter control on the incentives and trading activities of the employee. Indeed, it seems paradoxical to compensate employees with tradable securities only to impose restrictions that prohibit them from taking advantage of the tradability feature of their compensation packages.

Providing managers with instruments that can be traded opens up the possibility that a manager will take advantage of uninformed outsiders by engaging in insider trading based on his private information. One issue that this raises is that insider trading is "unfair" to outside investors. Another issue that arises due to the tradability feature of the manager's compensation package is that the manager by trading his contract can reduce the risk component of his contract and this may weaken the incentives of his original contract. The traditional solution for the owner to elicit effort from the manager is to impose some risk in the compensation of the manager. If the manager can trade his contract through insider trading it is possible for the manager to sell the risky part of his contract and receive full insurance thereby reducing his motivation to exert effort. The focus of the thesis is not to examine whether tradable securities should be included in compensation packages, hence I do not examine the situation where employees are compensated with tradable securities but not allowed to trade them. Rather, I take the tradability of the compensation package for granted and concentrate on the role of disclosure requirements in alleviating the two problems identified above. Hence, in the two versions of the model, I study the impact of compensating employees with tradable securities and allowing them to trade these securities anonymously. The popularity of tradable securities for purposes of compensation due to the above issues is in itself an interesting area of research.

To analyze the tradability feature of compensation packages, I employ the general framework of the principal-agent model with the possibility of "renegotiation." In particular, I utilize a model closely related to that of Fudenberg and Tirole (1990) where they allow the principal to renegotiate with the agent and show that due to renegotiation the principal cannot induce high effort as a pure non-degenerate strategy. Rather, the agent randomizes between high and low effort with a certain probability, which creates inefficiency relative to the second best model. Fudenberg and Tirole (1990) allow the principal and the agent the possibility to change the initial contract once effort has been exerted. Changes occur only if no party is made worse off, and at least one party is strictly better off. In this thesis I adopt the concept of renegotiation to analyze the effect of insider trading on effort and production as insider trading gives the agent the potential to change his contract once the game has started and is hence analogous to renegotiation. However, my model differs from the traditional interpretation of renegotiation because I allow the agent the possibility to trade with a third party – the market rather than the principal.

In the seminal Fudenberg and Tirole (1990) renegotiation model the only information asymmetry is the agent's action choice, that is, information generated endogenously within the firm. In the model I develop, the agent has private information about his action choice and his insider trading behaviour. With the possibility to engage in insider trading, the agent can include exogenous information from his interaction with the market into the relationship he has with the principal. In order to understand the effect of additional information asymmetry from engaging in insider trading on effort I use a simple version of the Glosten-Milgrom framework to solve for equilibrium prices in the market where allowing the agent to engage in insider trading creates information asymmetries. The market maker in the two versions of my model is concerned with earning zero expected profits in equilibrium and supports any Pareto improving solution consistent with that objective. The equilibrium price in the market is calculated as the market maker's rational expectation of the agent's effort choice. I analyze the impact of additional information asymmetry caused by including exogenous information through insider trading on the agent's effort and production.

The opportunity to engage in insider trading based on private information arises naturally if employees are compensated with tradable securities. Tradable securities can in principle always be replicated with non-tradable compensation vehicles that give the owners tighter control without changing the incentives of the employees. Therefore I explore why compensation packages in general include tradable securities while at the same time regulators impose restrictions on employees' trading of these securities. The regulation prohibiting the trading of compensation packages is paradoxical because compensating managers with tradable securities when these managers naturally have private information that could be valuable for trading as they are closely involved with the day-to day running of the firm results in a conflict. In the second version of my model

I analyze a situation where employees are compensated with tradable securities and study the impact of private information acquisition on the employee's action choice.

The main result of the thesis shows that by compensating employees with tradable securities and allowing employees to engage in insider trading under certain parameter values results in an increase in production. By including an additional source of information asymmetry through the mechanism of insider trading, the probability of (desirable) high effort as opposed to (undesirable) low effort in certain situations is greater than in situations without this additional information asymmetry.

This second version of the model extends the first in a manner consistent with the SEC notion of insider trading by allowing the agent to acquire additional private information that is correlated with the liquidation value. This extension enables me to highlight the desirable properties of private information to add to the disclosure regulation debate. The increase in production observed in the first version of my model is even more pronounced when the employee is allowed to collect private information relevant to his trading prior to engaging in insider trading. I identify three possible information structures that capture different properties of accounting information related to the valuation and stewardship roles that accounting information possesses. I show that especially when the private information collected by the agent has a valuation role it leads to an increase in production. These seemingly counterintuitive results hint at a potential (economic) reason for the popularity of tradable securities in compensation packages. Hence in situations where employees are compensated with tradable securities, the owners would prefer a regime that does not require disclosure of management's trading activities.

The approach in my thesis differs significantly from previous research where the results for the benefit of insider trading are derived from the liquidity traders being ripped off. The focus of this thesis is not on reallocation mechanisms but the benefits of insider trading that arise from an increase in total economic output. My model is not about allocation issues; rather, it is about defining the Pareto frontier through the amount of production in the overall economy. In the two versions of the model I also do not attempt to characterize the optimal arrangement between the shareholders and the employee; rather, I identify Pareto improvements that can be implemented since all parties benefit from it.

The key policy issue that I explore with this thesis is whether or not managers that hold tradable securities should disclose ahead of time their intentions to trade (sell in particular) thereby revealing at least a portion of their private information, or if it could actually be preferable to allow them to take full advantage of the tradability feature by trading their compensation on the market anonymously. Indeed, I demonstrate in my model that it actually can be better, both in terms of real production, and in a Pareto sense, to allow the manager under certain parameter values to take full advantage of the tradability feature of his compensation and, thus, engage in insider trading. Current accounting debates revolve around the argument that there should be regulation for companies to publicly disclose management shareholdings, stock options as well as any changes in the holdings of top management. My thesis directly addresses this issue by showing that there are certain situations where allowing executive shareholdings to be private information may increase the productivity of the manager and may hence be socially desirable.

The thesis is organized as follows. Chapter 2 briefly describes the relevant theoretical and empirical research on insider trading and how it relates to my thesis. Chapter 3 provides the first version of my model where the impact of allowing the agent to trade his compensation on the market is examined. Finally Chapter 4 gives the second version of my model where I examine the impact of the allowing the agent to gather private information relevant to the liquidation value of the firm prior to making his trading decisions.

Chapter 2: Literature Review On Insider Trading

In this chapter I provide an overview of both the existing theoretical and empirical literatures that have examined insider trading. The theoretical literature on insider trading can be divided into two main strands – one strand explains the capital market effects of insider trading while the other strand looks at theoretical explanations for allowing managers to trade on their private information. The empirical literature on the whole looks at the capital market effects such as and market reactions caused by insider trading especially changes in the stock price. The two models that I have developed attempt to contribute to the second strand of the theoretical literature. The models endeavor to give another possible theoretical explanation for the existence of insider trading through a limited commitment principal-agent model where the agent is compensated with tradable securities and allowed to renegotiate his contract through trading with the market.

THEORETICAL

There exists an extensive debate around the Securities and Exchange Commission (SEC) regulation of insider trading. In general, proponents of insider trading regulations argue that insider trading is harmful because it leads to (i) a loss of liquidity in the market, (ii) perverse managerial incentives, and (iii) a perception of unfairness and loss of investor confidence in capital markets (see Glosten (1989), Easterbrook (1985), Brudney (1979), Douglas (1988) and Manove (1989)). Opponents of insider trading regulations cite various social benefits associated with insider trading. One prominent argument is that trading by insiders with superior information leads to more informationally efficient stock prices. This is because insider trading helps security prices adjust more rapidly to reflect underlying information, hence increasing market efficiency and resulting in more real investment. Manne (1966) and Young (1985) in their papers give positive opinions that show that permitting insider trading would make the market more efficient and liquid, hence stimulating market investment. They also show that insider trading provides a meaningful form of compensation in large corporations for the entrepreneurial function; therefore it is an effective way of stimulating entrepreneurial activities. The main point in these articles favoring insider trading is that the social benefit of more efficient prices facilitate more efficient allocation of resources.

The merits of insider trading have been debated on two levels – (i) Is it "fair" to have trading when individuals are differentially informed? (ii) Is it economically efficient to allow insider trading? The Securities Exchange Act of 1934 justifies the regulation of insider trading on the presumption that such activity is "unfair" to outside investors (see for e.g. Brudney (1979)). Critics point out that trading is always unfair whenever one part has an information advantage over another. One observation to note is if the uninformed party knows that they are uninformed, it is paradoxical to term their trades as "unfair" as they choose to trade their shares. Because there is no commonly accepted definition of "unfair," this aspect of insider trading is not directly addressed. But the second aspect of insider trading, its impact on economic efficiency and welfare is more susceptible to economic analysis. One can show which parties gain, which lose, and how much is gained or lost. When the sum of the various gains and losses can be associated with economic welfare, the analysis can provide a measure of the net benefits that result from prohibiting insider trading.

To understand the nature of the current debate, it is important to review the common arguments referred to pro and con insider trading. Some of the arguments pro insider trading state that insiders will bring new and useful information into asset prices which will result for decision makers in reducing risk and improving performance as prices reflect better information. Also, due to reduced risk, asset prices will be higher and more real investment will occur. The model I develop contributes to this strand of literature by looking at the resulting production from allowing managers to engage in insider trading. Some of the arguments against insider trading are that outside investors will invest less because the market is "unfair." Asset prices will be lower and less real investment will occur. Another common argument is that market liquidity will be reduced; thereby disadvantaging traders who must trade for reasons other than information. Also, insider trading will cause prices to be more volatile, further hurting the liquidity traders. I will first proceed to look at the analytical papers that give various stories for and against insider trading, and then examine the evidence put forward by several empirical papers.

There are several theoretical papers such as Diamond and Verrecchia (1981), Douglas (1988), Grossman (1976), Grossman and Stiglitz (1980), Hellwig (1980), Kyle (1985), Manne (1966), Radner (1979), and Young (1985) that show that insider trading is unfair to ordinary traders if those who trade on inside information obtain significantly larger profits than those expected. Grossman (1976) viewed stock prices as aggregating various kinds of information. Radner (1979) proposed efficiency of information; his model included the possibility of different traders possessing different knowledge. Hellwig (1980) showed that common information elements would be reflected in prices and that "noise" would be filtered out. Diamond and Verrecchia (1981), Kyle (1985) and Grossman and Stiglitz (1980) showed that prices only partially reflect the diverse sources of information that traders possess. I will now proceed to examine in detail some of the theoretical arguments put forward in some of these papers. I first look at the papers that show theoretically that insider trading could generate some positive effects and then look at those papers that demonstrate that insider trading could have potential detrimental effects.

Ronen (1977) examines the possible effects of insider trading rules on the incentives for firms to produce and disseminate information about themselves. He contrasts in a theoretical model the incentives to produce and disseminate information in a market free of insider trading rules and a market with existing insider trading rules. Hence, he is able to examine the incremental effect of insider trading rules on the incentives for managers. He shows that the net effect of insider trading rules will most likely inhibit the generation, processing and communication of inside information. This deterrence of the production and dissemination of inside information then leads to the less efficient allocation of resources. The main argument in his paper is that the existence of rules can have an impact on the manner of impounding information in securities prices and thus on the pattern of wealth distribution. In the absence of insider trading rules, insiders can privately benefit from their information advantage whereas under existing rules, the benefits will be accrued to the existing shareholders.

The focus of Ronen's (1977) paper is similar to the second version of my model, in the sense that the second version looks at how private information acquisition by the manager impacts his trading strategies. But, the models differ in that I do not examine the incentive for acquiring information, rather I assume in the second version that as the private information is correlated to the stock price of the firm, the manager has an incentive in acquiring it. In addition, I also examine the incentives for the principal in allowing the agent to acquire information when there is a cost to its acquisition whereas Ronen (1977) does not take into account the cost of information production and dissemination in his model.

Leland (1992) examines how insider trading contributes in resolving uncertainty. He uses a rational expectations model with an endogenous investment level and differentially informed investors to show that when insider trading is permitted stock prices better reflect information and will be higher on average, expected real investment will rise, markets will be less liquid, owners of investment projects and insiders will benefit and outside investors and liquidity traders will be hurt. He also shows that total welfare may increase or decrease depending on the economic environment.

A main contribution of his paper is that it endogenizes the number of shares issued as well as the real investment. In addition his model examines the impact of reduced future price volatility on the level of current asset prices. He suggests that insider trading may be undesirable even when investment is flexible, and risk-averse outsiders behave competitively and cannot alter their information. Liquidity of financial markets decrease when insider trading is allowed and liquidity traders suffer welfare losses. Total welfare in his model may increase or decrease with insider trading. Welfare will tend to increase when the amount of investment is highly responsive to the current stock price. In this case the gains from greater investment efficiency more than offsets the costs to outside investors and liquidity traders. If investment is inflexible to current stock price, net welfare tends to be lower when insider trading is permitted. His model also shows that asymmetric information is likely to impose greater welfare costs when the employees of the firm have the information advantage rather than external investors. His results are in contrast to the one I generate in the first version of my model, where I show that production efficiency increases when the employee is allowed to trade on his superior information.

In another theoretical paper, Bushman and Indjejikian (1995) look at voluntary disclosures and the trading behavior of insiders. Empirical evidence suggests that corporate insiders profit from trading on their superior information. These insiders may also influence a firm's voluntary corporate disclosures. They consider a setting where non-insiders acquire information of less quality than that of the insider's information. Consequently an insider's trading profits are affected by the quality of his own private information as well as the behavior of other market participants. Their set-up follows the noncompetitive trading models of Kyle (1985) and Admati and Pfleiderer (1988) where the price of a single risky asset is set efficiently by a market maker based on all public information. Public disclosures reduce information asymmetry and alter the trading behavior of all informed traders, as in the presence of other informed traders the insider must compete for his share of the total available trading profits.

The main result of their paper shows that a public disclosure which reduces an insider's private information advantage can actually increase his expected trading profits. This is contrary to the general notion that insiders can profit only from trading before the release of private information. The intuition underlying their result is that public disclosure of information creates a trade-off. While it is true that voluntary disclosures reduce the insider's profits by dissipating some of his informational advantage, such disclosures also decrease the trading aggressiveness of other informed traders in a way in which it increases the insider's profits.

The model that I develop in this thesis differs from this paper as I embed a Glosten-Milgrom (1985) market model in a standard principal-agent moral hazard problem. In the two versions of my model I do not just analyze the prices in the market but also the contract offered to the manager by the firm as well as the production generated in the economy. In the economy that Bushman and Indjejikian (1995) examine, public disclosure affects both the aggregate trading (a size effect) and an individual trader's shares of those profits (a share effect). While disclosure reduces the information advantage of all informed traders relative to the market maker, which decreases the total size of the trading profits by increasing the market depth, disclosure also increases the competitive advantage of the insider relative to any remaining informed traders, and in equilibrium reduces the number of other informed traders. The latter two effects lead to increasing the insider's share of the available trading profits both by allowing him to trade more aggressively relative to other informed traders and by reducing the number of informed competitors. The Bushman and Indjejikian (1995) paper analyzes how mandatory disclosure affects insider's trading profits, while in the two versions of my model, the insider i.e. the manager does not make excess profits by trading, rather I examine the production or real effects generated by different scenarios.

The two versions of my model are also related to a theoretical paper by Dye (1984), where he analyzes shareholders' incentives to sanction insider trading. Dye (1984) uses a multiple principal-single agent model with full commitment with the manager's trades observable ex-post. He establishes improved risk-sharing as one of the reasons shareholders would want to allow the manager to trade on his private information. In his paper the desirability of insider trading depends on the distributional relationships among the inside information held by management, the manager's effort, and the output of the firm that employs him. Under certain distributional assumptions both the manager and the firm's owners may achieve strictly higher utility by allowing the manager some discretion in the selection of his compensation schedule than they would obtain if the manager were not given such discretion. This discretion in contract selection allows the manager to "communicate" his private information to the firm's owners. Insider trading is shown to be one such way in which discretion can be granted to the owners.

His model uses the assumption that the private information of the manager is so informative that the realized value of output contains no information about the manager's actions not contained in the manager's private signal. Providing the right incentives to the manager to reveal his private information truthfully leads to the improved risk-sharing result that drives the gain from allowing insider trading. The benefit of offering a menu to the manager only exists if the manager's private information is not independent of the realized output. In the Dye (1984) model trading by the manager reveals his private information which then allows the shareholders to compensate him accordingly. In the two versions of my model the insider trading by the manager does not reveal his private information; in fact I examine the effect of allowing the manager to engage in anonymous insider trading. In the versions of my model I demonstrate that under certain parameter values allowing the manager to engage in anonymous insider trading can lead to an increase in the production of the firm compared to a scenario where the manager is not allowed to engage in such anonymous trading. Hence in my models it is essential that the private information of the manager be private and is not revealed to the shareholders or to the market through his insider trades for the shareholders to benefit from the production advantages.

John and Mishra (1990) model trading by corporate insiders as a signal that interacts with corporate announcements such as capital expenditures, equity issues and repurchases, dividend announcements and can hence be used to explain price reactions of these announcements. In particular, they show that such interactions of corporate announcements and concurrent insider trading depends crucially on whether a firm is a growth firm, a mature firm or a declining firm. In the underlying efficient signaling equilibrium, investment announcements and insider trading convey private information of insiders to the market at least cost. In the two versions of the model I develop the portfolio holding of the insider (agent) is revealed to the investors (principal) prior to the insider receiving his cash bonus. Hence, in my model insider trading serves as a signal of the agent's effort level to the principal. However, the principal is unable to use this information ex-post because with renegotiation the principal in equilibrium writes a contract that is renegotiation proof and hence commits not to ex-post use the information generated at the renegotiation stage.

Paul (1992) develops a model to show the effectiveness of stock based compensation in providing incentives for managers to work hard and effectively. He shows that there is a fundamental conflict between aggregating information to assess value and aggregating information for the incentive problem. This conflict can have important effects on the operations of the firm. Intuitively, investors are interested in a signal to the extent that it resolves uncertainty about the firm's ultimate payoffs. The more uncertainty it resolves 'the more weight the signal receives. However, the principal is more interested in a signal that accurately measures the agent's unobservable effort. When the market can observe the profitability of all projects with equal precision, with stock-based compensation the weight of any given project in managerial compensation is independent of the marginal productivity of effort in the project. Also, the projects that are the noisiest indicators of managerial effort receive the most weight in compensation. Lastly, he finds that investors have the greatest incentive to collect information about projects that are the noisiest indicators of managerial effort.

Paul (1992) is similar in some regards to the second version of my model. In that model I show how private information collection by the agent can be useful to the principal and discuss its implication to outside investors as well. However, in my model I do not examine whether the investors can collect information. Even though the Paul (1992) paper and mine look at the effects of signals in a scenario where the agent is compensated with tradable securities, they differ significantly in that he looks at two types of information – value relevant and effort relevant whereas in my model I examine the implications of the private information that the agent collects on his effort choice.

In a related theoretical paper, Dow and Rahi (2003) show another benefit to allowing insider trading. They study the welfare economics of informed stock market trading. Their model shows that a greater degree of informed trading reduces the returns to speculation. They also prove that greater revelation of information that agents wish to insure against, leads to a reduction in hedging opportunities, but early revelation that is uncorrelated with hedging needs allows agents to construct better hedges. They demonstrate an important welfare gain due to the existence of insider trading. Their main result intuitively stems from the fact that informed trading increases investment efficiency, even though it entails higher volatility of the share price and of investment. The production efficiency gains in the two versions of my model come from increasing the market inefficiencies through an increased bid-ask spread whereas the economic benefits in Dow and Rahi (2003) comes from a decrease in market inefficiencies.

Looking at the potential detrimental effects of insider trading, Manove (1989) examines the harm from insider trading and informed speculation. He examines the fact that insiders and other speculators with private information are able to appropriate some part of the returns to corporate investments made at the expense of other shareholders. As a result, insider trading tends to discourage corporate investment and reduce the efficiency of corporate behavior. He then provides measures that give some indication of the sources and extent of the investment reduction. Manove (1989) looks at the fact that corporate shareholders support corporate investments because their shares convey the rights to the proceeds of those investments. Suppose corporate investments are risky and outsiders need to sell their shares before the outcome of the investments are realized. If insider trading exists, then future outsiders knowing themselves to be subject to adverse selection will be unwilling to pay for the full expected value of the unrealized investments. This means that the incumbent shareholders will not be able to recover the full expected value of the returns to corporate investments. As a result, insider trading will tend to dampen shareholder support for corporate investments. If outsider shareholders control corporate behavior, then corporate investment will tend to fall below its economically efficient level. The main result of the model that Manove (1989) develops is that the more often the average outsider trades, the smaller the effects of insider trading will be. When corporate investment is inherently risky, insider trading induces corporate investment. But when corporate investment is less risky, insider trading can, in principle, lead to corporate overinvestment.

Fishman and Hagerty (1992) analyze the effect of insider trading on the informational efficiency of stock prices in an imperfectly competitive market. They show that with insider trading, the aggregate amount of information processed by traders leads to less efficient stock prices. This is because insider trading in their model has two adverse effects on stock price efficiency. First, with insider trading, the number of informed traders is lower – the presence of better informed insiders deters non-insiders from acquiring information and trading. They show that in the extreme, there are no informed traders in the market and the market becomes extremely illiquid. Second, in their model, due to the presence of insider trading in the market, the informational advantage is not evenly distributed in the market. Both these effects lead to markets being less competitive and to less efficient prices. Hence in their paper, they stress upon the negative effects of allowing insider trading.

In a later paper, Fishman and Hagerty (1995) examine the fact that financial market regulations require various insiders to disclose their trades ex-post (i.e. after the trades are made). Their paper analyzes the effects of such mandatory disclosure rules on the operation of a market. Contrary to the general opinion that more public information concerning the trades of insiders limits the ability of insiders to profit on the basis of their superior information, they show that mandatory disclosure of insider's trades can increase the expected trading profits for the insider relative to a market without disclosure. This increase of profit for the insider in their model comes at the expense of non-insiders who trade at a wider bid-ask spread making the market less liquid. Thus, mandatory disclosure can make insiders better off and non-insiders worse off. The results are generated by the market's inability to observe an insider's motive for trading, which combined with mandatory disclosure, leads to profitable trading opportunities for insiders even though they may possess no fundamental information. The general intuition for their result is that with disclosure, an uninformed insider can manipulate the market because the disclosure of one more trade moves the prices and creates profitable subsequent trades. This is the main reason why an insider's expected trading profits can be higher with mandatory disclosure.

The aspect of an increase in the spread is similar in spirit to the first version of my model. In my model though the increase in the bid-ask spread generates a Pareto improvement over the case where there is no spread introduced in the model, due to the increase in production. In the Fishman and Hagerty (1995) model, the results are generated due to the inability of the market maker to observe an insider's motives for trading, which combined with mandatory disclosure, leads to profitable trading opportunities for insiders even if they possess no fundamental information. In their model, an insider can trade due to superior information or for liquidity reasons. In the two versions of the model that I develop, the insider trades only to take advantage of the superior information that they have and do not trade for liquidity or portfolio readjustment reasons.

