Three Essays in Corporate Finance

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Business Administration)
in The University of Michigan
2018

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To the memory of my mother.

ACKNOWLEDGEMENTS

I am extremely grateful to my committee members Uday Rajan, Amiyatosh Purnanandam, Martin Schmalz, David Miller and Raffi Indjejikian for their support, guidance, and encouragement. Specially, I am grateful to Uday for his guidance over the years that has helped me immensely in conducting research.

I am also thankful to Sugato Bhattacharyya, Paolo Pasquariello, M.P. Narayanan, and Indrajit Mitra for various helpful discussions on the chapters of this dissertation. Most importantly, I am grateful to my family and friends for their continuous support and encouragement. My wife, Yulia, and my daughter, Kira, have been a source of tremendous support and inspiration.

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ABSTRACT

This dissertation consists of three essays in corporate finance. The essays study the applications of information friction to various contexts in corporate finance.

In the first essay, I study a board's decision to fire or retain a CEO when board members care about their reputation in the labor market for directors. These concerns give the board an incentive to overweight public information and penalize (reward) the CEO for bad (good) luck, leading to an increase in turnover-performance sensitivity. I test the empirical predictions of the model using promotions of existing directors as a proxy for an increase in their reputational concerns. I find turnover-performance sensitivity is greater when a director is promoted. Further, I find CEO retention after a director takes on a new role culminates in lower future firm performance. Overall, the results suggest directors' incentives due to reputational concerns result in inefficient firing decisions.

In the second essay, I study the effect of a decrease in the analyst coverage on the covenants of a firm's debt contracts. The decrease in analyst coverage is caused by dismissal of redundant analysts after mergers of brokerage houses during 1984-2005. I find that the likelihood of inclusion of covenants and the number of covenants in debt contracts are greater for firms which had lower analyst coverage. These findings suggest that the creditors take measures to counteract the increase in the agency costs by increasing the restrictiveness of the contracts.

In the third essay, that is joint work with Sugato Bhattacharyya, I model a firm run by a manager who invests in a technology with uncertain returns. The manager has incentives to learn about fundamentals from the stock price, as well as to

acquire her own private information to make better investment decisions. However, such learning increases information asymmetry between the informed trader and the liquidity traders because the informed trader's private information now allows him to predict the manager's actions. The greater information asymmetry results in greater price impact and greater price volatility but does not affect the trading volume or price informativeness. Importantly, the greater information asymmetry that arises due to the manager acquiring private information (but not the asymmetry due to her learning from the stock price) results in greater expected profits to the informed trader. The model suggests that manager's learning increases the incentives of the informed trader to gather precise information.

CHAPTER I

Bad Luck, You're Fired! Firm Performance and CEO Dismissal

1.1 Introduction

The board of directors plays a complex and important role in governing a firm. One of the most important tasks of the board is to appoint and, if needed, replace a CEO. Directors are elected to the board to represent the interest of the firm's shareholders. In an ideal world, the board should maximize shareholder value using all available information. However, in the real world, the board of directors may not adhere to maximizing the interests of the shareholders of the firm. The board of directors has incentives to care about their reputation in the labor market for directors because favorable reputation is rewarded through additional board seats, prestige, and compensation of the directors (see, e.g., Levit and Malenko (2016)).

Reputational concerns have been shown to play a role in various settings in the fields of labor economics and financial economics. e.g. see Scharfstein and Stein (1990), Bar-Isaac and Shapiro (2011), Dasgupta and Prat (2008), Chevalier and Ellison (1999), Hong et al. (2000), and Boyson (2010). Due to these reputational concerns, the board may ignore some private information available while making the firing and retaining decision. An example where directors' ignore their private information is the fake accounts scandal of Wells Fargo. In September 2016, regulators fined Wells Fargo for creating millions of fake bank accounts. Press reports reveal that board of directors received "regular" reports[1] about suspicious activity related to sales and employee misconduct. It appears that board members chose to ignore that information and retain the CEO since the firm was performing well.

Do reputational concerns of the board of directors affect CEO dismissal? Existing research has studied various factors that affect CEO turnover and the sensitivity of CEO turnover to firm performance. For example, Huson et al. (2004) study the role of independent directors and institutional shareholders on CEO dismissal. Mobbs (2013) examines the CEO turnover-performance sensitivity for companies with access to replacement CEO candidates. He finds that boards with viable internal CEO replacement alternatives monitor the CEO better. Guo and Masulis (2015) study the role of board independence on CEO turnover. Jenter and Kanaan (2015) study whether CEO turnover is affected by factors outside of CEO's control. Despite so many important frictions being studied in the literature, still, not many papers[2] have studied the role of directors' reputational concerns on CEO turnover-performance sensitivity. My paper aims to fill this gap. I argue that reputational concerns about how its decision will be perceived in the labor market for directors give the board an incentive to ignore some of its own information when deciding whether to retain or fire a CEO. As a result, luck plays a prominent role in the board's decision to fire or retain a CEO.

I develop a model in which directors care about both firm value and labor market perception of their decision. In addition to observing firm performance, the board receives a private signal about the CEO type. However, the market only observes firm performance and the board's decision. Because the market's information about the CEO is inferior to that of the board, it perceives the board's decision to fire (retain) in

[1] http://fortune.com/2017/04/14/wells-fargo-fake-accounts-2/
[2] see Masulis and Mobbs (2014) and Fos et al. (2017)

response to poor (good) firm performance as favorable. When reputational concerns are high, the board has a greater incentive to fire a CEO after poor performance, even if it has a good private signal, because that decision is perceived as favorable. Similarly, after good firm performance, even if it receives a poor private signal, the board has an incentive to retain a CEO. In other words, the board penalizes (rewards) the CEO for bad (good) luck.

The model generates three main results. First, the board makes inefficient use of its own information due to reputational concerns. Because the directors care about the labor market's beliefs about their decision, they rely excessively on firm performance to make firing decisions. CEOs are fired more (less) often than they should after poor (good) firm performance. Second, when the publicly available information about the CEO is less precise, the agency friction is more severe, because the board's additional information advantage is greater. In this case, the effect of reputational concerns on turnover-performance sensitivity is stronger. Third, the inefficient decision of the board results in retaining a bad manager more often. Thus, the future firm performance of the retained managers declines if the decision to retain is driven by greater reputational concerns.

The main empirical prediction from the model is that turnover-performance sensitivity increases with directors' reputational concerns. I test this prediction using the number of years a director has been in a role (years-in-role) on the board as an inverse proxy for reputational concerns. I compute this measure at the firm-year level by taking the average of a director's years-in-role across all directors on the board. I find turnover-performance sensitivity is greater in the early years of a director's role when directors have greater incentives to care about reputational payoff. In terms of economic significance, a one-year decrease in a director's number of years in the role is associated with a 27% increase in turnover-performance sensitivity.

A clean identification of the relation between directors' years in their role and turnover-performance sensitivity faces several challenges. One might be concerned that increases in CEO turnover-performance sensitivity is driven by a less entrenched board. For instance, serving for a longer time in a role on the board might be correlated with weaker governance (if the board is entrenched or has stronger ties with the CEO). Moreover, directors who have served longer in their role may be better informed about the CEO type. In both scenarios, the longer the time in the role, the lower the turnover-performance sensitivity. Further, that association reflects the effect of weaker corporate governance or better information about the CEO type, instead of reputational concerns.

To address these concerns, I analyze the CEO turnover-performance sensitivity around the promotions of existing directors. For instance, in a particular year, a director may be promoted from an Independent Director to a Chairman. I argue that a director in a new role of greater visibility and responsibility, such as a Chairman or a Lead Independent Director, will be more careful in making decisions to establish himself as a smart director. Thus, I only consider the promotions in which a director takes on a new role of a Chairman or a Lead Independent Director. I label the firm year in which at least one of the directors on the board undergoes a promotion as treatment firm-year. For each year in the sample period, I use nearest-neighbor propensity score matching to obtain a set of control firms that are similar to the pre-role-change treated firms. Using the matched set of treated and control firms, I examine the effect of a promotion of a director on the turnover-performance sensitivity for treated firms over a four-year period before and after the promotion, relative to control firms at which no such promotion occurs. I find the promotion in the treated firms is associated with a 28% increase in the turnover-performance sensitivity over a four-year period.

The identifying assumption is that any confounding factor, such as board's private information or board entrenchment that affects the CEO turnover-performance sensitivity, affects the treatment and control group in the same manner. Another advantage of using the promotion of existing directors to capture the effect of reputational concerns is as follows. Because the tenure of the existing directors increases after the promotion, on average, the board's entrenchment, if anything, should increase after the promotion. Thus, in the years after the promotion, the board's greater entrenchment should decrease turnover-performance sensitivity. On the contrary, I find turnover-performance sensitivity increases after the promotion.

The test of the second prediction of the model allows me to shed some light on the drivers of the main result. The model predicts that the effect of reputational concerns on turnover-performance sensitivity is stronger for firms at which the public information about the CEO is worse. I capture the precision of public information about the CEO using three proxies: the number of analysts following the firm, size (measured by market capitalization) of the firm, and institutional ownership of the firm. For all three proxies, a lower measure signifies worse public information about the CEO. I divide the sample into three groups sorted by each proxy. I estimate the effect of director promotions on turnover-performance sensitivity using the matched set of treatment and control firms for the bottom and top tercile. I find the effect of a promotion on turnover-performance sensitivity is mainly driven by firms that are followed by fewer analysts, are smaller in size, and have lower institutional ownership.

The result on greater CEO turnover-performance sensitivity after director promotions suggests that an increase in reputational concerns affects CEO turnover-performance sensitivity. However, there can be alternative explanations for the same result. Perhaps, only boards with weaker governance have promotions as a mechanism to strengthen corporate governance. For instance, the director promotion happens in response to CEO or Chairman entrenchment, so entrenchment will be correlated with promotion. Perhaps shareholder activists drive promotions on the board as well as turnover-performance sensitivity. The test of the third empirical prediction of the model allows me to alleviate some of those concerns. Importantly, this test helps me to distinguish my story from alternative stories that may associate the increase in turnover-performance sensitivity after promotions with improved governance.

The third prediction is that the directors' reputational concerns lead to retaining the bad-type manager too often. To test this prediction, I compare the future firm performance of the retained managers of treated firms before and after the promotion relative to those of control firms. If boards with weaker governance, for instance, board with entrenched Chairman, are self-selected into the treatment group and the promotion improves internal governance, then the pool of retained managers should consist of prominently good-type managers, leading to better future firm performance. On the contrary, I find the future firm performance of retained managers declines for treated firms after the promotion. In terms of economic significance, the future firm performance (measured by the average firm profitability over three years) decreases by 1.3% for treated firms after a promotion. This result suggest the directors' reputational concerns may result in inefficient retention of bad-type managers.

I conduct several robustness tests on the main results. I use the equity compensation of directors as a proxy of alignment of their interest with the shareholders. I find turnover-performance sensitivity is lower when the proportion of equity compensation to total compensation of directors is high. I use board tenure as another inverse proxy for reputational concerns. I find turnover-performance sensitivity is lower for directors with longer tenure. I also use director deaths as an exogenous shock to a board's years-in-role and board tenure (arrival of new replacement directors). I find turnover-performance sensitivity is greater in the five-year period after the director death compared to five years before the director death.

In the empirical analyses, I control for CEO age, CEO tenure, firm size, board size, book leverage, board's busyness, proportion of non-executive directors on the board, and directors' past experience. I also include year, industry, industry-times-year and firm fixed effects to control for any time-specific macro shock, time-invariant or time-varying (observable or unobservable) industry specific variables, or time invariant (observable or unobservable) firm-specific variables. The main results remain unchanged.

My paper contributes to several strands of literature. First, my study is related to the literature on CEO turnover.[3] Two papers closest to my paper are Dow (2013) and Fisman et al. (2013). Dow (2013) analyzes a model in which the board retains the CEO more because firing sends a bad signal about firm prospects and increases the cost of capital. In that model, firing is a value-maximizing decision. Instead, in my paper, an agency friction exists between the board and the shareholders. Directors retain the CEO after good firm performance despite poor private information because they care about the labor market's beliefs about their decision. Fisman et al. (2013) show board entrenchment improves the firing decision. By contrast, in my paper, the agency friction between the board and the shareholders represented by the directors' reputational concerns lead them to make inefficient firing decisions.

Second, several papers have analyzed the role of board of directors in corporate governance.[4] My study is related to the papers that study the impact of labor market for directors on CEO turnover-performance sensitivity. Fos et al. (2017) examine electoral incentives of the directors and show that when directors are closer to election, turnover-performance sensitivity is greater. Masulis and Mobbs (2014) examine reputation incentives of directors and show turnover-performance sensitivity is greater for firms that directors consider more prestigious. In these papers, higher turnover-performance sensitivity is interpreted as an improvement in board monitoring. My

[3] see, e.g., Hermalin and Weisbach (1998), Adams and Ferreira (2007), Kaplan and Minton (2012), Coughlan and Schmidt (1985), Warner et al. (1988), Huson et al. (2004), Eisfeldt and Kuhnen (2013), Huson et al. (2001), Taylor (2010), Cornelli et al. (2013), Huang et al. (2015), Denis and Denis (1995).

[4] See Hermalin and Weisbach (2003) and Adams et al. (2010) for a survey. Various papers have studied the role of busy boards (Fich and Shivdasani (2006) and Falato et al. (2014)), co-opted boards (Coles et al. (2014)), female directors (Adams and Ferreira (2009)), outside directors (Weisbach (1988), Duchin et al. (2010), Guo and Masulis (2015)), and directors' financial expertise (Güner et al. (2008)) in corporate governance.

paper contributes to this literature in the following ways. First, it provides a novel measure to proxy for reputational concerns of the board. Second, I provide a novel perspective on turnover-performance sensitivity. The findings suggest the increase in turnover-performance sensitivity reflects the higher agency friction between the board and shareholders. As a result, the future firm performance is lower when managers are retained due to reputational concerns.