Baiman and Verrecchia (1996) in their paper attempt to establish a link between the nature of the capital market from which a firm secures its investment funds, the firm's chosen level of financial disclosure, the firm's cost of capital, the extent of its residual agency problems and the extent of insider trading in its shares. In their model, the costs and benefits associated with disclosure are endogenous. The nature of the capital market in their paper is characterized by the potential liquidity needs of investors from whom capital is raised. The level of disclosure in their model is determined by trading off the production efficiency effect and the compensation subsidy effect, both of which fall with increased disclosure, against a market illiquidity effect and its effect on the cost of capital, both of which also fall with increased disclosure. Production efficiency falls because more disclosure means less information about the manager's action is impounded in price, so that price-based performance measure becomes less efficient, agency problems increase and output falls. The compensation subsidy in their model falls because more disclosure reduces the manager's insider trading profits, thereby reducing the market subsidy associated with hiring and paying the manager. Market illiquidity and the cost of capital fall because more disclosure encourages investment by individuals who may have future liquidity needs. Thus, as investors' potential liquidity needs increases, the cost of capital decreases, the expected profits of insider trading decrease, and the manager's residual moral hazard problem increases.

Their paper is similar to mine in the sense that they impose a Kyle (1985) type market equilibrium process in a standard principal-agent moral hazard problem. In addition, similar to their paper, I examine the production effects of allowing the agent to engage in insider trading. However, their interpretation of trading remains different from mine. In my models I turn to the renegotiation literature to provide a framework to study insider trading as the renegotiation literature establishes the results that are obtained when the parties can change the contract once the game has begun.

In another strand of the theoretical literature Huddart, Hughes, Levine (2001) offer a rationale for contrarian trading. They study the effect of trade disclosure on the dynamic trading strategy of informed insiders. They show that an insider earns the same expected profit and dissipates a constant amount of his private information in every trading round. This is achieved by the insider including a random noise component in every trade. The random component may be a buy or a sell. The insider in their model trades the sum of this quantity and an information-based component. However, in the last round of trading the insider's strategy places strictly positive probability on all trade quantities, both buy and sell, irrespective of the insider's information. This strategy enables the insider to balance immediate profits from informed trades against the reduction in future profits following trade disclosure and hence some revelation of the insider's private information. They provide a rationale for contrarian trades – dissimulation which may underlie insiders' trading activities. This paper differs substantially from the versions of the model I develop as the focus of this paper is the dissemination of the private information that an insider possesses. In my model, the focus is on the impact on effort and production of the firm due to compensating employees with trading securities and allowing them to engage in insider trading.

Khanna, Slezak and Bradley (1994) present a model in which the parameter spaces under which entrepreneurs and society would want to impose restrictions on insider trading are different. When a manager is allowed to trade on his inside information he competes with the informed outsider which then reduces the expected profits of the outsider and leads to a reduction in the equilibrium quality of the outsider's information. This leads to a reduction in the amount of information the insider uses in allocating resources and it affects the liquidity of the secondary market. Both affect the initial offer price. Less outside search lowers the initial offer price since the potential liquidity traders, expecting to lose less to outsiders in the secondary market, are willing to offer a higher price. As the entrepreneur contracts on compensating with the insider, it allows the entrepreneur to capture the insider's expected trading profits by paying a lower contractual wage. This aspect is similar in my model as well as the investors in the firm only pay the agent his reservation wage, they appropriate the gains from the higher production of the firm. However, in the Khanna, Slezak and Bradley (1994) model because the entrepreneur cannot contract with the outsiders, the outsider's profits will reduce the offer price. Given the tradeoff between resource allocation and the relevant portions of the insider's and outsiders' trading profits, an entrepreneur favors insider trading whenever the net effect on the initial offer price is positive. A social planner however only cares about the value of the outside information relative to its cost.

Below I briefly describe some of the empirical literature on insider trading.

EMPIRICAL :

Several empirical papers provide evidence of insider trading in the securities market. Most of these papers use event studies to analyze the impact of insider trading on stock and other market prices. Researchers compare the average profits of traders to the profits of trades by registered insiders, attempting to identify inside information value as abnormal trading gains achieved by insiders. The results have been inconsistent. Early papers by Wu (1964), Lee and Solt (1986) have found no indication that insiders performed better than other traders. On the contrary, Jaffe (1974), Finnerty (1976) Penman (1982), Givoly and Palmon (1985), Seyhun (1986) and Rozeff and Zaman (1988) have found that insiders earned abnormal returns by trading on their privileged information. One of the major drawbacks of these empirical studies has been the lack of a control variable, hence, it is difficult to determine the nature and quality level of the inside information and precisely which traders directly or indirectly possess inside information.

Insiders can earn excess profit by either recognizing pricing errors made by outsiders or by having superior knowledge about future cash flow realizations. In the former case, insiders trade against current investor sentiment, recognizing that outside investors make valuation errors through the application of inferior valuation models and/or the incorporation of biased judgments. In the latter case, managers have private information about the patterns of future cash flows. Because prices respond to unexpected changes in cash flow, insiders trade when their private information of future performance of unexpected cash flows differs from current market expectations. In both settings though, the general idea is that insiders help push prices towards fundamental value.

Prior research supports the hypothesis that insiders are contrarian traders. Sehyun (1992) in his paper shows that insiders are more likely to sell shares following periods of significant price appreciation, consistent with insiders trading in anticipation of subsequent price reversals. Rozeff and Zaman (1998) show that insiders predominantly buy shares in value firms and interpret this as evidence of insiders trading against the market's over-reaction to past performance. Such trading behavior in general is consistent with insiders purchasing securities with high expected returns or the greatest amount of undervaluation (e.g. Fama and French (1992) and Lakonishok et al. (1994)).

Three fairly recent empirical studies by Meulbroek (1992), Cornell and Siri (1992) and Chakravarty and McConnell (1997) imply that insider trading leads to more rapid price discovery. These papers show that insider trading corrects prices significantly and in the right direction. All three papers use detailed data on trading by illegally informed insiders where the insider is a buyer. All three papers also use a measure of insider trading to estimate the impact of such trading on stock prices. Meulbroek (1992) uses an indicator variable to identify the days in which insider trading occurred. Cornell and Siri (1992) compute the fraction of total daily volume attributable to insiders, and Chakravarty and McConnell (1997) use daily and hourly insider trading volume. All the authors conclude that insider trading is significantly correlated with stock price run-ups implying that insider trades affect price discovery differently than non-insider (uninformed) trades. In a related paper Chakravarty and McConnell (1999) using the case-study of Boesky's purchase of Carnation's stock show that the effects of insider trading and non-insider trading (in the same direction) are statistically indistinguishable.

Another stream of empirical literature focuses on the impact on stock prices of legal trades by corporate insiders (Jaffe (1974), Sehyun (1986), Eckbo and Smith (1998), Sehyun (1992a), (1992b) and Ke, Huddart and Pettroni (2003)). These studies show that insiders tend to buy before an abnormal rise in stock prices and sell before an abnormal decline. Sehyun (1992a) finds compelling evidence that insider trading volume, frequency, and profitability all increased significantly during the 1980s. Over the decade, he documents that insiders earned over 5% abnormal returns on average. Sehyun (1992b) determines that insider trades predict up to 60% of the variation in year-ahead returns. Accordingly he concludes that insider trading continues to be an economically important phenomenon.

Elliot, Morse and Richardson (1984) test whether the abnormal returns earned by portfolios which are constructed on the basis of the trading behavior of insiders are associated the public release of information about earnings, dividends, bond rating, mergers and bankruptcies. They find evidence that insiders increase purchases in the 12 months before extreme earnings increases. However, their paper finds little evidence that insiders sell in advance of extreme earnings decreases, dividend changes or bond rating changes. Ke, Huddart and Pettroni (2003) in their paper show strong evidence that insiders anticipate earnings trends up to two years in the future and trade to profit from this information. Evidence points to interactions between legal constraints on trade and the timing of insider trades. They examine insider-trading patterns in advance of a break in quarterly earnings increases and find that insider sales increase three to nine quarters before the earnings break. They conclude that insiders trade ahead of earnings breaks, but do so several quarters ahead of the break so as to avoid the appearance of trading on near-term, material news about earnings.

Allen and Ramanan (1995) in their paper examine the link between reported insider trading and the information captured by annual unexpected earnings. They find that the slope of the coefficient when cumulative 15-month returns are regressed on annual unexpected earnings is highest for the group where insiders are net purchasers and the sign of the unexpected earnings is positive. Their results are consistent with the inference that insider buying interactively confirms the favorable information captured by positive unexpected earnings and this interaction reduces the noise in unexpected earnings. They find a similar but less pronounced effect in the group where insiders are net sellers and the sign of the unexpected earnings is negative. Their results support some of the theoretical work discussed above in showing that insider trading helps in conveying information not fully captured by that year's earnings.

Lakonishok and Lee (2001) in their paper look at stock price reactions to insider trade announcements. They observe very little market movement when insiders trade and report their trade to the SEC. The focus of their paper is longer-horizon returns and they also find evidence that insiders are contrarian investors and prefer to buy value stocks that have historically performed well. However, the paper shows that insiders' trades predict market movements better than simple contrarian strategies and hence could be used as a tool to time the market as previously documented by Sehyun (1988, 1998). In addition, insiders seem able to predict cross-sectional returns. The result they find is driven by insider's ability to predict returns in smaller firms. Also they find that the informativeness of insiders' activities comes from purchases, while insider selling seems to have no predictive ability. In the models I develop, insiders reveal information only through the selling of their shares. Also, my models are constructed such that the agent (insider) who has taken the high-cost action is at his maximum utility when the principal offers him the original compensation and hence this type of agent has no incentive to change his contract through either purchasing or selling shares. It is only the agent who has taken the low-cost action that has an incentive to sell his shares and receive full insurance.

In contrast, studies focusing on insider trading around short-window information events produce mixed results. For example, Givoly and Palmon (1985) are unable to document a link between insider trading profits and subsequent disclosure events (including earnings and dividend announcements). In a related paper, John and Lang (1991) develop and test a model on insider trading around dividend announcement. They develop a signaling model and solve for the efficient equilibrium with endogenous insider trading. They find that insider trading immediately prior to the announcement of dividend initiations has significant explanatory power. For firms that have insider trading prior to the dividend initiation announcement, the excess returns are negative and significantly lower than for the remaining firms. Another implication is that dividend increases may elicit a positive or negative stock price response depending on the firm's investment opportunities.

Noe (1999) examines insider trading around management forecasts of earnings and finds the trading patterns to be unrelated to the forecasted earnings news. Other empirical papers document evidence that managers profit by trading on the foreknowledge of corporate events, for example, Sehyun (1990) and Muelbroek (1992) look at mergers and acquisition activities, Seyhun and Bradley (1997) look at bankruptcy, Karpoff and Lee (1991) examine seasoned equity offerings, Lee et al (1992) looks at stock repurchases and Sehyun (1990) at takeover bids. Damodaran and Liu (1993) look at insider trades on the appraisal information of real estate investment trusts that choose to reappraise themselves. They examine the time that elapses between the appraisal and its public announcement. They find strong evidence that insiders buy after they receive favorable news and sell after they receive negative appraisal news, especially for negative appraisals. They also find that positive (negative) appraisals and net insider buying (selling) elicit significant positive (negative) abnormal returns for the appraisal period.

Piotroski and Roulstone (2005) in their paper, document that insiders are both contrarians and processors of superior information. Their paper extends the prior research in two ways. First, they attempt to disentangle the source of insiders' superior trading performance into two components – trading against current investor sentiment and trading on the basis of superior cash flow information. The tests build on the methodology of Rozeff and Zaman (1998) to document whether incremental associations between insider trades and the various proxies for contrarian beliefs and future cash flow news exist, and provide evidence on the relative explanatory strength of each set of variables.

They find that each relation has incremental explanatory power, but information about superior cash flow changes explains a smaller portion of insider purchases than do proxies for security misevaluations. Second, the research design incorporates all trading activity, not just trading around information events or extreme earnings innovations. The sample consists of a broad set of ordinary performance innovations that are less likely to attract regulatory scrutiny than extreme performance innovations. They also use a long measurement window which increases the odds that the sample captures both the performance signals being used by the insiders as well as the transactions. In addition, the long window research design allows them to use sample proxies for unexpected earnings information at the time of the trade, increasing the power of the tests to detect hypothesized relations.

Consistent with Rozeff and Zaman (1998), they measure contrarian beliefs using two variables – the firm's book-to-market ratio and recent returns. To operationalize the insider's information advantage about future cash flows, they use next year's annual market-adjusted stock return, next fiscal year's annual earnings innovation and the contemporaneous annual earnings innovation. In the tests they assume that these annual innovations represent unbiased proxies of future cash flow changes that are unexpected by market participants but are known by management at the time of insider trades. They find that insider trades are positively related to the firm's future earnings performance (proxy for superior cash flow information) and positively related to the firm's book-to-market ratio and inversely related to recent returns (proxy for trading against misevaluations).

Another recent strand of empirical literature looks at cross-country data to document evidence of the impact of insider trading. Bushman, Piotroski and Smith (2005) use data for 100 countries for the years 1987-2000 to empirically test that insider trading crowds out private information acquisition by outsiders. They study whether analyst following in a country increases following restriction of insider trading activities. They focus on one element of information infrastructure, sell-side analysts. They build on three strands of literature. The first is theoretical research predicting that insider trading crowds out private information acquisition by outside investors (Fishman and Hagerty (1992), Khanna, Slezak and Bradley (1994)). The second strand of literature examines responses to insider trading laws (Bhattacharya and Daouk (2002)). Lastly, they build on the literature that examines relations between legal regimes and financial market characteristics (Beck, Demirgüç-Kunt and Levine (2001,2003), Demirgüç-Kunt and

Maksimovic (1998), La Porta et al. (1997,1998)). They document that both the intensity of analyst coverage (the average number of analysts covering followed by firms within a country) and the breadth of coverage (the proportion of domestic listed firms followed by analysts) increase after initial enforcement of insider trading laws. They further find that this increase is concentrated in emerging market countries, but is smaller if the country has previously liberalized its capital market. They also find that analyst following responds less intensely to initial enforcement when a country has a preexisting portfolio of strong investor protections. Hence, their paper provides some evidence supporting the crowding out theory.

The merits of insider trading regulation have mostly focused on regulation as a way of placing investors on a more equal basis. The main idea being that outside investors that do not have access to private information are disadvantaged when trading with insiders. Opponents of insider trading regulation often cite improved resource allocation as one possible benefit of allowing insider trading, The fundamental question though that remains largely unexplored is why insiders are compensated with tradable securities. One possible explanation given by Dye (1984) is that by allowing managers discretion over their contract through insider trading improved risk sharing can be achieved. This thesis puts forward another possible benefit of allowing managers to engage in insider trading, namely increased firm production.

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Chapter 3: The Value of Asymmetric Information created by Tradable Securities and its Implications for Disclosure

Abstract: While tradable securities remain a popular means of compensating managers, there is constant discussion on the need for tighter regulation, including disclosure requirements, to prevent employees from being able to gain from trading these securities based on their private information. The purpose of this chapter is to provide insights into the role and economic consequences of disclosures aimed at reducing the ability to gain from insider trading. Using the principal-agent framework and relying on the renegotiation literature to capture the concept of insider trading, I show that in some situations allowing the agent to trade anonymously on his private information increases production and, more importantly, is socially desirable compared to the case where the agent's trades are required to be publicly disclosed. The intuition for this result is that the bid-ask spread imposed by the market maker makes it costly for the agent to sell his shares and get full insurance if he shirks. The consequence of the positive incentive effects for the agent makes the overall economy better off.

1. Introduction

In this chapter I develop a theory of, and study the effect of compensating employees with tradable securities on effort exertion and production in the overall economy. Even though there is much concern about employees trading on their private information, many firms continue to compensate employees with a large fraction of tradable securities. This chapter aims to identify a potential economic benefit to employers from compensating employees with tradable securities and allowing them to trade these securities anonymously. To study this problem, I utilize a principal-agent framework and rely on previous research on renegotiation to analyze the concept of insider trading. I also model a simple market with information asymmetry using a Glosten-Milgrom framework to determine the equilibrium price at which the agent can trade his shares. In this chapter do not attempt to characterize the optimal arrangement between the principal and the agent; rather, I identify Pareto improvements that can be implemented as all parties agree to it. The main result of this chapter shows that under certain parameter values in a model where employees are compensated with tradable securities, allowing them to engage in anonymous insider trading can potentially lead to greater production compared to a scenario where they are prohibited from engaging in insider trading. This thus suggests a potential economic reason for the popularity of tradable securities as compensation vehicles. This chapter contributes to the literature on the use of tradable securities in employee compensation packages, insider trading and the implication of additional information asymmetry created by insider trading in renegotiation models.

In this chapter I attempt to model the situation that is more descriptive of publicly traded companies, that is, that of diffused ownership, where the firm is owned by several atomistic shareholders who are residual claimants of the firm. As each "principal" only owns a claim to the residual value of the firm, it is natural to assume that each "principal" does not own or control a sufficiently large fraction of the firm himself to be able to offer to renegotiate with the agent. I term this situation of diffused ownership as having "weak principals." Hence in the model that I present the only option for the agent to "renegotiate" the contract that he is originally offered is to trade his compensation with the market. That is, the agent can reduce his risk-exposure only by selling at prevailing (equilibrium) market prices some or all of the tradable securities with which he was initially endowed.

The main result of this chapter shows that if the agent is compensated with tradable securities, under certain parameter values the economy as a whole can be better off if the agent is allowed to engage in (unobservable) insider trading. By including an additional source of information asymmetry through the mechanism of insider trading, the probability of (desirable) high effort as opposed to (undesirable) low effort in certain situations is greater than in situations without this additional information asymmetry. Indeed as I show, the setting where an agent facing "weak principals," modifies his contract by engaging in undisclosed insider trading may actually perform better than the setting of Fudenberg and Tirole (1990) where a "strong principal" is in control of re-contracting. There is no way of theoretically assessing the size of the region where my model dominates that of Fudenberg and Tirole (1990), however, since there are parameter values where this domination occurs, it is unclear that always requiring managers to disclose their insider trades is beneficial to the economy. If the region of domination is large, then clearly regulation that prohibits anonymous insider trading could have an adverse impact on the economy.

This seemingly counterintuitive result that allowing for anonymous insider trading can benefit the economy hints at a potential (economic) reason for the popularity of tradable securities in compensation packages. The model also helps to understand that allowing for insider trading in firms that have diffused ownership in some cases is beneficial to the owners of the company as the probability of high effort exerted by the manager is higher than in a regime where management's intent to trade has to be publicly disclosed. Hence in these situations the owners would prefer a regime that does not require disclosure of management's trading activities.

The Pareto improvement in this model comes from an increase in expected production. More precisely, an agent faced with a choice between a low and a high productive action will choose to take the high one with a higher probability. The intuition for this result follows from the fact that when the agent trades his compensation with the market, the market maker, knowing that there are traders trading on private information, induces a bid-ask spread that makes trading on private information less beneficial. In equilibrium, if the agent has taken the high-cost action, he prefers to hold on to his shares whereas if he taken the low-cost action he is indifferent between holding and selling all his shares. The market maker is aware of the fact that insider trading occurs only on the sell side of the market. Hence by imposing a large enough spread through a high ask price and a low bid price, the market maker can insure himself of the losses he will incur by buying from insiders. As a result of having to sustain the increased ask price the incentives for taking the high-cost action are increased. As a result, in equilibrium, the agent takes the high-cost action with a greater probability leading to the increase in overall production. Hence, the chapter shows that under certain parameter values insider trading may be socially desirable.

Another result of this chapter is that the more noise traders that trade in a firm's shares, the lower the bid-ask spread of the firm which then reduces the amount of discrimination by the market maker against the agent taking the low-cost action. Hence, the results suggest that the more liquid a firm is the more detrimental insider trading might be for that firm as the disciplining force of the market maker is lowered in these types of firms. Hence, regulation that prohibits insider trading could potentially adversely affect companies that are more liquid if employees are compensated with tradable securities.

In this chapter I do not attempt to characterize the optimal contract between the principal and the agent, rather I start out with a situation where the employees are compensated with tradable securities and determine a Pareto improvement. Hence I suggest a solution to a problem where employees are compensated with tradable securities and identify parameter values where allowing employees to engage in anonymous insider trading dominates compensating them with these securities and allowing for only public trading.

The remainder of the chapter is organized as follows. Section 2 gives the background of the existing literature on insider trading, empirical and theoretical. Section 3.1 lays out the framework of the contract that the "weak principals" (firm) offer the agent in a simple setting where there are two possible outcomes and two possible levels of effort for the agent. Section 3.2 explains the structure of the market that exists for trading in the shares of the firm. Section 3.3 explicitly lays out the time line of the model. Section 4 gives the theoretical foundations of the model used in this chapter. It highlights the important results of the paper by Fudenberg and Tirole (1990). Section 5 provides the analysis of the model in three parts – Section 5.1 explains the importance of Fudenberg and Tirole (1990) as an appropriate benchmark, Section 5.2 sets up an artificial benchmark where the market maker does not impose a spread and Section 5.3 analyzes a regime where the market maker responds to the information asymmetry in the market by imposing a spread. Section 6 concludes the chapter and offers some implications for accounting research.

2. Related Literature on Insider Trading

This chapter is closely related to a theoretical paper by Dye (1984), where he analyzes shareholders' incentives to sanction insider trading. Dye's paper differs from this one as he uses a multiple principal-single agent model with full commitment where he establishes improved risk-sharing as one of the reasons shareholders would want to allow the manager to trade on his private information. In his paper the desirability of insider trading depends on the distributional relationships among the inside information held by management, the manager's effort, and the output of the firm that employs him. His model uses the assumption that the private information of the manager is so informative that the realized value of output contains no information about the manager's actions not contained in the manager's private signal. Providing the right incentives to the manager to reveal his private information truthfully leads to the improved risk-sharing result that drives the gain from allowing insider trading. The benefit of offering a menu to the manager only exists if the manager's private information is not independent of the realized output.

On the other hand, this chapter establishes gains to trading on private information in a limited commitment model where due to diffused ownership, like in the Dye model, there are multiple principals. But these principals own only a small fraction of the firm, and hence do not own or control a sufficiently large fraction so as to be able to renegotiate with the agent. Hence in my model, the only option for the agent to renegotiate his original contract is to trade in the market. Unlike the Dye model, the benefit from insider trading is from increased production, while risk-sharing in the contract remains the same as in the full commitment literature.