Third, my paper is related to the broad idea in which myopic concerns may lead the agents to make inefficient decisions (Stein (1989)). Brandenburger and Polak (1996) show that stock price concerns may lead managers to partly ignore their superior information. Gao et al. (2017) suggest that investor myopia may lead to greater turnover-performance sensitivity in public firms relative to private firms. Similarly, in my paper, the board that cares more about the market perception, is more likely to dismiss the CEO in response to poor firm performance, even if it receives a good private signal. Finally, my paper also complements the papers that study the role of luck in CEO compensation (Bertrand and Mullainathan (2001), Gopalan et al. (2010), Garvey and Milbourn (2006)) and CEO dismissal (Jenter and Kanaan (2015), Jenter and Lewellen (2017), Fee et al. (2017), Cheng and Indjejikian (2009)).

The remainder of the paper is organized as follows. In the next section, I describe the model, obtain the comparative statics, and build empirical predictions of the model. In Section 3, I describe the research design, data, and variables and test the hypotheses using regression models. Section 4 concludes.

1.2 Model

The model uses three dates: 0, 1, and 2. At date 0, a manager works on a project. The project produces an output y_1 at date $t = 1$ and y_2 at date $t = 2$. The manager can be of two types, good (g) and bad (b). The good-type manager is drawn with a probability of $\frac{1}{2}$. The distribution of y_t depends on the type of the manager working on the project from $t-1$ to t. The output y can be either high (y_h) or low (y_l). I assume a good-type manager generates output y_h with probability ψ and output y_l with probability $1-\psi$. A bad-type manager generates output y_h with probability $1-\psi$ and output y_l with probability ψ where $\psi > 0.5$. For simplicity, I assume $y_h = 1$ and $y_l = 0$.

At date 1, output y_1 is realized. The board observes a signal s about the manager type after output has been realized. A good-type manager generates a signal s_g with probability α and signal s_b with probability $1-\alpha$. A bad-type manager generates a signal s_g with probability $1-\alpha$ and s_b with probability α. Once the board has received the signal s, it decides to fire or retain the manager. If retained, the manager continues to work for the second period and produces output y_2 at $t=2$. If the manager is fired, the board has to hire a new manager. The new manager works for the second period and produces output y_2 depending on his type.

The market does not observe the signal received by the board, but it observes the board's firing decision and updates its beliefs about the manager type using the firm output and the board's decision. Denote the market's posterior beliefs about the manager type by μ.

The board cares about long-term firm value and the labor market's beliefs about the board's decision. The directors on the board have incentives to care about labor market beliefs because favorable beliefs are rewarded through additional board seats, prestige, and compensation of the directors (see, e.g., Levit and Malenko (2016)). In the paper, I do not explicitly model board with different types. See Dow (2013) for a model in which the board's ability to select CEOs can vary. However, implicitly rewarding the directors based on favorable beliefs about their decision provides the labor market a way to screen the good directors from the bad ones who, perhaps, choose to fire randomly. That is, the directors' decision to fire the manager has to be correlated with the directors' ability. Directors with worse ability will make wrong decisions. In other words, if the market believes that the board has fired (retained) the bad (good) type manager, then it must be that the directors are good. For simplicity, I assume the board receives a reward 1 if the labor market believes the fired manager is a bad type or a retained manager is a good type, and 0 if the market believes the fired manager is a good type or a retained manager is a bad type. The results of the model will remain the same if I assume the reward to be 1 and -1 instead of 1 and 0.

I define the labor market beliefs about the board's decision to fire (retain) as more *favorable* to the board if the posterior probability that the manager is a bad (good) type given that he is fired (retained) is higher. I define the board's payoff by firing as $(1-\beta)v + \beta\mu(b|f)$, where v denotes the expected cash flows of the firm from $t = 1$ to $t = 2$ and $\mu(b|f)$ denotes the market's belief that the fired manager is a bad type. Because the reputational payoff is 1 (0) if the market believes the fired manager is a bad (good) type, $\mu(b|f)$ is also equal to the expected reputational payoff the board receives. Similarly, the board's payoff by retaining is defined as $(1 - \beta)v + \beta\mu(g|r)$, where $\mu(g|r)$ denotes the market's belief that the retained manager is a good type. $\beta \in [0, 1]$ denotes the extent of reputational concerns of the board of directors.

From the market's perspective, two states of the world exist: high-output state H and a low-output state L. I analyze perfect Bayesian equilibria in both states of the world. In any equilibrium of the game, the board receives signal s_g or signal s_b. The board has to decide to fire or retain the manager upon receiving both signals. Denote A_g as the board with signal s_g, and A_b as the board with signal s_b. To simplify exposition, if the board with signal s_g (s_b) retains or fires the manager, I say board A_g (A_b) retains or fires the manager, respectively.

First, I examine the equilibria when $\alpha < \psi$; that is, the precision of the board's private information is worse than the precision of information in output. In the lemma below, I show that in those equilibria, the agency friction β does not play a role in the firing decision.

In state H, board A_g beliefs about a good-type manager are strengthened by the realization of output H. Because $\alpha < \psi$, information in output dominates the board's information. Board A_b beliefs that the manager is a good type is more than the prior 0.5. Thus, retaining the manager maximizes firm value for both A_g and A_b.

Suppose an equilibrium exists in which both A_g and A_b choose to retain the manager. In this equilibrium, the board's decision to retain the manager does not give any information about the board's signal to the market. Thus, the equilibrium expected reputational payoff by retaining is ψ (because the state is H). Firing is off-equilibrium.

This equilibrium is sustained by an off-equilibrium belief that the board has signal s_b given that the manager is fired. Thus, the labor market beliefs that the fired manager is a bad type is smaller than the prior 0.5 (because $\alpha < \psi$). It implies the reputational payoff by firing is smaller than the equilibrium reputational payoff by retaining (ψ). Thus, retaining the manager maximizes the reputational payoff too. Therefore, it is strictly dominant for boards A_g and A_b to retain the manager for all $\beta \in [0, 1]$.

Similarly, in state L, because $\alpha < \psi$, the board's payoff from the project is smaller than the payoff from firing and hiring a new manager. Thus, firing the manager maximizes firm value. This equilibrium is sustained by an off-equilibrium belief that the board has signal s_g given that the manager is retained. The equilibrium reputational payoff by firing (ψ) is also greater than the reputational payoff by retaining (smaller than 0.5). Therefore, it is strictly dominant for boards A_g and A_b to fire the manager for all $\beta \in [0, 1]$.

Lemma I.1. *If $\alpha < \psi$ and*

(a) state is H, a pooling equilibrium exists in which the board with signal s_g and the board with signal s_b retain the manager for all $\beta \in [0, 1]$.

(b) state is L, a pooling equilibrium exists in which the board with signal s_g and the

board with signal s_b fire the manager for all $\beta \in [0, 1]$.

Proof. See Appendix. ■

This lemma shows that the agency friction does not play a role in the board's decision when $\alpha < \psi$. Because board's information is less precise than the information in output, both the market's and the board's beliefs are more responsive to the latter. In state H (L), the board's expected cash flows by retaining (firing) is greater than the expected cash flows by firing (retaining). Further, the board's decision to retain (fire) is perceived as more favorable than the board's decision to fire (retain) in state H (L). Thus, the board's optimal strategy is to retain the manager in state H and fire the manager in state L.

Next, I analyze the more interesting set of equilibria when $\alpha > \psi$. That is, the board's private information about the manager type is better than the information in output. In that set of equilibria, the agency friction β plays a significant role in the board's strategy.

1.2.1 State H

First, consider the case in which the state is H. Suppose an equilibrium exists in which A_g retains. In this equilibrium, A_b faces a trade-off between firing and retaining the manager. Because A_b has signal s_b, it is pessimistic about the future cash flows of the project from the retained manager. If A_b retains the manager, it receives lower expected cash flows from the project than by firing and hiring a new manager. Thus, firm shareholders would want A_b to fire the manager. On the other hand, by retaining the manager, A_b pools with A_g, leading to a greater reputational payoff. The reason is that, in state H, the board's decision to retain is perceived as more favorable than the board's decision to fire. Thus, the reputational payoff provides incentives to A_b to ignore its signal and retain the manager.

By firing the manager, A_b receives a greater payoff from the project, but reveals its signal to the market, thereby lowering the reputational payoff, because the market perceives the decision to fire in state H as less favorable. Therefore, if β is small enough, the payoff from the project dominates the reputational payoff and the board A_b chooses to follow its own signal and fire the manager.

Define $\beta_s(\alpha, \psi)$:

$$\beta_s(\alpha, \psi) = \frac{1}{1 + \frac{2\alpha(1-\alpha)}{(\alpha-\psi)(\psi\alpha+(1-\psi)(1-\alpha))}} .$$

If A_g retains the manager, it receives a greater payoff from the project because signal s_g strengthens the board's beliefs about the manager being a good type in state H. Further, it receives a greater reputational payoff because the market's beliefs about the board's decision to retain are more favorable in state H. Therefore, it is optimal for A_g to retain the manager for all β.

If $\beta < \beta_s(\alpha, \psi)$, the board prefers to maximize firm value; therefore, board A_b relies on its signal s_b and chooses to fire the manager. If $\beta > \beta_s(\alpha, \psi)$, the higher reputational payoff by retaining the manager in state H gives incentives to board A_b to ignore its signal and retain the manager.

If β is very high, the higher reputational payoff by retaining the manager outweighs the low expected cash flows due to pessimistic beliefs of board A_b. In that case, A_b has incentives to pool with A_g and retain the manager. This equilibrium is sustained by an off-equilibrium belief that the manager is being fired by board A_b. If either board A_g or A_b deviates to firing, it receives the same payoff (a combination of project payoffs from a new manager and reputational payoff by firing). In this equilibrium, the reputational payoff by retaining is equal to ψ. The payoff from the project is greater for A_g than for A_b because signal s_g makes the board more optimistic about future cash flows from the project. Thus, overall, A_g receives a higher equilibrium payoff than A_b. Therefore, if any board deviates to firing, the market must believe it is A_b.

Define

$$\beta_p(\alpha, \psi) = \frac{1}{1 + 2\frac{\psi^2(1-\alpha)-(1-\psi)^2\alpha}{(\alpha-\psi)(2\psi-1)}} .$$

If $\beta > \beta_p(\alpha, \psi)$, board A_b chooses to ignore its private information and retain the manager. The expected project payoff from the retained manager is lower, but the reputational payoff overcomes the decrease in the expected project payoff. Thus, it is an optimal strategy for the board A_b to retain the manager.

If β is in the range $[\beta_s, min(\beta_p, 1)]$, a hybrid equilibrium exists in which A_g retains the manager and A_b is indifferent between firing and retaining the manager.

Suppose the market believes the board A_b fires with probability one. In that case, if the market observes retention, it must believe the manager is retained by board A_g. If A_g retains the manager in state H, its reputational payoff is high because the board's decision to retain is perceived as more favorable than the board's decision to fire. This gives incentives to board A_b to retain the manager. If $\beta > \beta_s$, the board puts enough weight on the reputational payoff such that the separating equilibrium fails to hold and A_b does not fire with probability one.

Now, suppose the market believes board A_b retains with probability one. In this case, the reputational payoff from retaining is equal to ψ: this reputational payoff from retaining the manager is lower than that in the separating equilibrium when A_b fires the manager. Thus, the incentives for board A_b to retain the manager are lower. If $\beta < min(\beta_p, 1)$, the pooling equilibrium fails to hold.

In the hybrid equilibrium, A_b is indifferent between firing and retaining the manager. It fires the manager with probability δ_h. I summarize the results of this section in the following proposition.

Proposition I.2. *If $\alpha > \psi$ and*

(a) $\beta < \beta_s(\alpha, \psi)$, a separating equilibrium exists in which the board with signal s_g retains the manager and the board with signal s_b fires the manager.

(b) $\beta \in [\beta_s(\alpha, \psi), min(\beta_p(\alpha, \psi), 1)]$, a hybrid equilibrium exists in which the board with signal s_g retains the manager and the board with signal s_b mixes between firing and retaining the manager.

(c) $\beta > \beta_p(\alpha, \psi)$, a pooling equilibrium exists in which both the board with signal s_g and the board with signal s_b retain the manager.

Proof. See Appendix. ■

1.2.2 State L

Next, consider the case in which the state is L. In contrast to the previous section, in this state, it is optimal for board A_b to fire the manager for all $\beta \in [0, 1]$, whereas board A_g faces a trade-off between retaining and firing the manager. Due to the symmetric structure of the game, the intuition for the existence of various equilibria follows the same logic. Further, the parameter range of β necessary for the existence of the set of equilibria also remains the same. In this section, I briefly describe the intuition for the existence of a set of equilibria in state L.

Suppose an equilibrium exists in which A_b fires. In this equilibrium, A_g is optimistic about the future cash flows of the project from the retained manager. If A_g retains the manager, it receives greater expected cash flows from the project. Thus, shareholders would prefer A_g to retain the manager. On the other hand, by firing the manager, A_g pools with A_b, leading to a greater reputational payoff. The reason is that, in state L, the board's decision to fire is perceived as more favorable than the board's decision to retain. Therefore, the reputational payoff provides incentives to A_g to ignore its signal and fire the manager.

Therefore, if β is small enough, the payoff from the project dominates the reputational payoff and the board A_g chooses to follow its own signal and retain the manager. Specifically, if $\beta < \beta_s(\alpha, \psi)$, a separating equilibrium exists in which the board relies on its own signal to make the firing decision: A_g retains the manager and A_b fires the manager.

If A_b fires the manager, it receives a greater project payoff from the new manager because, in state L, signal s_b strengthens the board's beliefs about the manager being a bad type. Further, it receives a greater reputational payoff because market's beliefs about the board's decision to fire are more favorable in state L. Therefore, it is optimal for A_b to fire the manager for all β.

If $\beta < \beta_s(\alpha, \psi)$, the board prefers to maximize firm value; thus, board A_g relies on its signal s_g and chooses to retain the manager. If $\beta > \beta_s(\alpha, \psi)$, the higher reputational payoff by firing the manager in state L gives incentives to board A_g to ignore its signal and fire the manager.