Another important distinction between my model and that of Dye (1984) is that in Dye's (1984) model the agent communicates or reveals his information through the mechanism of insider trading while in my model it is crucial that the private information that the agent posses is not revealed through his insider trades, hence what I examine in my paper is the impact on production of allowing *anonymous* insider trading. In my model, similar to Dye's (1984) the manager's trades are observable ex-post after the markets are closed but before compensation is paid to the manager, which is consistent with insider reporting requirements specified in section 16(b) of the Securities and Exchange Act of 1934.

3.1 Model of the Firm

To study the implications of allowing for undisclosed insider trading and, in turn, providing a meaningful role for tradable securities in compensation packages, I analyze an extension of the Fudenberg and Tirole (1990) model of renegotiation with moral hazard in agencies with some key differences. This extended model allows me to distil the effect of insider trading on the agent's effort and in turn on production in the overall economy. In Section 5, I also explain why I consider the Fudenberg and Tirole (1990) model to be an appropriate benchmark as it provides the results when the agent's trades are required to be publicly disclosed.

In particular, I consider a simple agency setting modeled after most publicly traded companies that have diffused ownership. In my model there is no central principal as in the Fudenberg and Tirole (1990) model. Rather, I assume that there is a risk neutral set of "weak principals" (atomistic shareholders) that while being residual claimants of the firm, none of them owns or controls a sufficiently large fraction of the firm to have the power to offer to renegotiate with the agent.

As there is no central principal the contract is written by a board of directors who represent the shareholder's interests. Since the group of shareholders is diverse, that is, it includes long-term as well as short-term shareholders it is not clear whose interest the board of directors act in. The instantaneous preferences of shareholders may not be a mandate of the board. Hence, I assume that the board of directors offer the agent a contract at the beginning of the game, and due to the myriad interests of shareholders, they choose not to renegotiate with the agent themselves, but rather allow the agent to renegotiate his contract with the market through insider trading. The agent here receives compensation in the form of cash and tradable securities and renegotiation, if it takes place, can only take the form of the agent trading his claims at prices set in the market. Hence in this model, as I formally show later, trading is analogous to renegotiation.

I examine a discrete model where the agent has only two levels of effort to choose from; high or low $a \in \{a^h, a^l\}$. The choice of effort, in turn, affects the expected value of the firm by altering the probability distribution over final output to be realized, observed, and shared at the end of the game. Realized output is denoted by $x \in \{H, L\}$ where $H > L$, and the probability of outcome H when the agent chooses effort a^j is denoted by $p^j \equiv Prob(x = H \mid a^j)$, where $j = l, h$. By assumption, $p^h > p^l$. The agent's utility function is assumed additively separable in utility for consumption, represented by the strictly increasing and concave function $U(\cdot)$ defined over the entire real line, and dis-utility for "effort." For notational simplicity the cost of the low effort is normalized to zero while the (incremental) cost of high effort is represented by $C > 0$. As in the Fudenberg and Tirole (1990) model, I will assume that the value of the high output and the effect of the agent's effort on the probability that it materializes are so large that the principal wants to implement the high effort whenever possible. The probability of high effort induced by the randomization result is denoted by $\sigma \equiv Prob(a^j = a^h)$.

As the key focus of my analysis is on the economic consequences of insider trading, I assume that the agent has claims to the terminal (net) output of the firm. As usual, the contract between the principal and the agent can be written on what is observable, that is x, as well as on any messages the agent may choose to convey to the principal prior to the end of the game. In the benchmark setting of Fudenberg and Tirole (1990) the only private information the agent can (and does) communicate is the choice of effort. In the case considered here where the agent can (and does) alter his exposure to the firm through market transactions, he may also be induced to disclose his trading activities. Hence, the message space of the agent in this case includes his effort level and his trading activity.

Given the focus on insider trading it is useful to express the contract between the principal and the agent in terms of a cash component, denoted by $B \in \{B^*, B^0\}$, and a claim to a fraction of the final output of the firm. With only two potential levels of output, this is without loss of generality. Assume that the principal pays an agent B^* if he observes that the agent holds δ^* risky shares to the expected terminal value of the firm and B^0 if he observes that the agent does not hold $\delta *$ shares in the firm at the liquidation date. In equilibrium the terminal payment from the principal to the agent is $B *$ for an agent who holds shares in the firm (and thus has taken a^h) and an agent who exerts a^l will hold no shares in the firm and will receive B^0.

This assumption is consistent with the reasoning that the market in the firm's shares closes before compensation is paid to the agent, which is consistent with insider trading reporting requirements specified in section 16(b) of the Securities and Exchange Act of 1934, and hence the trading of the manager are revealed to the principal. It is also similar to the assumption made in the paper by Dye (1984). Analytically this assumption allows the principal to pay the agent enough cash so that the agent receives his reservation utility. Also, since the agent's portfolio holdings are revealed after the terminal value x is realized, it does not alter the agent's action choice or his trading choice at the "renegotiation" stage. Hence this assumption is without loss of generality.

This practice of conditioning the agent's bonus not just on firm performance but also on the agent's portfolio holdings is common in practice. For example, in a New York Times article, the author Leslie Wayne discusses that one way that Campbell Soup Company has responded to shareholder activism is by tying the executives' compensation to the company's performance and requiring that top officials have a certain portion of their net worth tied in Campbell stock.[1] This is one example of many companies that pay bonus compensation conditional on their employees' portfolio holdings. Hence, having $B* \neq B^0$ in the model is one way of capturing anecdotal evidence through the analytical structure.

[1] Taken from the article "Campbell Revises Executives' Rules" by Leslie Wayne published in New York Times on Tuesday October 12, 1993.

The risky part of the contract at the beginning of the game consists of δ^* shares in the firm. If insider trading occurs, the agent purchases ψ shares in the open market at the ask price denoted by ASK or sells as many as δ^* shares in the open market at the bid price denoted by BID. In the model, I assume that insiders are not allowed to short-sell.[2] The contract is constructed such that the agent trades in such a manner that at the end of the period an agent who took a^h holds δ^* shares of the firm, where δ^* is the fraction of the firm held by an agent facing a full commitment optimal contract which is the contract that is incentive compatible with that action. If the agent is given δ^* shares by the principal, in the equilibrium renegotiation-proof contract, the agent who exerts a^h should not have an incentive to purchase or sell shares. Before the agent has chosen his effort and traded accordingly, the contract also must be individually rational such that the agent is indifferent between the expected utility from high and low effort and, thus, willing to randomize between them with a probability σ.

In this chapter I do not attempt to solve for the optimal contract that is awarded to the agent. As the risk-sharing between the principal and the agent in my model is the same as that in Fudenberg and Tirole (1990), I can rank the contracts in terms of the production they generate. In this chapter, I establish that when the agent is compensated with tradable securities and allowed to trade them anonymously, under certain parameter values, I can push out the Pareto frontier as benchmarked against Fudenberg and Tirole (1990). If this contract that may or may not be optimal can demonstrate an increase in production, then this result will hold true for an optimal contract. Hence, I identify a Pareto improvement to the solution where employees are compensated with tradable

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[2] This is consistent with SEC rulings especially that of 10a-1 generally referred to as the 'uptick' rule.

securities and demonstrate one potential economic reason for the presence of a tradable component in compensation packages.

3.2 Model of the Market

This section explains the market structure imposed in the model in order to analyze the price at which the agent can trade his shares in the market. Similar to Glosten and Milgrom (1985), I assume that there exists a single competitive risk-neutral market maker in the market. The market maker is uninformed and faces an adverse selection problem, as there are informed traders and liquidity traders in the market. Assume that the number of liquidity traders in the market equals L, made up of L_S liquidity sellers and L_B liquidity buyers. To solve the problem of asymmetric information, caused by informed traders who in this case are agents who have already exerted effort, the market maker quotes a bid and ask price.

I assume that the market maker does not observe the order flow before setting competitive bid (sell) and ask (buy) prices and therefore he has an expected profit of zero in each period, which implies that the market maker cannot cross-subsidize over time. The bid price is termed as BID and the ask price is denoted by ASK, with $BID \leq ASK$. The market maker in my model is only concerned with earning zero expected profit in equilibrium and within this objective is willing to set prices that support Pareto improving solutions. In addition to the spread set by the market maker, the unconditional expected value (and potential market price) of the firm when the agent has exerted a^h (high effort) is denoted by $\pi_h = p^h H + (1-p^h)L$. Similarly, the unconditional expected value of the firm when the agent has exerted a^l (low effort) is denoted by $\pi_l = p^l H + (1-p^l)L$. The market maker sets prices at the expected value of the firm given the agent's equilibrium level of effort.[3]

The modeling approach in this chapter differs significantly from that of previous literature in that I show that under certain parameter values insider trading can lead to an increase in production in the overall economy without any adverse effects and may hence be socially desirable. This increase in output can always be redistributed to the liquidity traders (as long as they are risk-neutral) who may incur losses when trading with insiders. Hence, in this chapter due to the increase in production caused by allowing the agent to trade with the market, there is scope for a Pareto improvement. This model is not about allocation issues, rather it is about defining the Pareto frontier through the amount of production in the overall economy.

3.3 Time-line of the Model

At $t = 0$ the agent is offered a contract by the diffused owners who have claims to the residual value of the firm consisting of δ^* shares in the firm and a cash amount $B \in \{B^*, B^0\}$. At $t = 1$ the agent exerts action $a \in \{a^h, a^l\}$. Once the agent's action choice is sunk, he has the option at $t = 2$ to readjust his compensation portfolio by trading the shares in the firm with the market. At $t = 3$ the value of the firm is realized and the agent's portfolio is observed after the market in firm's shares has closed. At the last stage of the game $t = 4$, as the principal knows the agent's share holdings, the principal pays the agent conditional on the agent's share holdings he observes. The firm

[3] This is a simplifying assumption. I could extend the market to also perform the function of information aggregation, but as this will only complicate the model without changing the results, hence the simpler version is used in this model.

is liquidated and the proceeds are distributed among the residual claimants. The game is structured such that an agent that has no shares of the firm at the liquidation date has a preference for full insurance and hence is an agent who has exerted the low-cost action. On the other hand, an agent who continues to hold δ^* shares of the firm at the liquidation date is one that has taken the high-cost action. The timing of the game can be depicted by the following time-line:

At $t=0$ P gives A a contract C consisting of δ^* shares in the firm and cash amount $B \in \{B^*, B^0\}$	At $t=1$ A exerts action $a \in \{a^h, a^l\}$	At $t=2$ A is allowed to readjust his portfolio according to C	At $t=3$ terminal value of firm $x \in \{H, L\}$ is observed and A's portfolio holdings are observed by P as the market in the firm's shares is closed.	At $t=4$ A is compensated according to the portfolio revealed and the firm is liquidated.

4. Theoretical Foundations of the Model

In this section I highlight the important features of the Fudenberg and Tirole (1990) model and then go on to explain in the next section why their model serves as an appropriate benchmark for the one I consider. The Fudenberg and Tirole (1990) renegotiation model allows me to look at how trading by the agent effects production. Specifically, the agent trading his contract with the market once his effort choice has been made is analogous to allowing the agent to renegotiate his contract. In the Fudenberg and Tirole (1990) model the agent renegotiates his original contract with the principal whereas in my model the agent is allowed only to renegotiate his original contract through trading in the market. Hence, in my model I include a player in addition to the principal and the agent – the market. But, in both the Fudenberg and Tirole (1990) and my model, there is a lack of commitment created by the possibility of renegotiation (possibility of changing the original contract once the game has started). Information asymmetry is created in the Fudenberg and Tirole (1990) model by the principal being unknown about the agent's action choice and in my model by the principal being unknown about the agent's action choice as well as his trading activities.

The Fudenberg and Tirole (1990) model is structured such that the principal and the agent write a contract after which the agent exerts effort. At the next stage, that is, once the effort is sunk, the principal (in this case a "strong principal") offers to renegotiate the contract by offering the agent a menu of contracts to choose from. The key difference in my model is that once effort is sunk, the agent has the opportunity to trade the shares in his original contract in the market and hence giving the agent the opportunity to include exogenous information from the market in his relationship with the principal. In the Fudenberg and Tirole (1990) model once the agent has chosen the contract, output is realized and the agent is paid according to the contract he has chosen which holds in my model as well.

In their paper Fudenberg and Tirole (1990) show that with the possibility of renegotiation the principal cannot induce non-trivial pure strategies in the effort provision of the agent. When the effort choice is not observed by the principal, the anticipation of renegotiation may eliminate all incentives for the agent. To avoid this result, the outcome of full insurance once the action is sunk must somehow be prevented. Avoiding this outcome is possible only if the principal remains unsure about which action the agent chose. If the principal knows for sure the agent's action, he can determine exactly the expected value of the underlying investment and insure the agent thereby saving a risk-premium. However if the agent is randomizing his choice over several actions, the principal is put in a position of an asymmetrically informed insurer at the renegotiation stage (Bolton and Dewatripont (2005)). Hence, the complexity of the model comes from the fact that at the renegotiation stage the game switches from one of hidden action to one of hidden information.

The renegotiation stage in the game occurs after the agent's effort has been exerted, hence depending on the effort that the agent has taken, the agent chooses from a menu of compensation contracts offered by the principal. At this point the game becomes a standard adverse selection problem, where, by choosing from the menu that the principal offers, the agent reveals his type – here his effort choice. Two important observations must be made about the problem – the agent's cost of effort does not appear in the problem as it is a sunk at the renegotiation stage. Second, both types' individual rationality constraints may be binding here (Bolton and Dewatripont (2005)).

The principal offers a menu of contracts that solves the compensation-cost-minimization problem of extracting informational rent from the agent that exerted a^l who wants to pretend that he is type a^h. This is done by distorting the efficient allocation of type a^h. The menu that the principal offers the agent contains a less than full insurance contract (risky contract) for the agent that exerted a^h and a full insurance contract for the agent that exerted a^l (no distortion at the top). The menu of contracts offered by the principal is the same as in the standard full commitment model, except that the weights placed on them by the agent are different. Due to the randomization result, the probability of the agent exerting the high-cost action is less than one and the probability of the agent exerting the low-cost action is greater than zero. In this case the agent's benevolence lies in the assumption that the agent will take the high-cost action with the highest probability to avoid losses in production.

To be a bit more formal with the notation, Fudenberg and Tirole (1990) in the discrete case prove that the highest probability of high effort $x^*(c)$ that can be sustained in equilibrium is such that

$$\frac{x^*(c)}{1-x^*(c)} = \left(\frac{\phi'(\underline{U})}{\phi'(U_g(\bar{e})) - \phi'(U_b(\bar{e}))}\right)\left(\frac{p(\bar{e}) - p(\underline{e})}{p(\bar{e})(1-p(\bar{e}))}\right)$$

where $\phi(U)$ is the inverse function of the utility function U. This result shows that with the possibility of renegotiation, the principal cannot induce high effort as a pure non-degenerate strategy; rather the agent randomizes between high and low effort with a certain probability. As the agent gets his reservation utility whether he chooses the high or the low effort, he is indifferent between the two effort levels and hence it is presumed that the agent randomizes between them using $x^*(c)$.

A point to note here is that only contracts that offer full insurance to type a^l can be renegotiation-proof. In addition, the contracts that are in the menu offered by the principal in this setting with renegotiation are exactly the same as the ones used to elicit high and low effort respectively in the full commitment model. The only difference between the full commitment model and the renegotiation model is that in the full commitment model the principal can induce a^h with a probability one and (thus) a^l with probability zero. In the renegotiation case, the principal can at best induce mixed strategies where the agent randomizes between a^h and a^l with a certain probability less than one. Hence, with renegotiation the probability of a^l, which is greater than zero, represents a production and a Pareto loss relative to the full commitment case. In the sections that follow, I show that in my model where renegotiation takes place through trading in the market, a higher probability of high effort can be supported with the same contract menu when insider trading is allowed. Any model that can support a higher randomization of high effort without adverse risk-sharing will yield a Pareto improvement over the Fudenberg and Tirole (1990) model as it will be closer to the standard full commitment production.

5. Analysis

5.1 Full Disclosure Benchmark

While the Fudenberg and Tirole (1990) model differs from mine as there is a "strong principal" that has the ability to renegotiate directly with the agent, to evaluate the consequences of allowing for insider trading on private information I still use the results of Fudenberg and Tirole (1990) detailed above as a benchmark. The reason this is the appropriate benchmark in my setting with atomistic shareholders is that the important feature supporting their analysis is not whether the principal is strong or weak. Indeed, as an alternative to the Fudenberg and Tirole (1990) set-up, consider a model where shareholders are atomistic and individually "weak," but where a manager's trading in the stock of his company can only happen publicly. That is, a manager must identify himself as the trader should he choose to trade his shares.

With this set-up, the solution of Fudenberg and Tirole (1990) can be replicated by endowing the manager with the standard second-best contract constructed using shares and cash and then after the action has been taken, the market maker can offer the agent to buy back the shares for the amount that would correspond to the part of the Fudenberg and Tirole (1990) menu offered to the agent who has taken the low-cost action. As this maximizes the utility of the residual claimants at the time the agent's action has been taken, it seems reasonable that the market maker would be willing to do so and the same equilibrium with the same allocations as in Fudenberg and Tirole (1990) would then emerge in this setting. Hence, with the agent's trades being publicly disclosed, the market maker can at best act as the principal in Fudenberg and Tirole (1990) and set prices such that he replicates the allocations in that model.

The Fudenberg and Tirole (1990) allocations may not be the optimal strategy for the market maker in terms of his expected profit, but in terms of production, this is the best that can be achieved in this scenario – replication of the Fudenberg and Tirole (1990) allocations. In other words, being able to demonstrate that the solution to the problem where managers are not required to identify themselves can lead to improvement relative to Fudenberg and Tirole (1990) is equivalent to demonstrating that insider trading can provide economic benefits in a setting with diffused "weak" shareholders. Thus, if the manager is required to identify himself, the optimal solution makes him trade on terms specific to him and not market prices so that the market maker can replicate the allocations in Fudenberg and Tirole (1990). Of course then there is no point to using tradable securities as a means of compensation in this scenario as the securities offered to the agent in this case are not traded at market prices.

The model that I analyze is closer to the Fudenberg and Tirole (1990) model than to the one proposed by Ma, Ching-To Albert (1994) where he look at a renegotiation model where the agent, rather than the principal proposes the renegotiation contract. My model is similar to his as in my model as well the principal does not offer to renegotiate with the agent due to diffused ownership, rather it is the agent that proposes the renegotiation in the form of trading his contract in the market. In the model by Ma, Ching-To Albert (1994) the agent offers the principal a menu of contracts. The principal will believe that the agent has taken the low-cost action if the agent offers the principal a full insurance contract at the renegotiation stage. Anticipating a rejection of his renegotiation offer, the agent chooses the high-cost action.

To deal with the multiplicity of equilibria, he imposes a belief refinement which states that when the principal's initial contract and the agent's renegotiation contract support the same, unique best action for the agent, then the principal must believe that the agent has performed this action. This restriction on the beliefs of the principal allows him to get back the second-best allocation as a unique equilibrium. But, unlike his model, I do not restrict the principal's beliefs, and as I have established above, in my model I can replicate the Fudenberg and Tirole (1990) allocations when the agent is forced to publicly disclose his trades. Hence, in the rest of the chapter, I will benchmark the production results that I get in my model when the agent does not have to disclose with that of Fudenberg and Tirole (1990).

Again note that the aim of this chapter is not to characterize the optimal contract between the principal and the agent. Rather, I propose an alternative solution that yields a Pareto improvement to the problem where managers are compensated with tradable securities. One important point to note is that since the focus of this chapter is to find a potential value to the tradability feature of compensation packages I examine the scenario where managers are compensated with tradable securities and compare the situation where managers are allowed to engage in anonymous insider trading to a situation where managers must publicly disclose their trading activities. Hence, I do not look at the situation where managers are compensated with tradable securities and not allowed to engage in any sort of trading as this does not allow me to identify a potential economic reason for compensating managers with tradable securities.

5.2 Benchmark Case – No Spread Regime

I start my formal analysis by first focusing on a hypothetical benchmark case in which the manager can trade anonymously at market prices, but the market maker sets prices without considering the presence of an adverse selection problem in the market. Thus the agent who is informed about his effort choice has the option to trade his shares (as they are tradable) at their unconditional expected value. Stated differently, while I do introduce information asymmetry into the market here, the market maker fails to recognize this and does not induce a spread in the market prices. Hence, in this benchmark case, prices are set such that $BID = ASK$. For lack of a better name, I label this as the "no spread" regime.

Now suppose that the agent is endowed with $\delta *$ shares initially. Again, $\delta *$ is the agent's share-holdings in the standard full commitment contract that satisfies incentive compatibility given that the individual rationality constraint binds. The agent who has taken the high-cost action is compensated with $B *$ cash bonus at the end of the game if he continues to hold $\delta *$ shares. $B *$ is constructed such that the individual rationality constraint of this type binds so that in equilibrium he gets his reservation utility. Hence, this contract is the same as the risky contract that is paid to an agent who has taken the high-cost action in the standard full commitment model. This ensures that the contract given to the agent in my model is the same as the Fudenberg and Tirole (1990) contracts and hence I can rank the two models in terms of the production they yield.

At the time of trading effort is a sunk cost; hence, it does not enter the agent's future expected utility maximization problem. The expected utility, EU, of an agent who has chosen the high-cost effort a^h is given as

$$EU = p^h U[\delta^* H + B^*] + (1 - p^h) U[\delta^* L + B^*].$$

For this type of agent to settle on a contract that is ex-ante incentive compatible (in addition to satisfying exactly individual rationality) through his own utility maximizing trading activities, the equilibrium market price, $\hat{\pi}$, must be such that the optimal holdings for this agent is exactly δ^* shares. Lemma 1 establishes the necessary condition in equilibrium for an agent who has taken the high-cost action to hold exactly δ^* shares.

<u>Lemma 1:</u> A necessary condition for it to be optimal for an agent who has taken a^h to continue to hold (exactly) δ^* shares in the firm is that the price $\hat{\pi}$ satisfies:

$$\frac{(H - \hat{\pi})}{(L - \hat{\pi})} \frac{p^h}{1 - p^h} = -\frac{U'[\delta^* L + B^*]}{U'[\delta^* H + B^*]}$$

<u>Proof:</u> Suppose the agent who chooses a^h effort purchases ψ additional shares, his expected utility with the additional ψ shares is

$$EU = p^h U[\delta^* H + B^* + \psi(H - \hat{\pi})] + (1 - p^h) U[\delta^* L + B^* + \psi(L - \hat{\pi})]$$

His expected utility will be at the maximum when he holds exactly δ^* shares if the first-order condition in ψ equals zero when evaluated at $\psi = 0$,

$$\left.\frac{\partial EU}{\partial \psi}\right|_{\psi=0} = p^h U'[\delta^* H + B^*][H - \hat{\pi}] + (1 - p^h) U'[\delta^* L + B^*][L - \hat{\pi}] = 0$$

or
$$\frac{(H-\hat{\pi})}{(L-\hat{\pi})}\frac{p^h}{1-p^h} = -\frac{U'[\delta^* L + B^*]}{U'[\delta^* H + B^*]}.$$
■

$U'[\delta^* H + B^*]$ is the marginal utility of the a^h agent when $x = H$ is the outcome that is realized and is denoted for simplicity by $U'[S^*(H)]$. Similarly $U'[\delta^* L + B^*]$ is denoted by $U'[S^*(L)]$.