If β is very high, the higher reputational payoff by firing the manager outweighs the decrease in cash flows for board A_g. In that case, A_g has incentives to pool with A_b and fire the manager. This equilibrium is sustained by an off-equilibrium belief that board A_g is retaining the manager. In contrast to the pooling equilibrium in state H, in this state, the equilibrium payoff from firing the manager is the same for board A_g and A_b. Upon deviating to retaining, board A_g receives a higher payoff because it has signal s_g that makes it optimistic about the expected cash flows from the project. Therefore, if any board deviates to retaining, the market must believe it is A_g.

Thus, this pooling equilibrium in which A_g and A_b fire the manager exists if $\beta > \beta_p(\alpha, \psi)$. In this equilibrium, board A_g chooses to ignore its private information and fire the manager, because firing in state L provides a higher reputational payoff.

If β is in range $[\beta_s, min(\beta_p, 1)]$, a hybrid equilibrium exists in which A_b fires the manager and A_g is indifferent between firing and retaining the manager. I denote the probability of firing the manager in state L by δ_l.

Suppose the market believes the board A_g retains with probability one. In that case, the reputational payoff provides incentives to A_g to ignore its signal and fire the manager. If $\beta > \beta_s$, the reputational payoff breaks the separating equilibrium, and A_g does not retain with probability one. Now, suppose the market believes the board A_g fires with probability one. In this case, the reputational payoff from firing is equal to ψ: this reputational payoff from firing is lower than that in the separating equilibrium when A_g retains the manager. Thus, the reputational payoff breaks the pooling equilibrium if $\beta < min(\beta_p, 1)$.

I summarize the results of this section in the following proposition.

Proposition I.3. *If $\alpha > \psi$ and*

(a) $\beta < \beta_s(\alpha, \psi)$, a separating equilibrium exists in which the board with signal s_g retains the manager and the board with signal s_b fires the manager.

(b) $\beta \in [\beta_s(\alpha, \psi), \min(\beta_p(\alpha, \psi), 1)]$, a hybrid equilibrium exists in which the board with signal s_g mixes between firing and retaining the manager and the board with signal s_b fires the manager.

(c) $\beta > \beta_p(\alpha, \psi)$, a pooling equilibrium exists in which both the board with signal s_g and the board with signal s_b fire the manager.

Proof. See Appendix. ∎

The thresholds β_s and β_p are the same as in proposition I.2 (state H). The main difference, however, is that in state H, the reputational payoff provides incentives to board A_b to retain the manager because the market believes retaining is the correct decision. In state L, however, the reputational payoff provides incentives to board A_g to fire the manager, because the market believes firing is the correct decision. So, if β is high, board A_g chooses to ignore its own signal s_g and fire the manager.

The figure above shows the parameter space of α and β for the existence of the

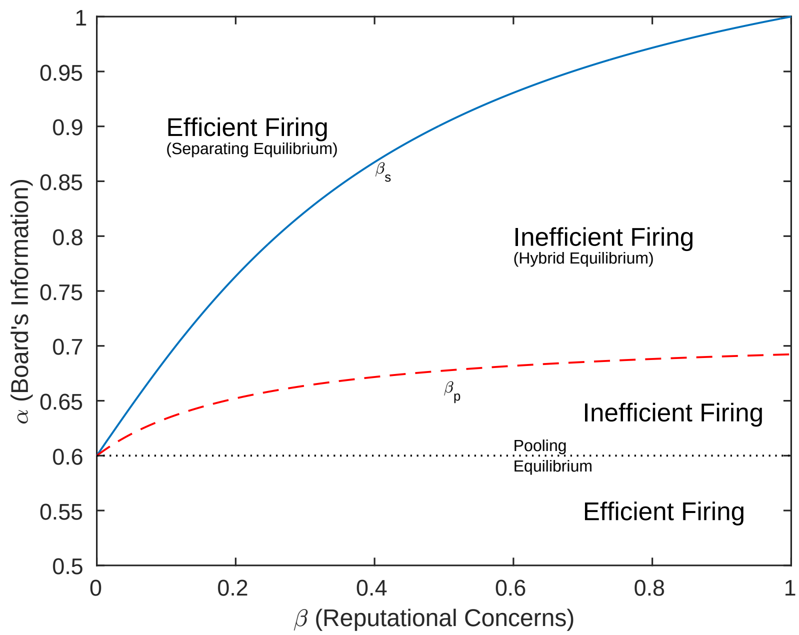

Figure 1.1: This figure shows the equilibrium cut-offs in the model. The parameter values used are $\psi = 0.6$.

set of equilibria in state H and state L in a numerical example. The parameter ψ is set equal to 0.6. The solid line shows the values of β that separates the separating and hybrid equilibria in both states. If $\beta < \beta_s$, board A_b (A_g) uses its own private signal and fires (retains) the manager in state H (L). This firing decision is efficient because the board uses its own private signal. If $\beta > \beta_s$, the reputational payoff provides incentives to the board to ignore its own signal and choose a decision the market believes to be correct. Therefore, A_b (A_g) has incentives to retain (fire) the manager in state H (L). The dashed line shows the values of β that separate the hybrid and pooling equilibria in both states. If $\beta > \beta_p$, board A_b (A_g) ignores its information completely and retains (fires) the manager in state H (L). Thus, board makes inefficient firing decisions (when $\beta > \beta_s$ and $\alpha > \psi$) by partially or completely ignoring its private information.

1.2.3 Comparative Statics

In this section, I obtain the comparative statics with respect to the main parameter of the model (β). First, I analyze how the sensitivity of CEO dismissal to firm performance is affected by β. Second, I examine how the strength of this relationship changes when the board's information is relatively more or less precise than the public information. Finally, I examine the consequence of the board's inefficient decision due to the incentives from reputational concerns. In particular, I analyze how the board's reputational concerns affect the future performance of the firm.

1.2.3.1 CEO Turnover

In this section, I analyze how the board's reputational concerns affect the sensitivity of the probability of firing to firm performance. First, I obtain the partial derivative of δ_h with respect to β:

$$\delta_h = f^{-1}\left(\frac{(1-\beta)(\alpha-\psi)(2\psi-1)}{2\beta(\psi(1-\alpha)+\alpha(1-\psi))} + \frac{(1-\psi)\alpha}{(1-\psi)\alpha+(1-\alpha)\psi}\right)$$

where

$$f(x) = \frac{\psi(\alpha+(1-\alpha)(1-x))}{\psi(\alpha+(1-\alpha)(1-x))+(1-\psi)(\alpha(1-x)+(1-\alpha))}\ .$$

.

Because $f(x)$ is an increasing function, the equilibrium firing probability (δ_h) of board A_b in state H is decreasing in β. If the board fires the manager more when its signal is poor, retention becomes a more credible signal about the board's good information.

Next, I obtain the partial derivative of δ_l with respect to β:

$$\delta_l = g^{-1}\left(\frac{(1-\beta)(\alpha-\psi)(2\psi-1)}{2\beta(\psi(1-\alpha)+\alpha(1-\psi))} + \frac{(1-\psi)\alpha}{(1-\psi)\alpha+(1-\alpha)\psi}\right)$$

where

$$g(x) = \frac{\psi(\alpha+(1-\alpha)x)}{\psi(\alpha+(1-\alpha)x)+(1-\psi)(\alpha x+(1-\alpha))}\ .$$

Notice that $g(x)$ is decreasing in x. Therefore, the equilibrium firing probability (δ_l) of board A_g in state L is increasing in β.

Next, I compare the unconditional ex-ante probability of firing the manager in state H and state L as β goes from 0 to 1. First, I obtain the probability of firing the manager in state H. If $\alpha > \psi$ and $\beta < \beta_s$, the board fires the manager after signal s_b in both states. The probability that the board receives s_b in state H is equal to $\psi(1-\alpha)+(1-\psi)\alpha$. If $\beta \in (\beta_s, \min(\beta_p, 1))$, the board fires the manager upon receiving s_b with probability δ_h. The probability of firing the manager in that range is equal to $(\psi(1-\alpha)+(1-\psi)\alpha)\delta_h$. If $\beta > \beta_p$, the board retains the manager after both signals.

In state L, if $\alpha > \psi$ and $\beta < \beta_s$, the board fires the manager after s_b. The probability that the board receives s_b in state L is equal to $(1-\psi)(1-\alpha)+\psi\alpha$. If $\beta \in (\beta_s, \beta_p)$, the board fires the manager after s_b and with probability δ_l after receiving s_g. The probability of firing the manager in that range is equal to $(1-\psi)(1-\alpha)+\psi\alpha+(\psi(1-\alpha)+(1-\psi)\alpha)\delta_l$. If $\beta > \beta_p$, the board fires the manager after both signals.

Because δ_h is decreasing with β and δ_l is increasing with β, overall, the turnover-performance sensitivity increases with β. I summarize this result in the following proposition.

Proposition I.4. *If* $\alpha > \psi$ *and* $\beta \in [\beta_s, \min(\beta_p, 1)]$*, the probability of firing the* *manager in state H (L) is decreasing (increasing) with β.*

Next, I analyze how the parameter ψ affects the above relation between the probability of firing and β in state H and state L. The result of the above proposition holds only if $\alpha > \psi$. It implies turnover-performance sensitivity increases with β, only for firms where the board's private information is relatively more precise than the public information. Lemma I.1 shows if $\alpha < \psi$, turnover-performance sensitivity does not vary with β. It suggests that for firms where the board's private information is relatively less precise than public information, turnover-performance sensitivity should remain the same for high β and low β firms.

1.2.3.2 Ex-Post Performance

In this section, I analyze how the board's decision affects the performance of the firm in the second period. If the board retains the manager due to reputational concerns, it is making an inefficient decision. In particular, if the board retains the manager despite its poor signal, that manager is more likely to have a bad type, leading to poor performance in the second period.

In state H, A_g retains the manager for all $\beta \in [0, 1]$. Board A_b relies on its own signal and fires the manager if $\beta < \beta_s$. If $\beta \in [\beta_s, \min(\beta_p, 1)]$, a hybrid equilibrium exists in which A_b fires the manager with probability δ_h and retains otherwise. In this equilibrium, conditional on retention, the probability that the manager in the second period has a good type is

$$\frac{\psi(\alpha + (1-\alpha)(1-\delta_h))}{\psi(\alpha + (1-\alpha)(1-\delta_h)) + (1-\psi)(\alpha(1-\delta_h) + (1-\alpha))}.$$

In state H, the board fires the manager less often if β is high (see Proposition I.4). This greater retention of the CEO decreases the value of retention as a signal of a good manager. Thus, given that the manager is retained, the posterior beliefs that he is a good type is lower if β is high. Similarly, in state L, A_b fires the manager for all $\beta \in [0,1]$. Board A_g relies on its own signal and retains the manager if $\beta < \beta_s$. If $\beta \in [\beta_s, \min(\beta_p, 1)]$, a hybrid equilibrium exists in which A_g fires the manager with probability δ_l and retains otherwise. In this equilibrium, retention reveals the board's signal. Therefore, conditional on retention, the probability that the manager in the second period is a good type does not vary with β.

Therefore, across states H and L, it is easy to see that given the manager is retained, the probability that he is a good type decreases with β. In that case, the expected cash flows in the second period are also decreasing with β because they are determined using the distribution of the retained-manager type.

Corollary I.5. *If $\alpha > \psi$ and $\beta \in [\beta_s, \min(\beta_p, 1)]$, then given that the manager is retained, the expected cash flows in the second period are decreasing with β.*

Instead, if the board chooses to fire the manager, he is replaced with a new manager. In the model, I have implicitly assumed the career of the fired manager ends after firing. Therefore, the model does not generate any comparative statics of the future performance of the manager who is fired.

1.2.4 Empirical Predictions

In this section, I develop empirical predictions on the relation between reputational concerns and turnover-performance sensitivity using the comparative statics of the model. The first prediction builds on the comparative statics with respect to parameter β in the model. The model predicts that, all else equal, if $\alpha < \psi$, the sensitivity of CEO turnover with respect to performance does not vary with β. However, if $\alpha > \psi$, the sensitivity of CEO turnover with respect to performance increases with β.

In the model, parameter α represents the precision of board's information. This parameter α might vary across firms. Thus, turnover-performance sensitivity increases with β for firms that have higher values of this parameter, and does not change with β for firms that have lower values of this parameter. However, on average, one would expect CEO turnover-performance sensitivity to increase with the board's reputational concerns (β). This results in the below hypothesis.

Hypothesis 1. CEO dismissal is more sensitive to firm performance when the board's reputational concerns are higher.

To test this hypothesis, I need to construct a proxy for reputational concerns of directors on the board. I exploit the promotions of a director to capture the director's reputational concerns. The motivation for using this approach is based on the idea that in the early years of their role on the board, directors have greater reputational concerns (Holmström (1999)). In the literature, researchers have used several proxies related to an agent's tenure to capture reputational/career concerns. Hong et al. (2000) study the career outcomes of security analysts and show inexperienced analysts face a greater threat of termination for inaccurate forecasts than experienced analysts. Chevalier and Ellison (1999) study mutual fund managers and show younger managers face a greater threat of termination for poor performance than older managers. Lim et al. (2016) show younger hedge funds receive greater future flows upon good current performance.

Recall that in this model, director's reputational concerns affect their firing decisions only if they have better information about the CEO type. So although director's age and experience on other boards may affect their long-term reputation, to have better information about the CEO, the director must have a seat on that firm's board. Therefore, a director's years-in-role is a reasonable way to capture his reputational concerns, because it allows the directors to obtain a signal about that firm's CEO. I describe other advantages of using this approach in the Research Design section below.

The second prediction builds on how the comparative statics in proposition I.4

change with respect to parameter ψ in the model. Parameter ψ represents the precision of information about the CEO type that can be extracted from firm performance. The model predicts that if ψ is high relative to α, turnover-performance sensitivity does not change with reputational concerns. When ψ is low relative to α, turnover-performance sensitivity increases with the board's reputational concerns.