Lemma 1 provides the necessary condition for the agent who has taken the high-cost action to hold exactly δ^* shares in equilibrium. This holds in equilibrium if the agent who has taken the high-cost action is at his maximum utility when he holds exactly δ^* shares in the firm and hence has no incentive to change his claim on the firm. Lemma 2 gives the sufficient condition for the agent who has taken the high-cost action to have no incentive in equilibrium to change his contract through trading in the market.

Lemma 2: A sufficient condition for this contract to characterize the case where the agent who has taken a^h is at his maximum utility when he continues to hold exactly δ^* shares is for his expected utility function to be concave in δ everywhere.

Proof: If the agent's expected utility function is concave in δ everywhere there must exist a unique maximum. This holds if and only if

1. $dEU/d\delta^* > 0$ at $\delta^* = 0$
2. $d^2EU/d^2\delta^* < 0$

See Appendix A for details of the proof. ■

I have established above the necessary and sufficient conditions for the agent who has exerted a^h to choose to hold exactly δ^* shares in equilibrium. In order for the agent who has taken a^h to hold δ^* shares, he must not have an incentive either to buy or sell his claim on the firm. This is achieved if the market maker chooses an appropriate price for the shares in the market such that there is no incentive for the agent who has exerted a^h to buy or sell his shares. Lemma 3 summarizes the details of the price for which this relationship holds in equilibrium.

Lemma 3: The expected value of the firm is given by the expression

$$\hat{\pi} = \hat{\sigma}[p^h H + (1-p^h)L] + (1-\hat{\sigma})[p^l H + (1-p^l)L],$$

where $\hat{\sigma}$ is the equilibrium probability of high effort.

Proof: In this regime the market price $\hat{\pi}$ is formed simply by the market maker's rational expectations on the final payoff which depend on the market maker's rational expectations on the probability of the agent taking the high-cost action when he randomizes. This can be calculated as a combination of the expected market price of the firm when the agent exerts high effort and the expected market price of the firm when the agent exerts low effort weighted by the equilibrium probability of high effort $(\hat{\sigma})$ and of low effort $(1-\hat{\sigma})$. Based on the market maker's expectation of the randomization of effort by the agent the firm is priced at $\hat{\pi}$ where

$$\hat{\pi} = \hat{\sigma}[p^h H + (1-p^h)L] + (1-\hat{\sigma})[p^l H + (1-p^l)L],$$

where $\hat{\sigma}$ takes the form that supports the price $\hat{\pi}$ that satisfies the necessary condition established in Lemma 1in equilibrium. ■

For the price established in Lemma 3 to be the equilibrium price, it must be that at this price when the agent who has exerted a^h with a probability $\hat{\sigma}$ is at the point where his utility is at the maximum. This ensures that the agent who has taken a^h has no incentive to buy or sell shares and hence continues to hold exactly δ^* shares until the liquidation date. This is done by substituting the value of $\hat{\sigma}$ that has been calculated in the equilibrium condition of $\hat{\pi}$ (Lemma 3) into the necessary equilibrium condition that has been found for the high-cost agent to hold δ^* shares (Lemma 1). Proposition 1 gives the necessary and sufficient condition for the contract to hold in equilibrium.

<u>Proposition 1:</u> The necessary and sufficient condition for the second best contract with tradable securities to be "renegotiation proof" is

$$\frac{(p^l - p^h)\hat{\sigma} + (1 - p^l)}{(p^l - p^h)\hat{\sigma} - p^l} \frac{p^h}{1 - p^h} = -\frac{U'[S^*(L)]}{U'[S^*(H)]}$$

<u>Proof:</u> Follows directly from Lemma 1 and Lemma 2. For details of the proof refer to Appendix A. ■

Proposition 1 establishes the probability of high effort $\hat{\sigma}$ when equilibrium prices are set so that there is no spread in the market, that is, the market maker ignores the adverse selection problem in the market and sets prices such that $BID = ASK \equiv \hat{\pi}$, and the necessary and sufficient conditions are met so that the agent who has taken the high-cost action holds his shares. Now I shift attention to the agent that has taken the low-cost action. Lemma 4 provides the necessary condition to prove that in equilibrium the agent who has taken the low-cost action is indifferent between selling his shares and keeping them till the firm is liquidated. One point to note is that there is no short selling allowed by the insiders here.[4]

<u>Lemma 4:</u> The necessary condition for the low-cost action agent (a^l) to be indifferent between holding his shares and selling them is that B^0 is constructed such that the individual rationality constraint binds for this type.

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[4] This is consistent with SEC uptick ruling.

Proof: In order for it to hold in equilibrium that the agent who randomizes between taking the high-cost action and not trading, and taking the low-cost action and selling his shares, it must be that he is indifferent between the two actions. That is, his utility from the two actions should be equal. This condition can be written as

$$p^h U(\delta * H + B*) + (1 - p^h) U(\delta * L + B*) - C = U(\delta * \hat{\pi} + B^0)$$

The incentive compatibility constraint for an agent who has taken the high-cost action is given by

$$p^h U(\delta * H + B*) + (1 - p^h) U(\delta * L + B*) - C = p^l U(\delta * H + B*) + (1 - p^l) U(\delta * L + B*)$$

where the LHS of the equation is the utility of the agent if he takes the high-cost action less the differential cost of effort and the RHS is the utility of the agent if he takes the low-cost action. Both sides of the equation assume that the agent holds his shares until the liquidation date.

Hence it is true that the low-cost action agent is indifferent between holding his shares till the liquidation date and selling them. This is given by the following constraint

$$p^l U(\delta * H + B*) + (1 - p^l) U(\delta * L + B*) = U(\delta * \hat{\pi} + B^0) \qquad \blacksquare$$

One point to note is that the cash component paid to the agent $B \in \{B*, B^0\}$ must be such that $B*$ binds the individual rationality constraint for the agent who has taken the high-cost action whereas B^0 is constructed such that the individual rationality constraint binds for the agent who has taken the low-cost action and sells his shares. Also, the condition on the cash component is such that the agent randomizes between taking the high-cost action and keeping his shares in the firm and taking the low-cost action and selling his shares, that is, the agent is indifferent between the two actions as his utility is the same from both choices. Hence, the cash component is constructed so that both types of agent are at their reservation utility. This means that the individual rationality constraint of both types of agent binds and hence $B^* > B^0$. Having established that the agent who has taken the low-cost action is indifferent between selling his shares and keeping them till the liquidation date, I now demonstrate that the low-cost agent will always choose to sell all his shares and not just a fraction of them.

Lemma 5: If B^0 satisfies Lemma 4 then the low-cost agent prefers to sell all his shares to only selling a portion.

Proof: Assume that the agent who has taken the low-cost action sells ψ shares of the total number of shares (δ^*) that he was awarded at the beginning of the game. His utility from selling a portion of his shares and keeping a portion till the liquidation date can be given by the expression

$$p^l U((\delta^* - \psi)H + B^0) + (1 - p^l)U((\delta^* - \psi)L + B^0) + U\psi\hat{\pi}$$

The agent in this case is compensated with B^0 as at the liquidation date, he does not hold δ^* shares in the firm and hence reveals that he is not the type who has exerted the high-cost action.

If instead the agent who exerted the low-cost action is given the certainty equivalent of the shares he holds rather than the lottery he receives when holding the shares till the liquidation date, his utility can be expressed as

$$U[((\delta^* - \psi)\pi_l) + \psi\hat{\pi} + B^0]$$

Since the agent is risk averse his utility is higher with the certainty equivalent than with the lottery. This is expressed by the following inequality

$$p^l U((\delta^* - \psi)H + B^0) + (1 - p^l)U((\delta^* - \psi)L + B^0) + U(\psi\hat{\pi}) <$$
$$U[((\delta^* - \psi)\pi_l) + \psi\hat{\pi} + B^0].$$

On the other hand, if the agent who has taken the low-cost action sells all his shares, his expected utility is

$$U(\delta^*\hat{\pi}+B^0) > U[((\delta^*-\psi)\pi_l)+\psi\hat{\pi}+B^0]$$

by construction $\hat{\pi} > \pi_l$, which implies that

$$p^l U((\delta^*-\psi)H+B^0)+(1-p^l)U((\delta^*-\psi)L+B^0)+U(\psi\hat{\pi}) < U(\delta^*\hat{\pi}+B^0).$$

By the above inequality the low-cost agent has a higher expected utility from selling all his shares rather than selling just a fraction of them. ■

Lemma 5 provides the sufficiency condition that must hold if B^0 is constructed such that it satisfies Lemma 4 and the agent who has taken the low-cost action randomizes between holding his shares and selling all of them. Lemma 5 establishes that selling only a fraction of the shares results in inefficient risk-sharing for the agent and hence it shows that no interior maximum exists when the agent who has taken the low-cost action holds a diversified portfolio. Rather, the agent who has taken the low-cost action has a higher expected utility from selling all his shares.

This section overall deals with the hypothetical situation where the market maker does not respond to the information asymmetry in the market when setting prices. Hence prices in this regime are set as if there is no adverse-selection in the market. Accordingly the market maker does not set a spread in this market and $BID = ASK \equiv \hat{\pi}$. The objective of the market maker in this game is simply to earn zero profit in expectation and he supports any Pareto improvement solution. To simplify matters algebraically I assume that the market maker seeks to make an expected profit of zero on both the sell and the buy side of the market and not simply in aggregate and sets prices accordingly.[5]

Lemma 6: In the "no spread" regime the market maker makes a negative profit overall.

Proof: Lemma 2 establishes that the agent who has exerted a^h is at his maximum utility; hence he has no incentive to change his shareholdings in the firm. On the other hand, the agent who has exerted a^l prefers to sell his claim on the firm and hence he liquidates his shares and gets full insurance. The market maker in this section sets prices such that there is no spread in the market, therefore, $BID = ASK = \hat{\pi}$. Since the agent who has taken a^h does not change his portfolio and the agent who has taken a^l sells his shares, insider trading occurs only in the sell side of the market. In this regime, prices in the buy side of the market are set such that $ASK = \hat{\pi}$ as there is no spread in this market, As there are only liquidity traders in this side of the market $L_B[ASK - \hat{\pi}] = 0$ so that the market maker makes zero expected profit. On the sell side though, there are liquidity traders as well as informed traders. The market maker sets prices such that $BID = \hat{\pi}$, his profits from this side of the market are given by

$$L_S[\hat{\pi} - BID] + \delta(1-\hat{\sigma})[\pi_l - BID] < 0.$$

In the "no spread regime" $BID = \hat{\pi}$ hence the market maker makes no profit on the liquidity traders but looses money when he trades with informed traders as $\pi_l < \hat{\pi}$. Hence, overall, the market maker's profits in this regime are negative. ■

[5] This restriction actually makes the production gains smaller, but as I am concerned about demonstrating a gain and not about the specific magnitude of this gain, the simplification this brings justifies this assumption.

As the market maker makes a negative profit in this regime it is hard to imagine that he would participate in such a regime. However, this regime only serves as a hypothetical benchmark and is not suggestive of a complete equilibrium.

5.2.1. Comparison of No Spread Regime with FT (1990)

In the above section I established that when the market-maker does not induce a bid-ask spread in the market and there are "weak principals" that do not offer to renegotiate with the agent, in equilibrium the agent will exert a^h with a probability $\hat{\sigma}$ when the equilibrium price of the firm is set at $\hat{\pi}$ by the market maker. The randomization probability derived in the above artificial benchmark case can now be compared to the probability of high effort in Fudenberg and Tirole (1990) where a "strong principal" offers the agent a renegotiation-proof contract that induces the agent to randomize and exert the high effort with a probability σ^{FT} (rewritten in my notation):

$$\frac{1-\sigma^{FT}}{\sigma^{FT}} = \frac{\phi'(H)-\phi'(L)}{\phi'(\underline{U})}\left(\frac{p^h(1-p^h)}{p^h-p^l}\right),$$

where ϕ' here as in FT (1990) denotes the derivative of the inverse of the agent's utility function. For notational simplicity $\phi'(U(S(H)))$ is denoted by $\phi'(H)$ and similarly $\phi'(U(S(L)))$ by $\phi'(L)$. Another way to think about the Fudenberg and Tirole (1990) model as I have explained in Section 5.1 is a scenario where the agent is compensated with tradable securities and allowed only to engage in public trading. Intuitively, the "no spread" regime should do worse than Fudenberg and Tirole (1990) as in this model the agent has the option to anonymously trade away the risk potential of his contract rather than revealing his trades publicly. This acts as an additional constraint to the Fudenberg and Tirole (1990) maximization program as in equilibrium the contract in their model is constructed such that the "strong principal" offers the agent a renegotiation-proof contract where the agent has no incentive to trade. Mathematically, this is true – comparing the probability of high effort in the "no-spread" regime with that of Fudenberg and Tirole (1990) shows that under all parameter values except those identified below, the probability of high effort in the "no-spread" regime is always lower than that derived in Fudenberg and Tirole (1990). Proposition 2 below provides the specifics of the parameter value for when the production in the "no-spread" regime equals that in Fudenberg and Tirole (1990).

Proposition 2: Production in the "no spread" regime is equivalent to that in the Fudenberg and Tirole (1990) model (only) when

1. $\phi'(\underline{U}) = \phi'(L)$
2. $p^l = 0$

Proof: To rank the two models, I consider the scenario where the Fudenberg and Tirole (1990) model has the biggest disadvantage, that is, which gives the lowest σ^{FT}. As $\phi'(\underline{U})$ is a weighted average between $\phi'(H)$ and $\phi'(L)$ this is equivalent to setting $\phi'(\underline{U}) = \phi'(L)$ which is just an imposition on the particular form of risk-aversion of the agent, intuitively it says that the agent's risk preferences change only for large amounts. Substituting $\phi'(\underline{U}) = \phi'(L)$ yields

$$\frac{1-\sigma^{FT}}{\sigma^{FT}} = \frac{\phi'(H)-\phi'(L)}{\phi'(L)}\left(\frac{p^h(1-p^h)}{p^h - p^l}\right)$$

$$\frac{(1-\sigma^{FT})(p^h - p^l)}{\sigma^{FT} p^h(1-p^h)} = \frac{\phi'(H)}{\phi'(L)} - 1$$

$$\frac{p^h - \sigma^{FT} p^h - p^l + \sigma^{FT} p^l}{\sigma^{FT} p^h(1-p^h)} + 1 = \frac{\phi'(H)}{\phi'(L)}$$

Suppose now that $p^l = 0$. This means that it is unlikely for the realized terminal value to be high ($x = H$) given that the agent has taken the low-cost action. This is a more extreme assumption, but it is instructive as it ensures that I get equivalence between the two models.

$$\frac{p^h(1-\sigma^{FT})}{\sigma^{FT} p^h(1-p^h)} + 1 = \frac{\phi'(H)}{\phi'(L)}$$

$$\frac{1-\sigma^{FT}}{\sigma^{FT}(1-p^h)} + 1 = \frac{\phi'(H)}{\phi'(L)}$$

$$\frac{1-\sigma^{FT} + \sigma^{FT}(1-p^h)}{\sigma^{FT}(1-p^h)} = \frac{\phi'(H)}{\phi'(L)}$$

$$\frac{1-\sigma^{FT} p^h}{\sigma^{FT}(1-p^h)} = \frac{\phi'(H)}{\phi'(L)}$$

Looking at the equivalent expression in my model for where the agent who has taken the high-cost action has no incentive to trade in the market with "no spread," the probability of high effort $\hat{\sigma}$ must satisfy

$$\frac{\hat{\sigma}(p^l - p^h) + (1-p^l)}{\hat{\sigma}(p^l - p^h) - p^l}\left(\frac{p^h}{1-p^h}\right) = -\frac{U'(L)}{U'(H)}$$

Similarly, now suppose $p^l = 0$. I then have

$$\frac{-\hat{\sigma}p^h p^h + p^h}{-\hat{\sigma}p^h(1-p^h)} = -\frac{U'(L)}{U'(H)}$$

$$-\frac{p^h(1-\hat{\sigma}p^h)}{\hat{\sigma}p^h(1-p^h)}=-\frac{U'(L)}{U'(H)}$$

$$\frac{1-\hat{\sigma}p^h}{\hat{\sigma}(1-p^h)}=\frac{U'(L)}{U'(H)}$$

The expressions for σ^{FT} and $\hat{\sigma}$ are equivalent because the derivative of the inverse of the utility function (ϕ') equals the inverse of the derivative of the utility function (U'). ■

With $\phi'(\underline{U})=\phi'(L)$ and $p^l=0$, I have the case where I get equivalence between the Fudenberg and Tirole (1990) model and the "no spread" model, that is, $\sigma^{FT}=\hat{\sigma}$. As expected, however, the model in this chapter is always dominated by the Fudenberg and Tirole (1990) model and at best I can only achieve equivalence between the two models under extreme circumstances. Intuitively, allowing the agent the possibility to trade his compensation under "weak principals" that cannot offer to renegotiate with the agent due to diffused ownership lowers the agent's incentives to exert high effort. Only in the special case where the agent's utility function has the shape where the slope of $U(L)$ and $U(\underline{U})$ are the same and the probability of getting the high outcome given that the agent has exerted the low-cost action is close to zero, can I achieve equivalence between the two models. Hence, production is generally lower in my model where there are "weak principals" that offer the agent compensation in tradable securities and the agent has the opportunity to alter his compensation package by engaging in anonymous insider trading.

5.3 Market with Spread

As the market maker in the previous section makes a negative profit when he ignores the information asymmetry and sets prices such that $BID = ASK = \hat{\pi}$, he will not participate in that regime. In this section then, I allow the market maker to respond to the asymmetry of information introduced by the possibility of insider trading by setting prices such that there is a spread in the market, i.e. $ASK > BID$. The objective of the market maker in this game is simply to earn zero profit in expectation. The market maker sets prices in such a manner that as long as he earns (at best) zero expected profit he supports any Pareto improvement solution. As discussed in the previous section, I rely on the simplifying assumption that the market maker seeks to make an expected profit of zero on both the sells and the buys and not simply in aggregate. Since it is assumed that each informed trader trades only once and the prices are pre-set, they do not care how their trade affects the future price path.

The unconditional expected value of the firm that is supported when the agent in equilibrium exerts high effort with a probability σ^* is

$$\pi^* = \sigma^* \pi_h + (1-\sigma^*)\pi_l ,$$

I identify the equilibrium prices that exist in the market when the market maker responds to the adverse selection in the market by imposing a spread such that $ASK > BID$ so as to make a zero profit on both sides of the market and support a Pareto improvement outcome.

As discussed earlier, in the second-best contract with full commitment the agent exerts the high-cost effort with probability one, whereas in the Fudenberg and Tirole (1990) model as the agent randomizes between high and low effort, he performs the high-cost action with a probability less than one. The central theme of this chapter is to try to get the randomizing probability of high effort as close to "one" as possible and hence get as close to the production generated in the full commitment model without changing the contract that the agent is endowed with. Hence, even though multiple equilibria could exist in this regime with adverse selection, the particular one that I am interested in is the one that supports the highest probability of high effort (σ^*).

Another point to note is that the market maker can impose a different set of prices to obtain a spread in the market, but I choose to focus on the one below as it generates a Pareto improvement and allows the market maker to earn zero profits in expectation. The focus of this paper is not to characterize the optimal contract, rather with the particular spread imposed by the market maker I can rank my model of anonymous insider trading with a model with public trading and demonstrate that under some parameter values allowing the agent to engage in insider trading yields a Pareto improvement

Lemma 7 establishes the price in the sell side of the market that supports the highest probability of high effort while Lemma 8 provides the price in the ask-side of the market so that the market maker makes zero profit on the buy side.

<u>Lemma 7:</u> To sustain a^h in equilibrium with the highest probability possible, it must be that the market maker sets $BID = \hat{\pi}$.

<u>Proof:</u> To get σ^* as high as possible the market maker sets the bid price to be as high as possible without creating an incentive for the agent taking a^h to sell his shares while an agent taking a^l should have an incentive to sell all his shares. This is the case if $BID = \hat{\pi}$. If $BID > \hat{\pi}$ both, an agent taking a^h and a^l,will profit from selling and hence the game would have a unique equilibrium where the principal will only be able to induce a^l. ■

<u>Lemma 8:</u> The ask price $ASK = \pi^*$ set by the market maker is such that the market maker earns zero expected profit on the buy side of the market.

Proof: The market maker's expected profit is required to be zero for either type of insider trading. With $ASK \geq \hat{\pi}$ only insider selling occurs in the market, that is, there is no informed buying. The expected profit for the market maker from liquidity buyers who buy at the ask price is $L_B[ASK - \pi^*] = 0$ which in turn requires that the market maker chooses the ask price so that $ASK = \pi^*$. ■

The above two lemmas establish the equilibrium prices set by the market maker in both the sell and buy side of the market. I have derived the equilibrium prices such that the market maker at best makes zero profit. Proposition 3 establishes that the equilibrium conditions needed so that the market maker in expectation makes zero profit on both sells and buys leads to the result that $\sigma^* > \hat{\sigma}$.

Proposition 3: When the market maker imposes a spread in the market, such that $ASK > BID$ and prices are set so that $BID = \hat{\pi}$ and $ASK = \pi^*$, higher production is achieved than when the market maker imposes no spread. Also in this regime the market maker makes zero expected profit on both the sell and the buy side of the market.

Proof: In Lemma 8 above, I established that the market maker makes zero profit in the buy side of the market with adverse selection by setting $ASK = \pi^*$. To demonstrate that the market maker also makes zero profit on the sell side of the market, I need to analyze the expected profit of the market maker from selling to liquidity traders and to inside traders who sell because the bid price is above the expected value of the stock at the end of the game. The expected profit is given by the expression

$$L_S[\pi^* - BID] + \delta(1-\sigma^*)[\pi_L - BID].$$

In Lemma 5, I established that with no spread imposed in the market, the market maker makes a negative profit when $BID = ASK = \hat{\pi}$. In order for the market maker to make a zero profit on the sell side of the market, it must be that $\pi^* > \hat{\pi}$. Given that in equilibrium the expected value of π^* is given by $\pi^* = \sigma^* \pi_h + (1-\sigma^*)\pi_l$ and $\hat{\pi} = \hat{\sigma}\pi_h + (1-\hat{\sigma})\pi_l$, for $\pi^* > \hat{\pi}$, it must be that $\sigma^* > \hat{\sigma}$.