The model results remain the same if the parameter ψ is interpreted as the market's beliefs about the CEO type given all publicly available information, not just firm performance. Arguably, when a firm has a higher number of analysts following, the publicly available information is more precise relative to the board's private information. The role of analysts is to provide a comprehensive analysis of cash flows of the firm and to provide forecasts to the investor community. This role requires them to obtain information about the drivers of future prospects of the firm including, but not limited to, CEO characteristics. Therefore, a greater number of analysts following a firm increases the precision of public information about the CEO characteristics.

In addition, firms with a larger market capitalization and greater institutional ownership have stronger external governance mechanisms that increase the precision of publicly available information. For instance, proxy fights by activists attract media and investor attention, thus providing an additional signal about the firm/CEO type to the market and improving the precision of public information. This results in the below hypothesis.

Hypothesis 2. The effect of reputational concerns on turnover-performance sensitivity is stronger for firms that are followed by fewer analysts, are smaller, and have lower institutional ownership.

The third prediction analyzes the consequences of a board's inefficient decision due to reputational concerns. The model predicts the board, due to reputational concerns, may ignore its private information and retain the manager despite its poor signal. In that case, the retained manager would be associated with lower future performance of the firm.

Hypothesis 3. The ex-post firm performance of the retained manager is lower when board of directors' reputational concerns are high.

The reputational concerns are measured using the same approach as in Hypothesis 1. For future firm performance, I compute the average firm performance (using ROA as a measure of firm profitability) for three years after the firing decision from year $t+1$ to $t+3$.

1.3 Empirical Analysis

In this section, I describe the research design, data and variables, test the hypotheses using regression models, and present the results.

1.3.1 Research Design

The main empirical prediction from the model is that turnover-performance sensitivity increases with the reputational concerns of the board of directors. I use the number of years a director has been in a role on the board as an inverse proxy for reputational concerns. A director who is new in a role has greater reputational concerns, because that director may want to create a favorable reputation of making the right decision regarding CEO dismissal.

A clean identification of the relation between directors' years-in-role and turnover-performance sensitivity faces several challenges. One might be concerned that a director's longer time on the board may be correlated with weaker governance (board entrenchment, stronger ties with the CEO). Moreover, a director with longer tenure in a role on the board may be better informed about the CEO type because the director has spent more time with the CEO. Both scenarios predict that a director's longer tenure in a role on the board is associated with lower turnover-performance sensitivity.

Therefore, by using a director's years-in-role, I may be spuriously capturing the effect of weaker corporate governance or better information.

To address these concerns, I use the following approach. I track the changes in the role of a director within the board. For instance, in a particular year, a director's may be promoted from an Independent Director to a Lead Independent Director or from an Independent Director to a Chairman. I create an indicator variable $PromotionDirector_{idt}$ that takes the value of one in the year t in which the director d of firm i is promoted, and zero otherwise. Then, I create a variable $Promotion_{it}$ that takes the value of one for firm i in year t, if at least one director is promoted in that year and zero otherwise.

This approach addresses two main concerns that may drive the relationship between a director's years-in-role and turnover-performance sensitivity in the following way. I only consider the new role of *existing* directors who were on the board and experienced a promotion. I do not count the directors who have been assigned a new role and are new to the board too. This approach alleviates the concern that a director in a new role is also new to the board and therefore is relatively less entrenched, leading to greater turnover-performance sensitivity. Because the tenure of the existing directors who undergo a promotion increases after the promotion, board entrenchment should, if anything, increase. Second, this approach addresses the concern that a director in a new role may be uninformed about the CEO type and that lack of information, instead of reputational concerns, drives the sensitivity of CEO turnover to firm performance. Again, because the tenure of the existing directors who experience a promotion increases after the promotion, the board's information should, if anything, increase.

To cleanly identify the change in turnover-performance sensitivity due to a promotion, I need to observe the turnover-performance sensitivity for the same firm with and without a promotion. Because this ideal counterfactual cannot be observed, I obtain the change in turnover-performance sensitivity for similar firms where the board of directors did not undergo a promotion. To obtain similar firms, I match the pre-role-change (treatment) firm-year observations using propensity score matching to a set of potential control firms. Specifically, for each year t, I use the nearest-neighbor matching to match the firms in which the variable $Promotion$ takes the value of one in year $t+1$ to a set of firms in the same year t for which the variable $Promotion$ takes the value of zero in year $t+1$. The set of firms that are closest in the propensity score of the treatment firm-years are labelled as the control firm-years. I use the following firm, board, and CEO characteristics for matching: two-digit SIC industry, size (measured by log Sales and log Assets), firm profitability (measured by ROA), average number of years in the role on the board, average board tenure, CEO age, CEO tenure, board size, book leverage, board's busyness, fraction of non-executive directors, and board experience.

The identifying assumption is that any confounding factor, such as board's private information or board entrenchment that affects the CEO turnover-performance sensitivity, affects the treatment and control group in the same manner. The matching of treatment and control groups on observable characteristics suggests that the assumption holds. However, the assumption might be violated if there are some unobservable characteristics that affect the treatment and control group in a different manner. For example, the boards that have promotions might have had weaker governance before the promotion, and the promotion is a mechanism to strengthen the corporate governance. To alleviate this concern, I conduct another test, in which I compare the ex-post performance of the retained managers before and after the promotion relative to control firms in which no such promotion occurs (Hypothesis 3). If the boards with weaker governance are self-selected into the treatment group that undergo a promotion, then, relative to control firms, I expect to observe an increase in performance. On the contrary, I show below that, relative to control firms, the future performance declines for treated firms after the promotion.

1.3.2 Data and Variables

The data on CEO characteristics are from ExecuComp. All CEO changes in ExecuComp are classified as forced or voluntary. Following Parrino (1997), any CEO change recorded in ExecuComp is classified as forced, using press reports and an age criterion. Peters and Wagner (2014) and Jenter and Kanaan (2015) describe the methodology in detail.[5] The data on board characteristics are from BoardEx. The data on firm characteristics are from Compustat and CRSP. The final matched data sample consists of 2,880 firms in the period 2000-2014.

The main variable of interest in the empirical analysis is the proxy for the reputational concerns of directors. I use the number of years a director has been in a role on the board as an inverse proxy for reputational concerns. For a director d at firm i in year t, I obtain the number of years the director has been in that role on the board of that firm up to and including year t. I aggregate this measure at the firm-year level (TR_{it}) by taking the average of directors' years-in-role on the board across all directors on the board of firm i in year t.

As a robustness test, I construct two more proxies for the reputational concerns of directors. First, I obtain the equity compensation of directors as a measure of alignment of their interests with the shareholders of the firm. If their interests are well aligned with the shareholders, the directors care less about their payoff in the labor market. For a director d at firm i in year t, the equity compensation (E_{idt}) is obtained as a proportion of total compensation based on the closing stock price of the annual report date in that year. I aggregate the equity compensation of directors at the firm-year level (E_{it}) by taking the average of the proportion of equity compensation to total compensation across all directors on the board of firm i in year t.