Since $[\pi_L - BID]$ is negative and $[\pi_H - \pi_L]$ is positive σ^* is positive.[6] ■

Proposition 3 shows that in equilibrium $\sigma^* > 0$ and that $\sigma^* > \hat{\sigma}$ under all conditions, so σ^* is closer to the standard full commitment second-best contract with moral hazard than $\hat{\sigma}$. As $\sigma^* > \hat{\sigma}$, if the market maker makes zero profit on both the sell and the buy side by imposing a spread in the market, the economy as a whole is better off as production increases.

The intuition behind the production efficiency gain result is that the agent who has exerted high effort has no incentive to trade in the market as long as $ASK \geq \hat{\pi}$ and $BID = \hat{\pi}$. On the other hand, the agent who has taken the low-cost action has an incentive to sell his shares at prevailing prices. Hence, the market maker knows that insider trading occurs only on the sell side of the market. Due to the fact that there is only inside selling, the market maker can set the ask price at the true conditional value of the firm. By imposing a large enough spread, the market maker can insure himself of the losses he will incur by buying from insiders. In order for the market maker to make zero profit on the sell price of the firm, the expected value of the firm π^* must be higher than that in the "no spread" regime. As a result of having to sustain the increased expected unconditional value π^* the incentives for taking the high-cost action are increased.

[6] $\hat{\sigma}$ can approach 0 in the extreme when $p^h \to 0$, whereas $\sigma^* > 0$ as $\delta > 0$, and $[\pi_L - BID] < 0$.

Hence, in equilibrium, the agent takes the high-cost action with a greater probability which results in an increase in production.

Another insight of this chapter is that the more noise traders that trade in a firm's shares, the tighter the bid-ask spread of the firm, which then reduces the disciplining force of the market maker against the agent taking the low-cost action. Hence, the results suggest that the more liquid a firm is the more potentially detrimental insider trading might be for that firm as the disciplining force of the market maker is lowered in these types of firms. Hence, regulation that prohibits insider trading could potentially adversely affect companies that are more liquid if employees are compensated with tradable securities.

It is true here that when the low-cost agent sells his shares the liquidity traders loose money on their trades. This is not an issue that is unique to this model, but is common to the literature. Holmstrom and Tirole (1993) in their paper also have a model where the "liquidity traders lose money when they must sell their shares."[7] But as I have demonstrated, allowing for insider trading under certain parameter values leads to a Pareto improvement due to the increased production and hence these gains can be reallocated by a redistribution method such as taxation, fees, etc. As the focus of this chapter is not on allocation issues, I do not explicitly design a redistribution mechanism, but as there is an increase in production with no adverse risk sharing, this efficiency gain can be redistributed to the liquidity traders (provided they are risk neutral) so that in equilibrium they are not worse off.

[7] p. 680.

5.3.2 Comparison of Fudenberg and Tirole (1990) and Spread Regime

As I have already established that in the model where there are "weak principals" and the agent anonymously trades his compensation on the market and the market-maker responds to this information asymmetry by imposing a bid-ask spread the probability of high effort is higher than the probability of high effort in a market with no bid-ask spread. That is, $\sigma^* > \hat{\sigma}$. Also, in the limiting case analyzed in Section 5.2.1, $\sigma^{FT} = \hat{\sigma}$. By continuity then $\sigma^* > \sigma^{FT}$ in cases where p^l is relatively close to zero and when $\phi'(\underline{U})$ is sufficiently close to $\phi'(L)$. In conclusion, for low enough value of p^l, it is better to rely on the market version of my model where there are "weak principals" and the agent anonymously trades his compensation on the market but the market maker imposes a spread in market prices. In this case, allowing the agent to engage in insider trading results in an increase in production that leads to a Pareto improvement where the economy as a whole is better off rather than allowing agents to engage only in public trading. Hence this chapter hints at a potential economic gain that derives from the tradability feature of the compensation package and can help explain the popularity of tradable securities being used as compensation vehicles.

Theoretically there is no way of assessing how large the region is where my model dominates that of Fudenberg and Tirole (1990) or as I have explained public trading. However, such parameter values do exist and hence it is unclear that regulation requiring managers to publicly disclose their insider trades always benefits the economy. If the region is potentially large then giving managers the right to engage in private anonymous trading could lead to a Pareto improvement.

6. Conclusion and Implications

The debate on insider trading has mainly focused on what constitutes appropriate regulation from a public policy standpoint. It is an issue that cannot be resolved easily as insider trading generates both positive and negative externalities, and hence the magnitude of these externalities must be known before a conclusion can be reached. This chapter attempts to contribute to this disclosure debate from a theoretical standpoint by looking at the positive externalities of compensating managers with tradable securities as they open the door for insider trading and allow employees to renegotiate their contract through trading in the market.

In this chapter, I do not attempt to evaluate the social consequences of insider trading instead, I show that by adding an additional source of information asymmetry through the mechanism of insider trading to a simple problem of renegotiation with moral hazard, under certain situations there are production efficiency gains without adverse risk sharing implications. Hence, under certain parameter values there are strict gains to anonymous private trading when there are atomistic shareholders for the owners of the firm to compensate managers with tradable securities compared to imposing regulation that always requires managers to publicly disclose their insider trades.

The model presented in this chapter has some direct implications for regulation on the disclosure of executive shareholdings and trading activities. The chapter shows that when there are "weak principals" who do not own or control a sufficiently large fraction of the firm to be able to renegotiate with the agent, and there exists adverse selection in the market, under certain conditions anonymity of trading leads to production efficiency gains and to an overall increase of wealth in the economy. Hence, I would argue that in these situations, welfare could be increased if regulation did not require companies to fully disclose executive shareholdings and trading activities as giving managers the freedom to change the risk potential of their contract through engaging in insider trading leads to greater production. If regulators in these situations imposed public disclosure of this private information it would potentially lead to lower production.

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Appendix A

Proof of Lemma 2: 1. To prove $dEU/d\delta^* > 0$ at $\delta^* = 0$

$$EU= p^h U[\delta^* H - (\delta^* - \psi)\hat{\pi} + B^*] + (1-p^h)U[\delta^* L - (\delta^* - \psi)\hat{\pi} + B^*$$

$$dEU/d\delta^* = p^h U'[\delta^* H - (\delta - \psi)\hat{\pi} + B^*][H - \hat{\pi}] + (1-p^h)U'[\delta^* L - (\delta - \psi)\hat{\pi} + B^*][L - \hat{\pi}]$$

$dEU/d\delta^*$ evaluated at $\delta^* = 0$ equals

$$p^h U'[\psi\hat{\pi} + B^*][H - \hat{\pi}] + (1-p^h)U'[\psi\hat{\pi} + B^*][L - \hat{\pi}]$$

$$= U'[\psi\hat{\pi} + B^*][p^h[H - \hat{\pi}] + (1-p^h)[L - \hat{\pi}]]$$

By assumption $U' > 0$

Need to prove $p^h(H - \hat{\pi}) + (1-p^h)(L - \hat{\pi})$ to be positive.

At $\hat{\sigma} = 0$ this expression equals

$$p^h[H - p^l H - (1-p^l)L] + (1-p^h)[L - p^l H - (1-p^l)L]$$

$$= p^h(1-p^l)(H - L) + (1-p^h)p^l(L - H)$$

By assumption $H > L$ which implies $H - L > 0$ and $L - H < 0$

Also, $p^h(1-p^l) > (1-p^h)p^l$ as we know $p^h > p^l$, hence the expression is positive.

2. To prove that $d^2EU/d^2\delta^* < 0$

$$EU= p^h U[\delta^* H - (\delta - \psi)\hat{\pi} + B^*] + (1-p^h)U[\delta^* L - (\delta - \psi)\hat{\pi} + B^*]$$

$$d^2EU/d^2\delta^* =$$

$$p^h U''[\delta^* H - (\delta - \psi)\hat{\pi} + B^*][H - \hat{\pi}]^2 + (1-p^h)U''[\delta^* L - (\delta - \psi)\hat{\pi} + B^*][L - \hat{\pi}]^2$$ By concavity of U we know that $U'' < 0$

Clearly, $[H - \hat{\pi}]^2$ and $[L - \hat{\pi}]^2$ are positive.

Hence, $d^2EU/d^2\delta^* < 0$. ■

Proof of Proposition 1: $\hat{\sigma}$ can be calculated by substituting the expression for $\hat{\pi}$ into the first-order condition derived earlier i.e.

$$\frac{(H - \hat{\pi})}{(L - \hat{\pi})}\frac{p^h}{1-p^h} = -\frac{U'[\delta^* L + B^*]}{U'[\delta^* H + B^*]}.$$

Accordingly, if in equilibrium, effort randomization occurs according to $\hat{\sigma}$, an agent taking a^h does not have an incentive to change his (risky) holdings of shares in the firm and hence at this price no trading occurs by this type of agent.

Performing the substitution now yields

$$\frac{H-[\hat{\sigma}[p^h H+(1-p^h)L]+(1-\hat{\sigma})[p^l H+(1-p^l)L]]}{L-[\hat{\sigma}[p^h H+(1-p^h)L]+(1-\hat{\sigma})[p^l H+(1-p^l)L]]}\frac{p^h}{1-p^h}=-\frac{U'[S*(L)]}{U'[S*(H)]}$$

$$\frac{H-\hat{\sigma}p^h H-\hat{\sigma}L+\hat{\sigma}p^h L-p^l H+\hat{\sigma}p^l H-L+\hat{\sigma}L+p^l L-\hat{\sigma}p^l L}{L-\hat{\sigma}p^h H-\hat{\sigma}L+\hat{\sigma}Lp^h-p^l H+\hat{\sigma}p^l H-L+\hat{\sigma}L+p^l L-\hat{\sigma}p^l L}\frac{p^h}{1-p^h}=-\frac{U'[S*(L)]}{U'[S*(H)]}$$

Rearranging the terms, the ratios equal

$$\frac{H(1-\hat{\sigma}p^h+\hat{\sigma}p^l-p^l)-L(-\hat{\sigma}p^h+1-p^l+\hat{\sigma}p^l)}{H(-\hat{\sigma}p^h+\hat{\sigma}p^l-p^l)-L(-\hat{\sigma}p^h-p^l-\hat{\sigma}p^l)}\frac{p^h}{1-p^h}=-\frac{U'[S*(L)]}{U'[S*(H)]}$$

$$\frac{(H-L)(1-\hat{\sigma}p^h+\hat{\sigma}p^l-p^l)}{(H-L)(\hat{\sigma}p^l-\hat{\sigma}p^h-p^l)}\frac{p^h}{1-p^h}=-\frac{U'[S*(L)]}{U'[S*(H)]}$$

$$\frac{\hat{\sigma}(p^l-p^h)+(1-p^l)}{\hat{\sigma}(p^l-p^h)-p^l}\frac{p^h}{1-p^h}=-\frac{U'[S*(L)]}{U'[S*(H)]}. \qquad \blacksquare$$

Chapter 4: The Economic Consequences of Private Information Acquisition in a Model where Employees are Compensated with Tradable Securities

Abstract: Tradable securities continue to be a popular compensation vehicle, yet there is tremendous regulatory discussion on the need to prevent employees from being able to gain from trading such securities by using their private information. This paper attempts to analytically capture the SEC notion of insider trading where a manager has material non-public information prior to trading his equity claims. To model this issue of interest I use a principal-agent framework where the concept of insider trading is captured by contract renegotiation. I identify three information structures and compare the production in the economy to a scenario where private information acquisition is prohibited. Contrary to general intuition, I show that situations may arise where private information collection and insider trading by employees results in higher production in the economy and can be socially desirable compared to a situation where the agent is only allowed to engage in public trading. I demonstrate that as long as the information collected by the agent has an impact on the expected liquidation value, the principal would prefer that the agent collects this private information as it leads to an increase in the production of the firm.

1. Introduction

In this chapter I build a theory about the impact of private information *acquisition* by employees on insider trading in a model where such employees are compensated with tradable securities. I assume that if employees could trade their compensation packages, they would take the opportunity and hence I examine the economic consequences on production of allowing employees to collect private information relevant to their trades. To analyze this problem, I use a principal-agent framework and rely on the notion of renegotiation to explore the concept of insider trading. I identify three information structures that have differential impacts on the agent's effort exertion and production in the total economy. These information structures have different properties and can be related to accounting information in their characteristics. This chapter contributes to the literature on renegotiation with private information, insider trading and compensation design.

Although the potential for insider trading appears to be of significant concern to investors and regulators alike, it is an empirical fact that executives receive large fractions of their compensation in the form of tradable securities. Any contract based on tradable securities can in principle always be replicated with non-tradable securities that would give the employer tighter control on the incentives and trading activities of the employee. Indeed, it seems paradoxical to compensate employees with tradable securities only to impose restrictions that prohibit them from taking advantage of the tradability feature of their compensation packages.

The Securities and Exchange Commission (SEC) maintains that "the detection and prosecution of insider trading violations" is "one of its enforcement priorities." Rule 10(b) 5-1 of the SEC defines insider trading as when a "person trades on the basis of material nonpublic information that he is aware of when making the purchase or sale."[8] According to the definition provided by the SEC it is important that the trader acquires private information *prior* to making his trading decision in order for the trade to fit the SEC's notion of insider trading. The model I develop captures the SEC's notion of insider trading by allowing the agent to collect private information that is relevant to the liquidation value of the firm prior to determining his trading strategy.

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[8] Emphasis is added by the SEC, for more details look at http://www.sec.gov/answers/insider.htm

The private information that I explore here is a private signal that gives the agent a better estimation of the liquidation value of the firm which he collects prior to trading a portion of his compensation on the market. Some examples of private information that the model captures are information that managers may acquire on competitors, on the success rate of future projects, on pending patents, and/or on future mergers and acquisitions. It is realistic to assume that since the manager has closer contact with the firm on a day-to-day basis, he can acquire private information that allows him to have a more accurate estimation of the liquidation value of the firm than the market.

I do realize that the type of information I attempt to capture in this model is hard to prevent the agent from acquiring since it is information that comes from the usual running of the firm. It is not likely for the agent to avoid having real private information; however, I demonstrate that for certain information structures having the agent gather such private information generates a Pareto improvement compared to a situation where the agent is only allowed to publicly trade. What is crucial for the results to hold in this model is that the information is private and has not yet been impounded into the market price of the firm; hence allowing the manager to extract the potential gains from trading on his private information acquisition.

In this chapter I attempt to model the situation that is more descriptive of publicly traded companies, that is, that of diffused ownership, where the firm is owned by several atomistic shareholders who are residual claimants of the firm. As each "principal" only owns a claim to the residual value of the firm, it is natural to assume that each "principal" does not own or control a sufficiently large fraction of the firm himself to be able to offer to renegotiate with the agent. I term this situation of diffused ownership as having "weak principals." Hence in the model that I present the only option for the agent to "renegotiate" the contract that he is originally offered is to trade his compensation with the market. That is, the agent can reduce his risk-exposure only by selling at prevailing (equilibrium) market prices some or all of the tradable securities with which he was initially endowed.

To analyze the problem of private information collection in a model with tradable securities I use a principal-agent framework and rely on previous research on renegotiation to model insider trading. In particular, I utilize a model closely related to that of Fudenberg and Tirole (1990) where they allow the principal to renegotiate with the agent and show that due to renegotiation the principal cannot induce high effort as a pure non-degenerate strategy. I also use Chapter 3 as a benchmark where possible since the results derived in that model show the impact on effort and production when an employee is compensated with tradable securities and can engage in insider trading but does not have access to any additional private information apart from his effort choice. The main result of that chapter shows that by allowing the agent to trade the securities in his compensation on the market results in the agent taking the high-cost action with a higher probability than in a scenario where he is not permitted to engage in insider trading and hence generates a Pareto improvement. This chapter extends the model in Chapter 3 in a manner consistent with the SEC notion of insider trading by allowing the agent to acquire additional private information that is correlated with the liquidation value. This extension enables me to highlight the desirable properties of private information to add to the disclosure regulation debate.

To ascertain the potential impact of private information collection by the agent, I identify three possible information structures that capture different properties of accounting information. Intuitively, one might expect that if the manager can acquire a private signal relevant to the liquidation value of the firm, he would engage in more aggressive insider trading which would then result in the manager trading with a higher probability and subsequently lower production than if he was restricted from gathering such private information. In the first information structure I identify, information acquisition by the agent has no impact on his trading behavior. The information collected by the agent in this structure has no impact on valuation, but can be used for internal reporting. The properties of the second information structure are such that private information acquisition has an impact only on the expected liquidation value of the firm and serves as a complete substitute for effort randomization and hence the agent exerts high effort with probability one. In the third information structure, the agent trades on both his action choice and private signal. The trading in this case is also beneficial as information collection acts as a partial substitute for effort randomization and hence generates a Pareto improvement compared to the situation where the agent can only engage in public trading. I also explore the results in the case where it is costly for the agent to gather private information.

This chapter adds further theoretical insight to the empirical phenomena of employees being compensated with tradable securities. More formally, this chapter helps in understanding the impact of private information acquisition by the agent in a renegotiation setting. It follows the spirit of other papers that highlight the tradeoffs of mandatory disclosure by showing that restricting the gathering of private information by managers who are compensated with tradable securities may result in losses in the overall economy by lowering production. It also highlights that insider trading based on certain types of information might be beneficial. This chapter provides theoretical support to the empirical phenomena of using tradable securities as compensation vehicles by showing the benefits that accrue to the principal through increased production. Hence, it adds nuance to the debate on regulation and advises regulators to be cautious when completely prohibiting insider trading as it may have unintended negative economic consequences.

The remainder of the chapter is organized as follows. The next section gives a brief literature review and Section 3 I explain the results of Chapter 3 which serves as a benchmark for this chapter and the main differences between that chapter and this one. Section 4 gives the model set-up that follows through in the three information structures that are identified in Section 5. In Section 6, I relate the information structures to types of accounting information. Section 7 investigates the case where information collection is costly and Section 8 concludes the chapter and discusses some implications for accounting regulation.

2. Literature Review

In a closely related paper, Gigler and Hemmer (2004) examine different properties of information in an agency model that allows for contract renegotiation. They analyze when it is advantageous to improve corporate transparency by allowing shareholders direct access to corporate information and when it is preferable to rely on a reporting system in which shareholders only gain access to information that managers choose to disclose. In full commitment models transparency is always desirable as making the agent's private information public leads to more efficient contracting. In their paper they show that in a renegotiation setting commitment not to produce information can be valuable. The commitment not to produce information in their model serves as a substitute for the assumed inability to commit not to use the information in the renegotiation stage.

Renegotiation in their model gives less scope for transparency of the agent's private information to have value. The very existence of the agent's information is necessary to prevent renegotiation from leading to a complete collapse of the incentives for the agent to take productive actions. It is not always the case that less transparency results in more efficient renegotiation-proof contracting. Rather, the optimal channel for disclosure depends on how much information about the agent's actions the signal conveys. They depart from Fudenberg and Tirole (1990) by introducing the additional assumption that the act of exerting effort produces information about future consequences of those efforts beyond knowledge of simply how much effort was supplied. In this model actions produce a separate contemporaneous signal about future outcome. As a result of introducing this learning-by-doing, renegotiation-proof contracts will be able to sustain a non-zero amount of effort without inducing the agent to randomize over effort choices.

In this chapter, I look at when it is advantageous for the shareholders to allow the manager to collect private information that is correlated with the liquidation value of the firm in an agency model that allows contract renegotiation. I examine different information systems and their impact on effort and production to determine under which situations shareholders would allow private information acquisition. However, the focus of my chapter is different from theirs in that I primarily examine the consequences of compensating employees with tradable securities where it is natural to assume that employees can trade their compensation with the market.

This chapter is also closely related to the paper by Dye (1984). Since I have already outlined the model and main results of the Dye (1984) paper earlier, in this section I will highlight the connections between my model where the agent is permitted to collect private information prior to trading and his paper. This information acquisition combined with the agent being able to engage in anonymous insider trading generates a Pareto improvement through an increase in production compared to a situation where the agent is prohibited from collecting private information but compensated with tradable securities and allowed to engage in anonymous trading. The Dye (1984) model differs from this chapter in a significant manner. In his model the agent trades reveal his private information, while in this model it is essential that the private information of the agent is not revealed through his trading for him to be able to gain from his private information. In this model it is crucial that when the agent engages in insider trading it is anonymous to obtain the Pareto improvement through an increase in production.

The next section provides the rationale for Fudenberg and Tirole (1990) as a benchmark for examining the case for public trading. I then explain in detail the model set-up for Chapter 3 which serves as a benchmark for this chapter as that model examines the impact on effort and production without private information acquisition by the agent in a situation where the employee is compensated with tradable securities and permitted to "renegotiate" his compensation by engaging in anonymous trading with the market.

3.Background Set-up

3.2 Model with No Private Information Collection

In Chapter 3 I turn towards the renegotiation literature as a framework for understanding the effect of an employee changing his contract through insider trading. In the model in this chapter, the principal is uninformed not just about the agent's action choice, but also the private information he has collected and his trading strategy. Chapter 3 however sets up a model to analyze the impact on production when employees are compensated with tradable securities and allowed to engage in anonymous insider trading with no private information acquisition on the agent's part. A key contribution of that chapter that I adopt in this model is the analytic construction of insider trading. In the remainder of the chapter, I attempt to benchmark the production that I get in my model against the production generated in the Fudenberg and Tirole (1990) model and the one generated in the REM[9]. Again, the focus of this model is not to characterize the optimal arrangement between the principal and the agent but to suggest a Pareto improvement solution beyond that achieved in the REM model.

The main result of Chapter 3 is that for certain parameter values allowing the employee to anonymously trade based on the private information he has, that is, his effort choice, yields higher production than situations where only public trading is permitted. The intuition for this result comes from the fact that to respond to the information asymmetry in the market caused by the agent trading on his private information, the market maker imposes a spread that reduces the profit the agent can make trading on his private information. In that situation, the market maker acts as a disciplining force and

[9] REM signifies randomization of effort model (Chapter 3) and IAM signifies information acquisition model (Chapter 4).

sets prices in such a manner that the agent is forced to take the high-cost action with a higher probability than if insider trading was prohibited. Hence, the incentive for the agent to take the low-cost action is reduced. This leads to an increase in production and hence a Pareto improvement is obtained. The probability of the agent taking the high cost action when the market-maker does not impose a spread in that model is denoted as $\hat{\sigma}_1$.[10] When the market-maker imposes a bid-ask spread in the market, the spread serves as a disciplining force and the probability of the agent taking the high-cost action increases to σ_1^*. I will refer to the Chapter 3 model throughout this chapter as the randomization of effort model or REM for short.

The agent in the REM trades his compensation based only on the action choice he has made. The REM model is set-up so that the trading strategy and action choice of the agent have a one-to-one correspondence such that if the agent has taken the high-cost action in equilibrium he holds on to his shares until the liquidation date. On the other hand if he has taken the low-cost action his equilibrium trading strategy is to sell his shares and receive full insurance. The agent's trading choice in the REM model is such that it is a sequentially rational response to the action choice he has already made. However, the action choice and trading points in the time-line could be interchanged without affecting the results. In other words, the results would be unchanged if the agent traded first and then took the equilibrium action choice that was a best response to his trading strategy. A strength of the REM model is that the structure is fluid, but at the same time it could be argued that this fluidity between the trading and action choice strategies may not be completely consistent with the way the SEC defines insider trading

[10] A subscript of 1 indicates variables from Chapter 3 (REM model) and subscripts of 2 indicate variables in this chapter (IAM model).

as discussed in the introduction of this chapter as it is not necessary in the REM that the agent has any material nonpublic information (i.e. has chosen a particular action) before engaging in insider trading.

In this chapter I attempt to capture the notion of insider trading in a manner that is perhaps more consistent with the definition of the SEC as discussed in the introduction. In this chapter the model is constructed such that the agent secures private information prior to his trading. Here, the private information that the agent secures affects his subsequent trading strategy, hence in this model, it is important that the agent secures private information before trading. In this model then, the trading and action choice strategies of the agent cannot be interchanged, here trading occurs sequentially after the action choice. I will refer to this model throughout this chapter as the information acquisition model or IAM for short. Hence in the IAM model, the agent relies on two pieces of private information – his private signal and his effort choice – prior to engaging in insider trading while in the REM the agent only relied on one piece of private information – his effort choice.

In this model, the agent collects a private signal that alters his beliefs on the estimation value of the firm in addition to his effort choice. As the agent collects private information that then influences his trading strategy, this model seems more consistent with the SEC definition of insider trading as the agent has "material nonpublic information" before engaging in insider trading. In the IAM similar to the REM, the only opportunity the agent has to change the contract that he was initially endowed with is to trade the shares in his original compensation on the market.

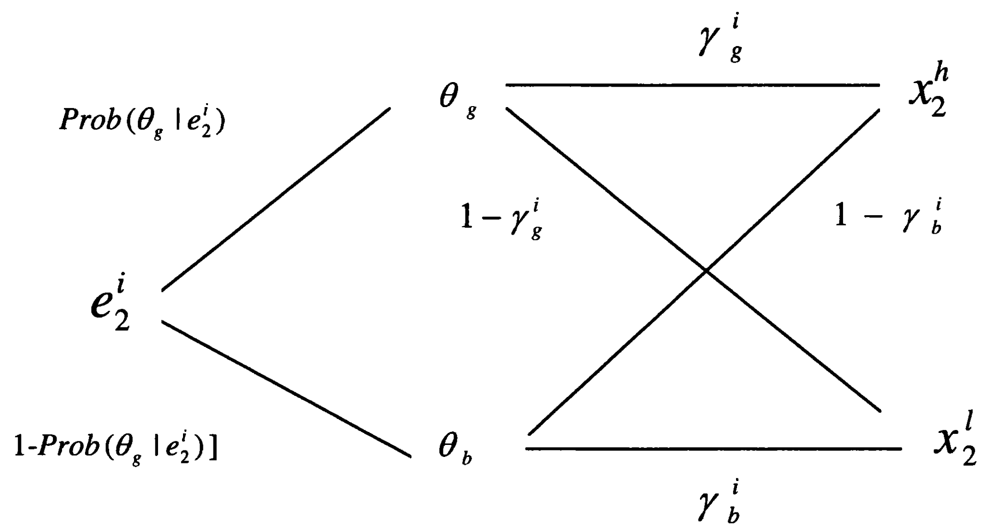
4. Timeline and Structure of the Model

The sequence of events in this model can be summarized by the following time-line.

$t=0$	$t=1$	$t=2$	$t=3$	$t=4$
The Principal and the Agent agree to a contract	Agent chooses e_2^i where $i \in \{l,h\}$	Agent observes θ_j where $j \in \{g,b\}$	Agent "renegotiates" his contract by trading his claim on the firm in the market	Terminal value of the firm x_2^i where $i \in \{l,h\}$ is observed, the agent's portfolio holdings are observed, he is compensated and the firm is liquidated

At $t=0$ the principal and agent agree on an incentive contract (δ_2, B_2) where δ_2 is the number of shares awarded to him that entitles him to a fraction δ_2 of the liquidation value of the firm and $B \in \{B_2^*, B_2^0\}$ is the cash component that the agent receives. With only two potential levels of output, this assumption of differential cash bonuses is without loss of generality. At $t=1$ the agent chooses an unobservable action e_2^i where $i \in \{l,h\}$ that effects the liquidation value of the firm as well as the agent's private signal θ_j where $j \in \{g,b\}$.

At $t=2$ the agent observes a private signal θ_j where $j \in \{g,b\}$. The signal is not the true value of the firm but is correlated with the liquidation value of the firm x_2^i where $i \in \{l,h\}$ and thus gives the agent a better estimate of the terminal value of the firm and hence can potentially alter the agent's trading behavior. The agent only privately observes θ_j but does not observe the true liquidation value x_2^i of the firm. The probability structure between the agent's private information and the liquidation value is given by the parameter γ_j^i where $i \in \{l,h\}$ and $j \in \{g,b\}$. The effect of the agent's action e_2^i where $i \in \{l,h\}$ on earnings can be given by the following probability structure:



At $t = 3$ the agent "renegotiates" his contract by trading ψ shares in the market at the market clearing price. His trading strategy is potentially affected by both his action choice and his private signal unlike the REM model where he only relied on his action choice to determine his trading strategy. Similar to the REM model, it is also true here that the liquidity traders are "ripped off" when trading with the insider. In the IAM I show that by allowing the agent to collect private information relevant to his trading decision leads to a Pareto improvement due to increased production. The gains in production can be reallocated by a redistribution method such as taxation, fees, etc. to the liquidity traders. As the focus of this chapter is not on allocation issues, I do not explicitly design a redistribution mechanism, but as there is an increase in production with no adverse risk sharing, this efficiency gain can be redistributed to the liquidity traders (provided they are risk neutral) so that in equilibrium they are not worse off.

Finally, at $t = 4$ the terminal value of the firm x_2^i where $i \in \{l, h\}$ is observed by the principal. Also at this time, the manager's portfolio holdings are observed and the principal pays him his cash bonus accordingly. In equilibrium the terminal cash payment from the principal to the agent is B_2^* for an agent who holds δ_2^* shares in the firm and an agent who holds no shares in the firm receives B_2^0. This assumption is similar to the one in Chapter 3 and is consistent with the reasoning that the market in the firm's shares closes before compensation is paid to the agent, which is consistent with insider trading reporting requirements specified in section 16(b) of the Securities and Exchange Act of 1934, and hence the trading of the manager are revealed to the principal. It is similar to the assumption made in the paper by Dye (1984). Similar to the REM model, this assumption is without loss of generality as it does not affect the agent's effort and trading choices and is made only so that in equilibrium the agent receives his reservation utility.

This practice of conditioning the agent's bonus not just to firm performance but also to the agent's portfolio holdings is common in practice. For example, in a New York Times article, the author Leslie Wayne discusses that one way that Campbell Soup Company has responded to shareholder activism is by tying the executives' compensation to the company's performance and requiring that top officials have a certain portion of their net worth tied in Campbell stock.[11] This is one example of many companies that pay bonus compensation conditional on their employees' portfolio holdings. Hence, having $B^* \neq B^0$ in the model is one way of capturing anecdotal evidence through the analytical structure. Finally, the firm is liquidated.

In this chapter I make the assumption that the agent is not permitted to short sell, which means that δ_2^* is required to be non-negative. This assumption is consistent with the SEC's uptick rule which maintains that insiders are prohibited from short-selling their claim on the firm. I also make the assumption throughout Section 5 that the agent can initially collect perfect information costlessly. I will later on discuss the implications of introducing cost into the information acquisition function.

5. Analysis

5.1 Information Acquisition is Trade Neutral

It is immediately clear that it is possible to have a scenario where the agent can acquire a private signal but, it has no impact on his trading strategy compared to a scenario where he does not collect private information, which is the REM. This is true when the information collected by the agent does not have an impact on the estimation value of the firm and hence does not alter his trading behavior compared to the REM. To formally verify this, assume that the agent can costlessly acquire a private signal θ_j^i, where $i \in \{l,h\}$ and $j \in \{g,b\}$, that does not change the agent's beliefs about the terminal value of the firm. Formally, $\gamma_g^i = 1-\gamma_b^i$ this means that the probability of x_2^h being

[11] Taken from the article Campbell Revises Executives' Rules, by Leslie Wayne published in New York Times on Tuesday October 12, 1993.

realized conditional on observing the good signal θ_g or the bad signal θ_b is equal. Hence, the only information relevant to the agent's trade is his effort choice. This case is interesting because even though it does not change the probability of effort randomization by the agent compared to that in the REM, the private information acquired by the agent could be useful to the principal.

In standard communication games, when the agent has perfect private information, the principal generally benefits (weakly) from this information acquisition by appealing to the revelation principle. In renegotiation games, the benefits of perfect private information acquisition are not always so clear-cut. It may not always be possible with renegotiation to exploit the revelation principle as binding the truth telling constraint might be too costly for the principal. Therefore the principal may not be able to extract rents from the agent's private information in such models.

As the information acquisition in this case does not change the agent's trading strategy from the REM, the probability of the agent exerting the high-cost action in this scenario is the same as the REM which is equal to σ_1^*. In the REM model the only private information the agent has prior to trading is his effort choice. In this case, as the information collection does not impact the agent's trading behavior or the production in the overall economy compared to the REM there is no consequence for the agent to acquire this information. However, there exist information structures for which private information collection by the agent can impact production in the economy. I identify two particular information structures – one, where information acquisition by the agent acts as a complete substitute for effort randomization and the other, where it acts as a partial substitute. In both cases the economy as a whole benefits from the increased production from the agent collecting private information. These information structures are discussed below in turn.

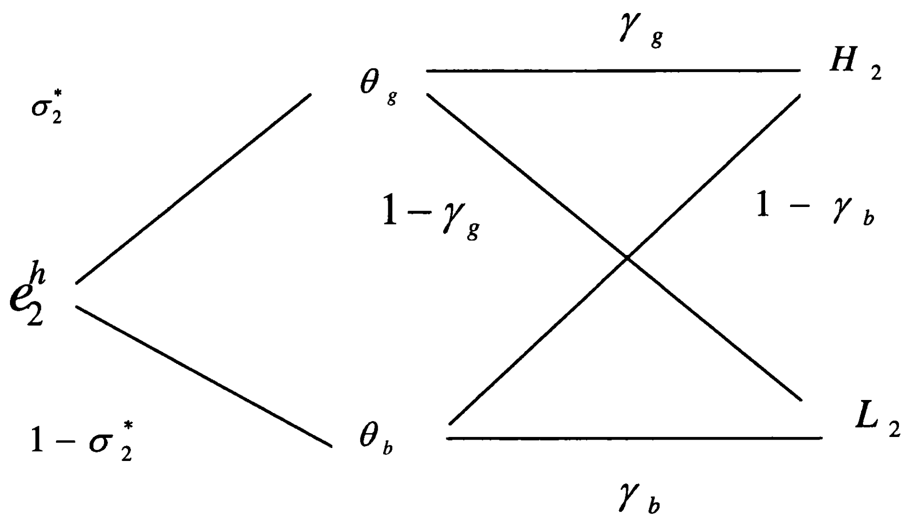
5.2 Information Acquisition Is a Complete Substitute for Effort Randomization

In the REM model with the possibility of renegotiation due to insider trading, the agent randomizes his effort with a probability equal to σ_1^* when the market maker imposes a spread in the market. In this section, I show that it is possible to substitute the randomization of effort result with an information system that yields the same probability of trading but has the agent taking the high-cost action with a probability equal to one. In this section, the agent engages in insider trading with the same probability as the REM. The only difference being that trading here is set up conditional on the agent's private signal and in equilibrium the agent is incentivized to take the high-cost action with probability one. Hence, in this scenario, the standard second best effort and production are achieved. In the REM the agent randomizes between the high-cost and the low-cost action with probability $\sigma_1^* < 1$ and hence, production is less than second best. The information structure that I identify in this section of IAM model achieves a Pareto improvement compared to the REM model as production is increased without changing the contract awarded to the agent.

Suppose that the expected value of the shares conditional on θ_j is the same regardless of whether the agent has exerted e_2^h or e_2^l. This means that $\gamma_g^h = \gamma_g^l = \gamma_g$ and $\gamma_b^h = \gamma_b^l = \gamma_b$. Hence, the agent holds his shares till the liquidation date if he has seen θ_g and sells if he has seen θ_b. The agent then in this information structure trades based only on one signal – the private signal he receives and effort is irrelevant in determining his trading strategy. Hence in this information structure, the predictive ability of θ_j does not depend on the agent's effort choice.

Assume further that I denote the $Prob(\theta_g \mid e_2^h) = \sigma_2^*$. What follows is that the agent in this scenario trades his shares in equilibrium with probability $1-\sigma_2^*$ as he trades only when he observes θ_b. In the REM, the agent in equilibrium takes the high-cost action with probability σ_1^* and hence trades his shares with probability $1-\sigma_1^*$. By denoting the $Prob(\theta_g \mid e_2^h) = \sigma_2^*$ in the IAM, the agent trades with the same probability in the IAM as in the REM, that is $1-\sigma_1^* = 1-\sigma_2^*$, but as I will show there is no effort randomization in the IAM resulting in production in the IAM being higher than the REM.

The diagram below represents the information structure in this scenario. The agent receives a private signal θ_j that is correlated with the true outcome of the firm through the conditional probability γ_j^i, where $i \in \{l,h\}$ and $j \in \{g,b\}$. This structure can be denoted by the following diagram



To guarantee equivalence between the two models, however, I also need to set the value of the output x_2^i in the IAM equal to the value of output in the REM, so that the underlying production parameters in both settings are the same and hence, when I compare the two settings I am holding constant the production problem. That is, in order to compare the production between the IAM and the REM, the production process should be the same in both models. To achieve this I set the output in both models as equal.

Given my assumptions on the information structure, when the agent takes e_2^h the expected liquidation value in the IAM can be given by the following equation.

$$\sigma_2^*(\gamma_g H + (1-\gamma_g)L) + (1-\sigma_2^*)((1-\gamma_b)H + \gamma_b L)$$

Going back to the REM, the expected liquidation value when the agent takes the high-cost action can be given by the following expression.

$$p_1^h H + (1-p_1^h)L$$

To ensure that the production problem as well as the contract given to the agent is the same in the REM as in the IAM I set the two expressions for the expected liquidation value as an equality.

$$\sigma_2^*(\gamma_g H + (1-\gamma_g)L) + (1-\sigma_2^*)((1-\gamma_b)H + \gamma_b L) = p_1^h H + (1-p_1^h)L$$

$$\sigma_2^*\gamma_g H + \sigma_2^* L - \sigma_2^*\gamma_g L + H - \sigma_2^* H - \gamma_b H + \sigma_2^*\gamma_b H + \gamma_b L - \sigma_2^*\gamma_b L = p_1^h H - p_1^h L + L$$
$$\sigma_2^*\gamma_g [H-L] - \sigma_2^*[H-L] - \gamma_b[H-L] + \sigma_2^*\gamma_b[H-L] = p_1^h[H-L] + 1[H-L]$$

Dividing through by $H-L$ gives

$$\sigma_2^*\gamma_g - \sigma_2^* - \gamma_b + \sigma_2^*\gamma_b = p_1^h + 1$$

Which can be rearranged to yield

$$\sigma_2^* = \frac{p_1^h + \gamma_b - 1}{\gamma_g + \gamma_b - 1} \tag{A}$$

Similarly, the same system of equations can be solved for when the agent takes the low-cost action e_2^l, where I denote the *Prob* $(\theta_g \mid e_2^l) = \tilde{\sigma}_2$.

$$\tilde{\sigma}_2 = \frac{p_1^l + \gamma_b - 1}{\gamma_g + \gamma_b - 1} \tag{B}$$

Hence, if the parameter values are such that the two conditions (A) and (B) hold for γ_g and γ_b, then the agent has exactly the same level of private information in the IAM as in the REM. Since by assumption, $\gamma_g^h = \gamma_g^l = \gamma_g$, $\gamma_b^h = \gamma_b^l = \gamma_b$ and $p_1^h > p_1^l$, it follows from (A) and (B) that $\sigma_2^* > \tilde{\sigma}_2$.

Another way of equating the agent's private information in the IAM and REM models is to focus on just the probabilities of the expected liquidation values in both the models. Hence, I can rewrite the probability of the expected liquidation value in the REM in terms of the conditional probabilities in the IAM. Since the production in both models is the same, that is $x_1 = x_2$ I can denote the expectation of the liquidation value of $x = H_1$ in the REM by the conditional probabilities of the expected liquidation value $x = H_2$ in the IAM as $p_1^h = \sigma_2^* \gamma_g + (1-\sigma_2^*)(1-\gamma_b)$. Similarly, the expected liquidation value of $x = L_1$ in the REM can be denoted by the conditional probabilities for $x = L_2$ in the IAM as $p_1^l = \tilde{\sigma}_2 \gamma_g + (1-\tilde{\sigma}_2)(1-\gamma_b)$.

It is clear that under the conditions above, the underlying production problem is the same under this information structure in both the IAM and the REM. Lemma 1 establishes the necessary condition for the agent who has taken the high-cost action and seen θ_g in the IAM not to have an incentive to trade his contract with the market through the mechanism of (unobservable) insider trading. Once the necessary condition is established, I then characterize equilibrium prices in this setting. Following that, I show that in equilibrium the renegotiation proof contract for the agent who has taken the high-cost action is such that he trades with a probability $(1-\sigma_2^*)$, that is, equal to the probability with which the he observes θ_b.

<u>Lemma 1:</u> A necessary condition for it to be optimal for an agent who has taken e_2^h not to have an incentive to trade when he has seen θ_g is that the price $\hat{\pi}_2$ satisfies the condition

$$\frac{(H-\hat{\pi}_2)}{(L-\hat{\pi}_2)} \frac{\gamma_g}{1-\gamma_g} \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

<u>Proof:</u> Suppose the agent who has chosen e_2^h effort and seen θ_g trades, his expected utility can be given by

$$EU = \gamma_g U[\delta_2^* H + B_2^* + \psi(H-\hat{\pi}_2)] + (1-\gamma_g) U[\delta_2^* L + B_2^* + \psi(L-\hat{\pi}_2)]$$

In the above equation for the expected utility (EU), ψ takes on a positive value if the agent purchases additional shares on the market and correspondingly the value of ψ is negative if the agent sells shares from the initial contract that the principal has given him. One point to note is that the agent is prohibited from engaging in short selling, which means that δ_2^* is required to be non-negative.

For the lemma to hold, it must be that the agent's expected utility is at a maximum when he does not trade his shares in the market, that is $\psi = 0$. Formally, this can be expressed by the first-order condition in ψ being greater than or equal to zero when evaluated at $\psi = 0$.

$$\left.\frac{\partial EU}{\partial \psi}\right|_{\psi=0} = \gamma_g U'[\delta_2^* H + B_2^*][H - \hat{\pi}_2] + (1-\gamma_g) U'[\delta_2^* L + B_2^*][L - \hat{\pi}_2] \geq 0$$

Rearranging yields

$$\frac{(H-\hat{\pi}_2)}{(L-\hat{\pi}_2)} \frac{\gamma_g}{1-\gamma_g} \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

■

Lemma 1 establishes the necessary condition for the agent who has taken the high-cost action and seen θ_g not to have an incentive to trade. The above (weak) inequality would have to hold exactly as an equality if the market maker would set only one price in equilibrium. The necessary condition can also be satisfied with two prices (setting a spread), as long as they are set such that the low price (bid-price) is set such that the condition is satisfied as "=" and the high price (ask-price) is set such that the condition is satisfied as "$\geq$" inequality. Due to the spread set by the market maker, the condition above ensures that the agent will hold exactly δ_2^* shares in equilibrium. Lemma 2 defines the equilibrium price.

Lemma 2: Suppose the agent has taken e_2^h in equilibrium and $\hat{\pi}_2$ satisfies the necessary condition in Lemma 1, then $\hat{\pi}_2$ can be given by the following expression

$$\hat{\pi}_2 = \sigma_2^*[\gamma_g H + (1-\gamma_g)L] + (1-\sigma_2^*)[(1-\gamma_b)H + \gamma_b L]$$

Proof: The expected value of the firm is given by the market maker's rational expectation of the value of the firm given that in equilibrium the agent exerts e_2^h and observes θ_g with a probability σ_2^*. ■

As discussed above, the market maker can satisfy the necessary condition in Lemma 1 either by imposing one price or a spread in the market. If the market maker imposes a spread, then the bid price is set at $\hat{\pi}_2$ which ensures that the agent who has taken e_2^h and observed θ_g does not have an incentive to sell his shares in equilibrium (Lemma 1). In addition, if the ask price is set strictly greater than the bid then the agent does not have an incentive to buy additional shares in the market. This is because the ask price is such that it is set above the expected value of the firm. Hence, in equilibrium the agent has no incentive to change the contract portfolio that he was initially endowed with. Proposition 1 makes formal that trade in this particular information structure depends only on the agent's private information and not on his effort choice.

Proposition 1: Trade by the agent in this regime depends only on the agent's private signal θ_i where $i \in \{g, b\}$.

Proof: Refer to the Appendix B for the proof. ■

Having analyzed the agent's actions when he has taken e_2^h and observes θ_g, below I establish the necessary condition for the agent who has taken e_2^h and observes θ_b to strictly prefer selling his shares to holding them. For this to be true it must be that B_2^0, that is, the agent's cash bonus given that he sells the δ_2^* that were given to him by the principal in his original contract, is constructed such that the individual rationality constraint binds for this type.

In order for it to hold in equilibrium that the agent who has taken e_2^h strictly prefers selling his shares to holding them if he has observed θ_b it must be that his utility from selling is greater than or equal to his utility from holding on to his shares. This can be formally denoted by

$$(1-\gamma_b)U(\delta_2^* H + B_2^*) + \gamma_b)U(\delta_2^* L + B_2^*) \leq U(\delta_2^* \hat{\pi}_2 + B_2^0) \qquad \text{(C)}$$

The LHS of equation (C) is the expected utility of the agent when he holds on to his shares, and the RHS is the agent's expected utility when he sells his shares. By construction $\hat{\pi}_2$ is a linear combination of the expected value of the firm when the agent has taken the high-cost action and seen the good signal and the expected value of the firm when the agent has taken the high-cost action and seen the poor signal. As the expected value of the firm is higher when the agent has taken the high cost action than the low-cost action, the LHS < RHS of equation (C).

The sufficient condition above also ensures that if the agent has observed θ_b he prefers selling all his shares rather than a fraction of his shares. The price at which the agent sells his shares is formed by the market maker's rational expectation of the value of the firm when the agent has taken the high-cost action. This expected price will be higher than the expected value of the firm when the agent has observed the bad signal, hence the agent will prefer selling all his shares and receiving full insurance rather than just a fraction of them when he has taken observed the bad signal as he is assumed to be risk-averse.

Proposition 1 establishes that trading under this information system depends only on the agent's private signal and not on his effort choice in such a manner that in equilibrium the agent takes the high-cost action and holds on to his shares if he has seen the good signal and sells otherwise. Lemma 3 shows that the contract that the agent receives in equilibrium under the information structure identified in the IAM is equal to the contract that the agent receives in equilibrium in the REM, that is, the agent's utility under both models is the same, which then allows me to focus the comparison on the production in the two models.

Lemma 3: $\dfrac{U'[\delta_1^* L + B_1^*]}{U'[\delta_1^* H + B_1^*]} = \dfrac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$

Proof: In the REM model the individual rationality constraint can be given by

$$\sigma_1^*[p_1^h U(\delta_1^* H + B_1^*) + (1-p_1^h)U(\delta_1^* L + B_1^*) - C] + (1-\sigma_1^*)[p_1^l U(\delta_1^* H + B_1^*) + (1-p_1^l)U(\delta_1^* L + B_1^*) \geq \underline{U}$$

and the incentive compatibility constraint can be given by

$$p_1^h U(\delta_1^* H + B_1^*) + (1-p_1^h)U(\delta_1^* L + B_1^*) - C = p_1^l U(\delta_1^* H + B_1^*) + (1-p_1^l)U(\delta_1^* L + B_1^*)$$

Substituting the incentive compatibility constraint in the individual rationality constraint gives

$$p_1^h U(\delta_1^* H + B_1^*) + (1-p_1^h)U(\delta_1^* L + B_1^*) - C = \underline{U}$$

In the IAM model, the incentive compatibility and the individual rationality constraints of the agent are the same as the REM, hence it must be true that $\delta_1^* = \delta_2^*$ and $B_1^* = B_2^*$. Hence it must also be true that

$$\frac{U'[\delta_1^* L + B_1^*]}{U'[\delta_1^* H + B_1^*]} = \frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]} \qquad \blacksquare$$

In this section, I have proved that if the information structure is set up in a particular way such that private information acquisition by the agent in the IAM is a complete substitute for the effort randomization generated in the REM and second best production is achieved. Intuitively, trading on the signal swamps the effort component and hence the agent only relies on his private signal to determine his trading strategy. The important point to note is that even though production in the IAM model is greater than the REM model, the private information that the agent acquires and therefore the probability of him renegotiating his contract with the market through insider trading is the same in both the IAM and REM as $\sigma_2^* = \sigma_1^*$. But, as the principal is able to generate higher production in the IAM than in the REM while giving the agent the same contract, the principal would prefer when compensating the agent with tradable securities that the agent acquires and trades on his private information relevant to the liquidation value than prohibiting the collection of private information if the information structure is set-up as under the information structure identified above.

5.3 Information Acquisition Is a Partial Substitute for Effort Randomization

In the previous section I identified an information structure where private information acquisition by the agent acts as a complete substitute for effort randomization. In the case identified, the private information that the agent collects allows the information asymmetry in the model to be the same as the REM and hence the agent trades with the same probability as in the REM with no effort randomization. The information structure is such that the agent only trades on his private signal and not based on his effort choice. Hence, the principal gets back second best production while permitting the agent to collect private information in a regime where anonymous insider trading is permitted. In that case, the principal is better off allowing the agent to collect private information as production increases.

In this section, I identify an information structure where the agent relies on both – his private signal and his effort choice to base his trading behavior. In this case, the private information that the agent collects acts as a partial substitute for the effort randomization result of the REM. Hence in this case as well, the agent takes the high-cost action with a greater probability than in the Fudenberg and Tirole (1990) model resulting in an increase in production when the agent in allowed to gather private information in a model where anonymous insider trading is permitted compared to a model where the agent is only allowed to fully disclose his trading activities. This section provides support to the argument that in general when employees are compensated with tradable securities allowing them to collect private information that is relevant to their trading behavior is potentially socially desirable due to the increase in production.

The agent in the IAM has two sources of private information – his action choice and a private signal. Hence, here there are four possible action-state combinations that the agent could have – { e_2^h, θ_g }, { e_2^h, θ_b }, { e_2^l, θ_g } and { e_2^l, θ_b }where e_2^i refers to his private information about the action choice he has made and θ_j refers to the private signal about the liquidation value that the agent receives. Importantly, there is a possibility that when the agent takes the high-cost action he could still get the low signal and similarly when he takes the low-cost action he could receive the high signal. Also, in this case it is not so clear-cut under which conditions the agent would choose to continue to hold on to his claim on the firm and under which conditions he would choose to liquidate his claim and sell his shares. For example in contrast to the REM, the agent in this case could decide to hold on to his shares when he has taken the low-cost action and observed the good signal.

To identify the potential adverse implication of this added complexity, suppose that an equilibrium exists such that the probability of the expected liquidation value for the two action-state combinations $\{ e_2^h, \theta_b \}$ and $\{ e_2^l, \theta_g \}$ are equal. That is, the probability of the high expected value being realized is the same for the two action-state combinations. The probability of realizing the high value given the action choice of the agent and the private signal he has observed can hence be ordered as follows:

(High) $Prob(H \mid e_2^h, \theta_g) >$ (Medium) $Prob(H \mid e_2^h, \theta_b) =$ (Medium) $Prob(H \mid e_2^l, \theta_g) >$ (Low) $Prob(H \mid e_2^l, \theta_b)$, which in terms of the notation of the model is equivalent to

$$(\theta_g \mid e_2^h)\gamma_g^h > (\theta_g \mid e_2^h))(1-\gamma_b^h) = (\theta_g \mid e_2^l)\gamma_g^l > (\theta_g \mid e_2^l))(1-\gamma_b^l).$$

Suppose that the agent always holds his shares in the high action-state combination and always sells his shares in the low action-state combination, however, the agent's trading strategy is not so clear-cut in the medium action-state combinations. There are two possible equilibria for the medium action-state combinations – the agent can either choose to hold on to his shares or he can choose to sell his shares in those action-state combinations. I first consider the equilibrium where the agent holds on to his shares in the medium action-state combinations $\{ e_2^h, \theta_b \}$ and $\{ e_2^l, \theta_g \}$ and in the high action-state combination $\{ e_2^h, \theta_g \}$ and sells only in the low action-state combination $\{e_2^l, \theta_b\}$. Lemma 4 gives the necessary condition for the agent who is either in the medium and high action-state combination not to have an incentive to change his original contract by trading in the market.

Lemma 4: The necessary conditions that must be satisfied for it to be optimal for an agent who is in either medium action-state combination { e_2^h, θ_b } or { e_2^l, θ_g } to have no incentive to "renegotiate" his contract through trading his shares on the market is given by

$$\left(\frac{H-\hat{\hat{\pi}}_2}{L-\hat{\hat{\pi}}_2}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)=-\frac{U'(\delta_2^* L+B_2^*)}{U'(\delta_2^* H+B_2^*)}$$ for action-sate combination { e_2^h, θ_b }, and

$$\left(\frac{H-\hat{\hat{\pi}}_2}{L-\hat{\hat{\pi}}_2}\right)\left(\frac{\gamma_g^l}{1-\gamma_g^l}\right)=-\frac{U'(\delta_2^* L+B_2^*)}{U'(\delta_2^* H+B_2^*)}$$ for action-state combination { e_2^l, θ_g }.

Proof: As the two action-state combinations have the same probability of the high expected value being realized, I need to establish the necessary condition for the agent not to trade in each of the action-state combinations. This is true if the original contract given by the principal is such that the agent is at his maximum utility with this contract and hence does not have an incentive to change his contract. The expected utility of the agent who purchases ψ additional shares and has taken the high-cost action and observed the poor signal, that is, is in action-state combination { e_2^h, θ_b }, can be given by the following expression.

$$EU=(1-\gamma_b^h)U(\delta_2^* H+B_2^*+\psi(H-\hat{\hat{\pi}}_2))+\gamma_b^h U(\delta_2^* L+B_2^*+\psi(L-\hat{\hat{\pi}}_2))$$

In order for it to be that the agent is at a local maximum with his original contract and hence does not want to trade with the market, the first-order condition of the agent's expected utility with respect to ψ at $\psi=0$ should be 0.

$$\left.\frac{\partial EU}{\partial \psi}\right|_{\psi=0} = (1-\gamma_b^h)U'(\delta_2^* H + B_2^*)(H - \hat{\hat{\pi}}_2) + \gamma_b^h U'(\delta_2^* L + B_2^*)(L - \hat{\hat{\pi}}_2) = 0$$

Rearranging yields

$$\left(\frac{H-\hat{\hat{\pi}}_2}{L-\hat{\hat{\pi}}_2}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)} \qquad \text{(D)}$$

Similarly, the expected utility of the agent who purchases ψ additional shares and has taken the low-cost action and observed the good signal, that is, is in action-state combination { e_2^l, θ_g }, can be given by the following expression

$$EU = \gamma_g^l U(\delta_2^* H + B_2^* + \psi(H - \hat{\hat{\pi}}_2)) + (1-\gamma_g^l)U(\delta_2^* L + B_2^* + \psi(L - \hat{\hat{\pi}}_2))$$

Similarly, the first-order condition for his no-trade behavior to be a local maximum can be given by the first-order condition

$$\left.\frac{\partial EU}{\partial \psi}\right|_{\psi=0} = \gamma_g^l U'(\delta_2^* H + B_2^*)(H - \hat{\hat{\pi}}_2) + (1-\gamma_g^l)U'(\delta_2^* L + B_2^*)(L - \hat{\hat{\pi}}_2) = 0$$

Rearranging yields

$$\left(\frac{H-\hat{\hat{\pi}}_2}{L-\hat{\hat{\pi}}_2}\right)\left(\frac{\gamma_g^l}{1-\gamma_g^l}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)} \qquad \text{(E)}$$

Since the two action-state combinations have the same probability of the high value output being realized, the agent's utility ex-ante must be the same in both action-state combinations. This means that since $\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right) = \left(\frac{\gamma_g^l}{1-\gamma_g^l}\right)$ is true by assumption, the contracts or the RHS of equations (D) and (E) must be equal.

I have now established the necessary conditions (D) and (E) that must hold in equilibrium for the agent to hold his shares in the medium action-state combinations $\{ e_2^h, \theta_b \}$ and $\{ e_2^l, \theta_g \}$. ■

Lemma 5 establishes that if the agent chooses to hold his shares in the medium action-state combinations, then it is true that he will also hold his shares in the high action-state combination.

<u>Lemma 5:</u> If the agent holds the shares given to him in his original contract in the medium action-state combinations, then he must necessarily hold the shares given to him in his original contract in the high-action state combination.

<u>Proof:</u> Consider the condition that must be satisfied for it to be optimal for the agent to hold his shares in the high action-state combination $\{ e_2^h, \theta_g \}$, that is, when he has exerted the high-cost action and privately observed the good signal. The expected utility of this type of agent when he purchases ψ additional shares is given by

$$EU = \gamma_g^h U(\delta_2^* H + B_2^* + \psi(H - \hat{\hat{\pi}}_2)) + (1-\gamma_g^h) U(\delta_2^* L + B_2^* + \psi(L - \hat{\hat{\pi}}_2))$$

Similarly, the first-order condition that establishes his no-trade behavior can be given by

$$\left. \frac{\partial EU}{\partial \psi} \right|_{\psi=0} = \gamma_g^h U'(\delta_2^* H + B_2^*)(H - \hat{\hat{\pi}}_2) + (1-\gamma_g^h) U'(\delta_2^* L + B_2^*)(L - \hat{\hat{\pi}}_2) \geq 0$$

Rearranging yields the necessary condition for this type of agent not to have an incentive to trade

$$\left(\frac{H - \hat{\hat{\pi}}_2}{L - \hat{\hat{\pi}}_2} \right) \left(\frac{\gamma_g^h}{1-\gamma_g^h} \right) \geq -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)} \qquad \text{(F)}$$

As $\gamma_g^h > \gamma_g^l$ it must be true that $\frac{\gamma_g^h}{1-\gamma_g^h} > \frac{\gamma_g^l}{1-\gamma_g^l}$. Hence the condition above is satisfied when Lemma 4 is satisfied. ■

Lemma 4 and 5 establish the necessary conditions for the agent types who are in either the high or medium action-state combinations not to have an incentive to "renegotiate" their contract by trading their shares in the market. Lemma 6 determines the equilibrium price that is consistent with Lemma 4 and 5.

Lemma 6: The equilibrium price can be given by the following expression

$$\hat{\hat{\pi}}_2 = \sigma_2^{**}[[Prob(\theta_g \mid e_2^h)[\gamma_g^h H + (1-\gamma_g^h)L] + (1-Prob(\theta_g \mid e_2^h))[(1-\gamma_b^h)H + \gamma_b^h L]] +$$

$$(1-\sigma_2^{**})[[Prob\,\theta_g \mid e_2^l)][\gamma_g^l H + (1-\gamma_g^l)L] + (1-Prob(\theta_g \mid e_2^l))[(1-\gamma_b^l)H + \gamma_b^l L]]$$

Proof: The equilibrium market price is formed by the market maker's rational expectations of the final payoff. This in turn depends on the market maker's rational expectations of the probability of the agent taking the high cost action (σ_2^{**}) when he randomizes between the effort choices. The equilibrium price can be calculated as a weighted average of the expected price when the agent takes the high-cost action and the expected price when the agent takes the low-cost action. The expected price when the agent takes the high-cost action is weighted by the probability of him observing the good signal and the bad signal. Similarly the expected price when the agent takes the low-cost action is weighted by the probability of his private signal outcomes. As the price $\hat{\hat{\pi}}_2$ is based on the market maker's expectation of the randomization of effort by the agent, σ_2^{**} in equilibrium takes the form that supports the price $\hat{\hat{\pi}}_2$ that satisfies the necessary condition established in Lemma 4. ■

At this price it is clear that the agent has no incentive to purchase additional shares, hence the bid-price can be set such that $BID = \hat{\hat{\pi}}_2$ as it is the lower price in the spread. Also, to ensure that the agent does not have an incentive to purchase additional shares, the market maker can set the ask price higher than or equal to the bid-price, that is, $ASK \geq \hat{\hat{\pi}}_2$. By imposing such a spread in the market, the market maker can ensure that Lemma 4 and 5 hold in equilibrium, that is, agent types that are in the medium and high action-state combinations do not have an incentive to "renegotiate" their contract in the market.

Assume the special case where $Prob(\theta_g \mid e_2^h) = Prob(\theta_g \mid e_2^l) \equiv \alpha$. This allows me to ensure that the contract given in both medium action-state combinations to the agent is the same and hence his utility from being in either action-state combination is the same, it also makes the problem more tractable. The above equilibrium price can be re-written as

$$\hat{\hat{\pi}}_2 = \sigma_2^{**}[[\,\alpha[\gamma_g^h H + (1-\gamma_g^h)L] + (1-\alpha)[(1-\gamma_b^h)H + \gamma_b^h L]] +$$

$$(1-\sigma_2^{**})[[\,\alpha[\gamma_g^l H + (1-\gamma_g^l)L] + (1-\alpha)[(1-\gamma_b^l)H + \gamma_b^l L]]$$

The condition in Proposition 2 defines the equilibrium randomization probability σ_2^{**} with the particular information structure identified in this section. This then allows me to compare in Proposition 3 the maximum probability of the agent taking the high-cost action to that obtained in the REM which serves as a benchmark for no private information acquisition.

Proposition 2: The necessary and sufficient condition for the contract with tradable securities and private information acquisition by the agent to be renegotiation proof is

$$\left(\frac{-\sigma_2^{**}[\alpha(\gamma_g^h-\gamma_g^l)-(1-\alpha)(\gamma_b^h-\gamma_b^l)]-\alpha\gamma_g^l+(1-\alpha)\gamma_b^l+\alpha}{-\sigma_2^{**}[\alpha(\gamma_g^h-\gamma_g^l)-(1-\alpha)(\gamma_b^h-\gamma_b^l)]-\alpha\gamma_g^l+(1-\alpha)\gamma_b^l-(1-\alpha)}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)=-\frac{U'(\delta_2^*L+B_2^*)}{U'(\delta_2^*H+B_2^*)}$$

Proof: Substituting the value of $\hat{\hat{\pi}}_2$ in the necessary condition from Lemma 4

$\left(\frac{H-\hat{\hat{\pi}}_2}{L-\hat{\hat{\pi}}_2}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)=-\frac{U'(\delta_2^*L+B_2^*)}{U'(\delta_2^*H+B_2^*)}$ yields the expression in the proposition. ■

I have established the necessary conditions such that the agent in the { e_2^h,θ_g }, { e_2^h,θ_b } and { e_2^l,θ_g } action-state combinations do not have an incentive to "renegotiate" their contract with the market by engaging in insider trading. As I have turned to Fudenberg and Tirole (1990) as it is an appropriate benchmark to examine the scenario where the agent is required to fully disclose his trading activities, in proposition 3, I compare the maximum probability of the agent taking the high-cost action in the IAM model under this information structure (σ_2^{**}) with the maximum probability of the agent taking the high-cost action in the Fudenberg and Tirole (1990) model $(\hat{\sigma}_1)$. For an understanding of how to modify the notation of Fudenberg and Tirole to my model where the agent is permitted to engage in anonymous insider trading but is prohibited from acquiring private information (Jaffer 2007), please refer to the Appendix B.

Proposition 3: The probability of the agent exerting high effort in the IAM with this information structure is higher than that in the Fudenberg and Tirole (1990) model (public trading), that is, $\sigma_2^{**}>\hat{\sigma}_1$.

Proof: By construction $(1-\gamma_b^h)+\gamma_b^h=1$ and $(1-\gamma_g^l)+\gamma_g^l=1$ and from equation (F)

$\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)=\left(\frac{\gamma_g^l}{1-\gamma_g^l}\right)$, it must be that $\gamma_g^l=(1-\gamma_b^h)$.

I now equate the probabilities from the REM with the probability construction that includes private information acquisition in the IAM

$p_1^h = \alpha\gamma_g^h + (1-\alpha)(1-\gamma_b^h)$ and $p_1^l = \alpha\gamma_g^l + (1-\alpha)(1-\gamma_b^l)$

$p_1^h - p_1^l = \alpha(\gamma_g^h - \gamma_g^l) - (1-\alpha)(\gamma_b^h - \gamma_b^l)$

Substituting the probabilities from the REM model into the necessary condition yields

$$\left(\frac{\sigma_2^{**}(p_1^h - p_1^l) + (1-p_1^l)}{\sigma_2^{**}(p_1^h - p_1^l) - p_1^l}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)}$$

As $p_1^h = \alpha\gamma_g^h + (1-\alpha)(1-\gamma_b^h)$

$$(1-\gamma_b^h) = \frac{p_1^h - \alpha\gamma_g^h}{1-\alpha} \text{ and } \gamma_b^h = 1 - \frac{p_1^h - \alpha\gamma_g^h}{1-\alpha}$$

Re-written $\gamma_b^h = \dfrac{1 - p_1^h - \alpha(1-\gamma_g^h)}{1-\alpha}$

$$\frac{1-\gamma_b^h}{\gamma_b^h} = \frac{p_1^h - \alpha\gamma_g^h}{1 - p_1^h - \alpha(1-\gamma_g^h)}$$

Comparing $\dfrac{1-\gamma_b^h}{\gamma_b^h}$ and $\dfrac{p_1^h}{1-p_1^h}$ first by numerator and then by denominator

$p_1^h - \alpha\gamma_g^h < p_1^h$ and $1 - p_1^h - \alpha(1-\gamma_g^h) > 1 - p_1^h$ as long as $p_1^h > \gamma_g^h$.

As the numerator of the equation $\dfrac{1-\gamma_b^h}{\gamma_b^h}$ is smaller and the denominator is larger,

$\dfrac{1-\gamma_b^h}{\gamma_b^h} < \dfrac{p_1^h}{1-p_1^h}$ when $p_1^h > \gamma_g^h$.

As the contracts are the same the RHS is the same, I can now compare σ_2^{**} with $\hat{\sigma}_1$.

$$\frac{(p_1^l - p_1^h)\hat{\sigma}_1 + (1-p_1^l)}{(p_1^l - p_1^h)\hat{\sigma}_1 - p_1^l}\frac{p_1^h}{1-p_1^h} = -\frac{U'[S*(L)]}{U'[S*(H)]} \quad \text{(REM)}$$

$$\left(\frac{\sigma_2^{**}(p_1^h - p_1^l) + (1-p_1^l)}{\sigma_2^{**}(p_1^h - p_1^l) - p_1^l}\right)\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)} \qquad \text{(IAM)}$$

To do this I need to sign the derivative $\dfrac{d\sigma_2^{**}}{d\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)}$.

I obtain this derivative by taking the implicit derivative of the function

$\left(\dfrac{\sigma_2^{**}(p_1^h - p_1^l) + (1-p_1^h)}{\sigma_2^{**}(p_1^h - p_1^l) - p_1^h}\right)\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right) = -\dfrac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)}$ with respect to $\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)$ which is a constant. I refer to $\left(\dfrac{\sigma_2^{**}(p_1^h - p_1^l) + (1-p_1^h)}{\sigma_2^{**}(p_1^h - p_1^l) - p_1^h}\right)\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)$ as "Ω" in the remainder of the proposition.

For $\sigma_2^{**} > \hat{\sigma}_1$ $\dfrac{d\sigma_2^{**}}{d\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)} < 0$

$$\frac{d\sigma_2^{**}}{d\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)} = -\frac{\dfrac{d\Omega}{d\sigma_2^{**}}}{\dfrac{d\Omega}{d\left(\dfrac{1-\gamma_b^h}{\gamma_b^h}\right)}}$$

$$\frac{d\Omega}{d\sigma_2^{**}} = \frac{-\sigma_2^{**}(p_1^h - p_1^l) + (1-p_1^l)}{-\sigma_2^{**}(p_1^h - p_1^l) - p_1^l}\left(\frac{p_1^h}{1-p_1^h}\right)$$

$$\frac{d\Omega}{d\left(\dfrac{p_1^h}{1-p_1^h}\right)} = \frac{(p_1^h - p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right)}{-\sigma_2^{**}(p_1^h - p_1^l) - p_1^l} - \frac{(p_1^h - p_1^l)[(1-p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right) - \sigma_2^{**}(p_1^h - p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right)}{[-\sigma_2^{**}(p_1^h - p_1^l) - p_1^l]^2}$$

$$\frac{d\sigma_2^{**}}{d\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)} =$$

$$-\frac{(-\sigma_2^{**}(p_1^h - p_1^l) + 1 - p_1^l)(-\sigma_2^{**}(p_1^h - p_1^l) - p_1^l}{(-\sigma_2^{**}(p_1^h - p_1^l) - p_1^l)(p_1^h - p_1^l)\left(\frac{p_1^h}{1-p_1^h}\right) - (p_1^h - p_1^l)[(1-p_1^l)\left(\frac{p_1^h}{1-p_1^l}\right) - \sigma_2^{**}(p_1^h - p_1^l)\left(\frac{p_1^h}{1-p_1^h}\right)}$$

Algebraically then, the sign of $\frac{d\sigma_2^{**}}{d\left(\frac{1-\gamma_b^h}{\gamma_b^h}\right)}$ is negative and hence I conclude that

$\sigma_2^{**} > \hat{\sigma}_1$. ■

To summarize, I have identified a case where the properties of the information structure are such that the agent collects private information that leads to the high-cost action being taken with a higher probability than in the Fudenberg and Tirole (1990) model which is a benchmark for examining production in a setting where the agent is only permitted to engage in public trading. Production increases relative to the benchmark where private information acquisition is not allowed and the agent can only engage in public trading and this has socially desirable implications for the overall economy. The intuition behind this result is that information asymmetry generated from gathering private information acts as a substitute for the information asymmetry that is generated by effort randomization. Hence, the more the agent can rely on the private information to determine his trading behavior the less he randomizes on his effort choices. The information structure identified above helps support the general notion that allowing the agent to collect private information in a scenario where the agent is compensated with tradable securities increases the agent's effort and positively impacts production in the economy. This is a bit surprising as one would have conjectured that allowing the agent to collect private information relevant to his trading choice while at the same time allowing him to also engage in insider trading would result in the agent taking the high-cost action less often. However, as the results show, allowing the agent to collect private information results in a Pareto improvement as the agent takes the high-cost action more often than if he were not allowed to collect private information and only engage in public trading.

6. Properties of Accounting Systems that Relate to the Above Identified Information Structures

The first information structure identified was one where private information does not have an impact on the agent's trading behavior as it does not change the agent's estimation of the expected liquidation value of the firm. This private information has no impact on valuation and to the extent that financial reports are used as a means for valuation, the information is not relevant to investors. However, the information can potentially be beneficial to the principal as it can be used for internal reporting.

The second information system is orthogonal to that identified first. In this case the private information gathered acts as a perfect substitute for effort randomization. This occurs exactly because the information system is price relevant and hence would alter both the agent and principal's assessment of firm value. The information produced by a system impacts the estimation of the firm value and could be of potential interest to an external audience such as third-party investors of the firm if used for valuation purposes.

Lastly, for the third information structure identified, the properties of the information obtained by the agent are such that the agent takes the high-cost action with a higher probability and production in the overall economy is increased compared to a scenario where the agent is required to publicly disclose his trading activities. The characteristics of such an information system are that it generates information that is relevant about the expected liquidation value and about the agent's action choice. As the agent uses both his action choice and his private information to base his trading behavior, the information collected acts as a partial substitute for the effort randomization and hence has positive consequences. Hence, the information gathered under this structure can be useful both for internal purposes as well as by parties external to the firm such as outside investors and analysts.

7. Information Acquisition is Costly

The analysis in the previous section relied on the assumption that information was acquired at no cost to the agent. In this section I investigate the results in the event that private information is costly to acquire. It is immediately clear that if the agent bears a cost in collecting the information the best case analyzed above (the second information structure) cannot be implemented. Hence, the agent will not exert high effort with a probability one. Rather the agent will randomize between the effort levels as in the REM. If on the other hand, the principal incurs the cost of the agent gathering the private information, the results differ; the results of second best production as in the second information structure identified can still be implemented. This section analyzes the case where the principal bears some of the cost of gathering the private information. One point to note is that the cost of collecting the information cannot be too high otherwise it will be too costly for the principal to satisfy the agent's participation constraint, and hence the principal will want to deter private information collection by the agent.

The agent similar to the costless case has private information about his action choice and the private signal. As described in the case where information collection is a partial substitute for effort randomization (Section 5.3), there are four possible action-state combinations that the agent could have – { e_2^h, θ_g }, { e_2^h, θ_b }, { e_2^l, θ_g } and { e_2^l, θ_b }where e_2^i refers to his private information about the action choice he has made and θ_j refers to the private signal about the liquidation value that the agent receives. Similar to the case where information is a partial substitute, suppose that an equilibrium exists such that the probability of the expected liquidation value for the two action-state combinations { e_2^h, θ_b } and { e_2^l, θ_g } are equal. In other words, the probability of the high expected value being realized is the same for the two action-state combinations. The probability of realizing the high value given the action choice of the agent and the private signal he has observed can hence be ordered as follows:

(High) $Prob(H \mid e_2^h, \theta_g)$ > (Medium) $Prob(H \mid e_2^h, \theta_b)$ = (Medium) $Prob(H \mid e_2^l, \theta_g)$ > (Low) $Prob(H \mid e_2^l, \theta_b)$, which in terms of the notation of the model is equivalent to

$(\theta_g \mid e_2^h)\gamma_g^h > (\theta_g \mid e_2^h))(1-\gamma_b^h) = (\theta_g \mid e_2^l)\gamma_g^l > (\theta_g \mid e_2^l))(1-\gamma_b^l)$.

Below, I examine the equilibrium where the agent holds on to his shares only in the high action-sate combination and sells his shares and receives full insurance in the medium and low action-state combinations.

Lemma 7: The necessary condition for it to be optimal for an agent to continue to hold on to his shares only in the high action-state combination { e_2^h, θ_g }, that is, when he has exerted the high-cost action and privately observed the good signal can be given by

$$\left(\frac{H-\pi_2^C}{L-\pi_2^C}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)=-\frac{U'(\delta_2^* L+B_2^*)}{U'(\delta_2^* H+B_2^*)}$$

Proof: The expected utility of this type of agent when he purchases ψ additional shares is given by

$$EU=\gamma_g^h U(\delta_2^* H+B_2^*+\psi(H-\pi_2^C))+(1-\gamma_g^h)U(\delta_2^* L+B_2^*+\psi(L-\pi_2^C))$$

Similarly, the first-order condition that establishes his no-trade behavior can be given by

$$\left.\frac{\partial EU}{\partial\psi}\right|_{\psi=0}=\gamma_g^h U'(\delta_2^* H+B_2^*)(H-\pi_2^C)+(1-\gamma_g^h)U'(\delta_2^* L+B_2^*)(L-\pi_2^C)=0$$

Rearranging yields the necessary condition for this type of agent not to have an incentive to trade

$$\left(\frac{H-\pi_2^C}{L-\pi_2^C}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)=-\frac{U'(\delta_2^* L+B_2^*)}{U'(\delta_2^* H+B_2^*)}$$ ■

Under this scenario, the equilibrium price as given by the market maker's rational expectations on the agent's probability of taking the high-cost action is summarized in Lemma 8.

Lemma 8: The equilibrium price can be given by the following expression

$$\pi_2^C=\sigma_2^C[[Prob(\theta_g\mid e_2^h)[\gamma_g^h H+(1-\gamma_g^h)L]+(1-Prob(\theta_g\mid e_2^h))[(1-\gamma_b^h)H+\gamma_b^h L]]+$$

$$(1-\sigma_2^C)[[Prob\,\theta_g\mid e_2^l)][\gamma_g^l H+(1-\gamma_g^l)L]+(1-Prob(\theta_g\mid e_2^l))[(1-\gamma_b^l)H+\gamma_b^l L]]$$

Proof: The equilibrium market price is formed by the market maker's rational expectations of the final payoff. This in turn depends on the market maker's rational expectations of the probability of the agent taking the high cost action (σ_2^C) when he randomizes between the effort choices. ■

Again, let us examine the special case where $Prob(\theta_g \mid e_2^h) = Prob(\theta_g \mid e_2^l) \equiv \alpha$. This allows me to equate the contract given to the agent in both medium action-state combinations and hence their utility from being in either action-state combination is the same. The above equilibrium price can be re-written as

$$\pi_2^C = \sigma_2^C[[\ \alpha[\gamma_g^h H + (1-\gamma_g^h)L] + (1-\ \alpha)[(1-\gamma_b^h)H + \gamma_b^h L]] +$$

$$(1-\sigma_2^C)[[\ \alpha[\gamma_g^l H + (1-\gamma_g^l)L] + (1-\ \alpha)[(1-\gamma_b^l)H + \gamma_b^l L]]$$

The condition in Proposition 4 defines the randomization probability σ_2^C with the particular information structure identified in this section.

<u>Proposition 4:</u> The necessary and sufficient condition for the contract with tradable securities and costly private information acquisition by the agent to be renegotiation proof is

$$\left(\frac{-\sigma_2^C[\alpha(\gamma_g^h-\gamma_g^l)-(1-\alpha)(\gamma_b^h-\gamma_b^l)]-\alpha\gamma_g^l+(1-\alpha)\gamma_b^l+\alpha}{-\sigma_2^C[\alpha(\gamma_g^h-\gamma_g^l)-(1-\alpha)(\gamma_b^h-\gamma_b^l)]-\alpha\gamma_g^l+(1-\alpha)\gamma_b^l-(1-\alpha)}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)=-\frac{U'(\delta_2^*L+B_2^*)}{U'(\delta_2^*H+B_2^*)}$$

<u>Proof:</u> Substituting the value of π_2^C in the necessary condition from Lemma 7

$\left(\frac{H-\pi_2^C}{L-\pi_2^C}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)=-\frac{U'(\delta_2^*L+B_2^*)}{U'(\delta_2^*H+B_2^*)}$ yields the expression in the proposition. ■

Following the case where information collection is a partial substitute, to compare the probability of the agent taking the high-cost action with costly information collection to that in the REM, I need to take the implicit derivative. Proposition 5 gives the results of this comparison.

Proposition 5: The probability of the agent exerting high effort under costly information collection with this information structure is higher than that in the Fudenberg and Tirole (1990) public trading model, that is, $\sigma_2^C > \hat{\sigma}_1$.

Proof: I first equate the probabilities from the REM with the probability construction that includes private information acquisition in the IAM

$p_1^h = \alpha\gamma_g^h + (1-\alpha)(1-\gamma_b^h)$ and $p_1^l = \alpha\gamma_g^l + (1-\alpha)(1-\gamma_b^l)$

$$p_1^h - p_1^l = \alpha(\gamma_g^h - \gamma_g^l) - (1-\alpha)(\gamma_b^h - \gamma_b^l)$$

Substituting the probabilities from the REM model into the necessary condition from Lemma 7 yields

$$\left(\frac{\sigma_2^C(p_1^h - p_1^l) + (1-p_1^l)}{\sigma_2^C(p_1^h - p_1^l) - p_1^l}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)}$$

As $p_1^h = \alpha\gamma_g^h + (1-\alpha)(1-\gamma_b^h)$

$\gamma_g^h = p_1^h - 1 + \alpha + \gamma_b^h - \alpha\gamma_b^h$ and $1-\gamma_g^h = p_1^h + \alpha + \gamma_b^h - \alpha\gamma_b^h$

Comparing $\frac{\gamma_g^h}{1-\gamma_g^h}$ and $\frac{p_1^h}{1-p_1^h}$ first by numerator and then by denominator, I find that

$p_1^h - 1 + \alpha + \gamma_b^h - \alpha\gamma_b^h < p_1^h$ and $p_1^h + \alpha + \gamma_b^h - \alpha\gamma_b^h > 1 - p_1^h$, hence $\frac{\gamma_g^h}{1-\gamma_g^h} < \frac{p_1^h}{1-p_1^h}$.

As the contracts are the same the RHS is the same, I can now compare σ_2^C with $\hat{\sigma}_1$.

$$\frac{(p_1^l - p_1^h)\hat{\sigma}_1 + (1-p_1^l)}{(p_1^l - p_1^h)\hat{\sigma}_1 - p_1^l}\frac{p_1^h}{1-p_1^h} = -\frac{U'[S*(L)]}{U'[S*(H)]} \qquad \text{(REM)}$$

$$\left(\frac{\sigma_2^C(p_1^h - p_1^l) + (1-p_1^l)}{\sigma_2^C(p_1^h - p_1^l) - p_1^l}\right)\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right) = -\frac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)} \qquad \text{(IAM with cost)}$$

To do this I need to sign the derivative $\dfrac{d\sigma_2^{**}}{d\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)}$.

I obtain this derivative by taking the implicit derivative of the function

$\left(\dfrac{\sigma_2^C(p_1^h - p_1^l)+(1-p_1^l)}{\sigma_2^C(p_1^h - p_1^l)-p_1^l}\right)\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right) = -\dfrac{U'(\delta_2^* L + B_2^*)}{U'(\delta_2^* H + B_2^*)}$ with respect to $\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)$ which is a constant. I refer to $\left(\dfrac{\sigma_2^C(p_1^h - p_1^l)+(1-p_1^l)}{\sigma_2^C(p_1^h - p_1^l)-p_1^l}\right)\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)$ as "Δ" in the remainder of the proposition.

For $\sigma_2^C > \hat{\sigma}_1$ $\dfrac{d\sigma_2^{**}}{d\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)} < 0$

$$\frac{d\sigma_2^C}{d\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)} = -\frac{\dfrac{d\Delta}{d\sigma_2^C}}{\dfrac{d\Delta}{d\left(\dfrac{\gamma_g^h}{1-\gamma_g^h}\right)}}$$

$$\frac{d\Delta}{d\sigma_2^C} = \frac{-\sigma_2^C(p_1^h - p_1^l)+(1-p_1^l)}{-\sigma_2^C(p_1^h - p_1^l)-p_1^l}\left(\frac{p_1^h}{1-p_1^h}\right)$$

$$\frac{d\Delta}{d\left(\dfrac{p_1^h}{1-p_1^h}\right)} = \frac{(p_1^h - p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right)}{-\sigma_2^C(p_1^h - p_1^l)-p_1^l} - \frac{(p_1^h - p_1^l)[(1-p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right) - \sigma_2^C(p_1^h - p_1^l)\left(\dfrac{p_1^h}{1-p_1^h}\right)}{[-\sigma_2^C(p_1^h - p_1^l)-p_1^l]^2}$$

$$\frac{d\sigma_2^C}{d\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)} =$$

$$-\frac{(-\sigma_2^C(p_1^h - p_1^l) + 1 - p_1^l)(-\sigma_2^C(p_1^h - p_1^l) - p_1^l}{(-\sigma_2^C(p_1^h - p_1^l) - p_1^l)(p_1^h - p_1^l)\left(\frac{p_1^h}{1-p_1^h}\right) - (p_1^h - p_1^l)[(1-p_1^l)\left(\frac{p_1^h}{1-p_1^l}\right) - \sigma_2^C(p_1^h - p_1^l)\left(\frac{p_1^h}{1-p_1^h}\right)}$$

Algebraically then, the sign of $\frac{d\sigma_2^C}{d\left(\frac{\gamma_g^h}{1-\gamma_g^h}\right)}$ is negative, hence I conclude that $\sigma_2^C > \hat{\sigma}_1$. ■

In this section, I show that as long as information acquisition is not too costly, the agent collects information which has a positive impact on production in the economy. This result is interesting because if the information collection has any cost to it, the agent does not end up in the best case scenario with complete substitution in the costless case. Rather, with costly information collection, the principal prefers the partial substitution of effort randomization which still results in an increase in production relative to the scenario where the agent can only engage in public trading.

8. Conclusion and Implications for Further Research

In this chapter I have attempted to analytically capture the notion of insider trading consistent with the definition provided by the SEC. The agent in this chapter has the opportunity to collect private information correlated with the liquidation value prior to deciding his trading strategy. Intuitively, one might expect that allowing the agent to collect private information would result in the agent shirking more often and selling his shares in the market and receiving full insurance. This chapter shows that in general, private information collection by the agent acts as a substitute for effort randomization. Hence when the information has a significant impact on the agent's estimation value it alters the agent trading behavior in this model. The agent substitutes the effort randomization with private information collection and takes the high-cost action more often than in a model with public trading resulting in an increase in the overall production. In this chapter I provide analytically one possible explanation for why companies choose to compensate employees with tradable securities.

This chapter also opens up the avenue to empirically examine the impact of insider trading regulation on production. Most empirical studies have concentrated on the impact of insider trading by looking at the abnormal returns earned by insiders whereas this chapter's focus calls for studying the impact of insider trading by looking at the production generated by the firm. One way to empirically test the conclusions of this chapter is by looking at the impact of insider trading regulation on production and/or investment of the firm. This chapter adds nuance to the regulation debate around insider trading and forces an examination of the tradeoffs that go along with prohibiting insider trading.

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Appendix B

Proof of Proposition 1: I will prove the above proposition in two parts – I will first show that if the agent has observed θ_g and in equilibrium he does not trade his shares (Lemma 1), the contract that he receives from the principal is renegotiation proof.

The necessary condition for the second best contract with tradable securities given that the agent has exerted e_2^h and seen θ_g with a probability σ_2^* to be renegotiation proof can be calculated by substituting the value of

$\hat{\pi}_2 = \sigma_2^*[\gamma_g H + (1-\gamma_g)L] + (1-\sigma_2^*)[(1-\gamma_b)H + \gamma_b L]$ in the weak inequality from

Lemma 1 $\dfrac{(H-\hat{\pi}_2)}{(L-\hat{\pi}_2)}\dfrac{\gamma_g}{1-\gamma_g} \geq -\dfrac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$ which then gives:

$$\frac{\sigma_2^*(1-\gamma_g-\gamma_b)+\gamma_b}{\sigma_2^*(1-\gamma_g-\gamma_b)-(1-\gamma_b)}\left(\frac{\gamma_g}{1-\gamma_g}\right) \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

$$\frac{(H-[\sigma_2^*\gamma_g H + \sigma_2^* L - \sigma_2^*\gamma_g L + H - \gamma_b H - \sigma_2^* H + \sigma_2^*\gamma_b H + \gamma_b L - \sigma_2^*\gamma_b L])}{(L-[\sigma_2^*\gamma_g H + \sigma_2^* L - \sigma_2^*\gamma_g L + H - \gamma_b H - \sigma_2^* H + \sigma_2^*\gamma_b H + \gamma_b L - \sigma_2^*\gamma_b L)}\frac{\gamma_g}{1-\gamma_g^h} \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

$$\frac{-\sigma_2^*\gamma_g[H-L]+\sigma_2^*[H-L]-\gamma_b[H-L]-\sigma_2^*\gamma_b[H-L]}{-1[H-L]-\sigma_2^*\gamma_g[H-L]+\sigma_2^*[H-L]-\gamma_b[H-L]-\sigma_2^*\gamma_b[H-L]}\frac{\gamma_g}{1-\gamma_g} \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

$$\frac{[H-L][-\sigma_2^*\gamma_g+\sigma_2^*-\gamma_b-\sigma_2^*\gamma_b]}{[H-L][-1-\sigma_2^*\gamma_g+\sigma_2^*-\gamma_b-\sigma_2^*\gamma_b}\frac{\gamma_g}{1-\gamma_g} \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

Dividing by $[H-L]$ yields

$$\frac{\sigma_2^*(1-\gamma_g-\gamma_b)+\gamma_b}{\sigma_2^*(1-\gamma_g-\gamma_b)-(1-\gamma_b)}\left(\frac{\gamma_g}{1-\gamma_g}\right) \geq -\frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

Substituting the value of $\sigma_2^* = \dfrac{p_1^h + \gamma_b - 1}{\gamma_g + \gamma_b - 1}$ in the weak inequality above gives

$$\frac{1-p_1^h}{p_1^h}\left(\frac{\gamma_g}{1-\gamma_g}\right) \leq \frac{U'[\delta_2^* L + B_2^*]}{U'[\delta_2^* H + B_2^*]}$$

The above condition ensures that the agent is at a local maximum and hence has no incentive to trade with the market.

A sufficient condition for this contract to characterize the case where the agent who has taken e_2^h and seen θ_g with a probability σ_2^* is at his maximum utility when he continues to hold exactly δ_2^* shares is for his expected utility function to be concave everywhere in δ. This ensures that there is a global maximum and the agent does not have an incentive to change his contract at any point on his utility function.

If the agent's expected utility function is concave everywhere in δ there must exist a unique maximum. This holds if and only if

1. $dEU/d\delta_2^* \geq 0$ at $\delta_2^* = 0$
2. $d^2EU/d^2\delta_2^* < 0$

To prove $dEU/d\delta_2^* > 0$ at $\delta_2^* = 0$

$$EU = \gamma_g U[\delta_2^* H + B_2^* + (\delta_2^* - \psi)\hat{\pi}_2] + (1-\gamma_g)U[\delta_2^* L + B_2^* + (\delta_2^* - \psi)\hat{\pi}_2]$$

$$dEU/d\delta_2^* = \gamma_g U'[\delta_2^* H - (\delta_2^* - \psi)\hat{\pi}_2 + B_2^*][H - \hat{\pi}_2] + (1-\gamma_g)U'[\delta_2^* L - (\delta_2^* - \psi)\hat{\pi}_2 + B_2^*][L - \hat{\pi}_2]$$

$dEU/d\delta_2^*$ evaluated at $\delta_2^* = 0$ equals

$$\gamma_g U'[\psi\hat{\pi}_2 + B_2^*][H - \hat{\pi}_2] + (1-\gamma_g)U'[\psi\hat{\pi}_2 + B_2^*][L - \hat{\pi}_2]$$

$$= U'[\psi\hat{\pi}_2 + B_2^*][\gamma_g[H - \hat{\pi}_2] + (1-\gamma_g)[L - \hat{\pi}_2]]$$

By assumption $U' > 0$

I need to prove that $\gamma_g(H - \hat{\pi}_2) + (1-\lambda_g)(L - \hat{\pi}_2)$ is positive.

At $\sigma_2^* = 0$ this expression equals

$$\gamma_g[H - \gamma_b H - (1-\gamma_b)L] + (1-\gamma_g)[L - \gamma_b H - (1-\gamma_b)L]$$

$$= \gamma_g(1-\gamma_b)(H - L) + (1-\gamma_g)\gamma_b(L - H)$$

By assumption $H > L$ which implies $H - L > 0$ and $L - H < 0$

Also, $\gamma_g(1-\gamma_b) > (1-\gamma_g)\gamma_b$ as we know $\gamma_g > \gamma_b$, hence the expression is positive.

2. To prove that $d^2EU/d^2\delta_2^* < 0$

$$EU = \gamma_g U[\delta_2^* H + B_2^* + \psi(H - \hat{\pi}_2)] + (1-\gamma_g)U[\delta_2^* L + B_2^* + \psi(L - \hat{\pi}_2)]$$

$$d^2EU/d^2\delta_2^* =$$

$$\gamma_g U''[\delta_2^* H - (\delta_2^* - \psi)\hat{\pi}_2 + B_2^*][H - \hat{\pi}_2]^2 + (1-\gamma_g)U''[\delta_2^* L - (\delta_2^* - \psi)\hat{\pi}_2 + B_2^*][L - \hat{\pi}_2]^2$$

By concavity of U we know that $U'' < 0$

Clearly, $[H - \hat{\pi}_2]^2$ and $[L - \hat{\pi}_2]^2$ are positive.

Hence, $d^2 EU / d^2 \delta_2^* < 0$