[5] I am grateful to Dirk Jenter, Florian Peters, and Alexander Wagner for graciously sharing the data with me.

Second, I obtain the directors' tenure on the board as a proxy for the reputational concerns. In the early years of their tenure, the directors' actions have a greater affect on their future payoff through additional board seats, larger network, and prestige. Therefore, directors would care about reputational payoff more in the early years of their tenure than in the later years. For a director d at firm i in year t, I obtain the number of years the director has been on the board of that firm up to and including year t. I aggregate this measure at the firm-year level (T_{it}) by taking the average of directors' tenure on the board across all directors on the board of firm i in year t.

Table 1.2 presents the summary statistics of the proxy for reputational concerns and other firm and board characteristics. Equity compensation as a fraction of total compensation at the firm-year level has a sample mean of 60% with a standard deviation of 26%, which suggests substantial variation across boards in the equity compensation of directors. Directors' tenure at the firm-year level has a sample mean of 8.22 with a standard deviation of 3.89. The years-in-role variable at the firm-year level has a mean of 6.57 and a standard deviation of 3.14.

During the sample period 2000-2014, 826 forced CEO turnover events occur. The CEO of a median firm is about fifty-six years old and stays in the firm for a tenure of five years. A board is considered to be busy if more than half the directors sit on three or more boards. In the sample, about 5% of boards are busy. A median board has nine directors, and about 86% of them are non-executive directors.

In the sample, I only consider the role changes that involve an increase in the director's responsibility. Therefore, I include the role changes that involve moving to a new role of either a Lead Director or a Chairman. I argue that those promotions are associated with an increase in the director's reputational concerns due to the following reason. Moving to a new role of a Chairman or a Lead Independent Director increases the visibility of the director. The director in the role of a Chairman will be more careful in making decisions to establish himself as a smart director in that role. I find 5,063 promotions that occur at the director-year level. Upon aggregating at the firm level, I obtain 2,958 firm-year observations for which at least one of the directors had a role change. Table 1.3 presents the top promotions captured in the sample using this method. A promotion from an Independent Director to a Lead Independent Director occurs in over 46% of the promotions. The promotion from an Independent Director to a Chairman occurs in about 25% of the promotions in the sample.

1.3.3 Directors' Years-in-Role on the Board and CEO Turnover-Performance Sensitivity

In this section, I study the relation between the number of years a director has been in a role on the board as an inverse proxy for β and turnover-performance sensitivity using the following linear probability regression model:[6]

$$\begin{aligned} CEO\ Turnover_{it} = & \eta_t + \eta_i + \eta_1 ROA_{it} + \eta_2 TR_{it} \\ & + \eta_3 TR_{it} \times ROA_{it} + \eta_4 X_{it} + \epsilon_{it} , \end{aligned} \tag{1.1}$$

where TR_{it} represents the directors' years-in-role on the board, calculated using the average of the number of years a director has been on the board across all directors on the board. The motivation for using this proxy is that in the early years of their role, directors have greater reputational concerns than in the later years.

Table 1.4 presents the results of this regression. In column (1), the coefficient on the interaction term is positive and significant at the 1% level. It suggests that in the later years of the director's role, turnover-performance sensitivity becomes weaker. In terms of economic significance, a one standard deviation change in the

[6]In all the empirical analyses in this paper, I use the linear probability regression model to obtain unbiased coefficients on the interaction between firm performance and the proxy for reputational concerns (see Ai and Norton (2003) for a discussion on how logit and probit models may incorrectly estimate the interaction effect.).

director's years-in-role is associated with an 83% change in the turnover-performance sensitivity. Moreover, firms with older CEOs, busier boards, and inexperienced boards are less likely to experience CEO turnover. The results in columns (2), (3), and (4) show the main results are robust to including industry, industry-times-year, and firm fixed effects, respectively. They imply time-invariant industry-level variables or time-varying industry-specific variables or firm-specific variables do not drive the results.

1.3.4 Director Promotions and CEO Turnover-Performance Sensitivity

The results from the estimation of regression equation 1.1 shows a strong association between a director's years-in-role and CEO turnover-performance sensitivity. However, the results may be biased due to omitted variable concerns. To alleviate some of those concerns, I consider only promotions within a board. I label the observation for firm i in year t as treatment if at least one promotion occurs in that firm in that year. Figure 2 shows the variation of the number of treatment firms across all years in the sample period. Then, for each year, I use the nearest-neighbor matching to obtain a set of control firms that are similar to the pre-role-change treatment firm-year observations. Table 1.5 presents the difference in the means of the set of firm, CEO, and board characteristics for the treatment and control-group firms. Panel A (Panel B) presents the difference between the treatment and control-group firms before (after) matching. The t-stat column in Panel B suggests the observable characteristics of the treatment and control-group firms are very similar.

Using the matched set of treatment and control firms, I examine the effect of a promotion of a director on the turnover-performance sensitivity using the following linear probability regression model:

$$
\begin{aligned}
CEO\ Turnover_{it} =& \eta_t + \eta_i + \eta_1 ROA_{it} + \eta_2 Post_{it} + \eta_3 ROA_{it} \times Post_{it} \\
& + \eta_4 Treat_{it} + \eta_5 Treat_{it} \times ROA_{it} + \eta_6 Treat_{it} \times Post_{it} \\
& + \eta_7 Treat_{it} \times Post_{it} \times ROA_{it} + \eta_8 X_{it} + \epsilon_{it}\ , \qquad (1.2)
\end{aligned}
$$

where the dependent variable $CEO\ Turnover$ is an indicator variable that takes the value of one if the CEO is fired from firm i immediately after year t, and zero otherwise. η_i represents firm fixed effects, η_t represents year fixed effects, η_j represents industry fixed effects, and η_{jt} represents industry-times-year fixed effects. ROA_{it} is the return on assets (ROA) of firm i in year t. $Treat_{it}$ is an indicator variable that takes the value of one for firm i from year $t-4$ to year $t+3$, where the promotion happened in year t, and takes the value of zero for the matching control firm during the years $t-4$ to $t+3$. $Post_{it}$ is an indicator variable that takes the value of one for both control and treatment firms from year t to year $t+3$, where t is the year of a promotion. X_{it} represents a vector of controls including CEO age, CEO tenure, board size, firm size (measured by logarithm of Sales), book leverage, busyness of board, fraction of non-executive directors on the board, and directors' past experience. All variables are defined in Table 1.1 in the appendix. The main coefficient of interest is η_7, which estimates the difference in turnover-performance sensitivity for the treated firms from four years before the promotion to four years after, relative to the same difference in control firms where no such promotion occurs.

Table 1.6 presents the results of this regression. In column (1), the coefficient η_3 is statistically insignificant. It suggests that for control firms in which no promotion occurs, the turnover-performance sensitivity does not change. The coefficient on the triple-interaction term (η_7) is negative and significant at the 1% level. It suggests the effect of performance on CEO dismissal increases after the promotion for the treatment firms relative to the matching control firms. In terms of economic significance, promotion in the treatment firms, relative to control firms, is associated with an 84% increase in the turnover-performance sensitivity in the four-year period after the promotion. The results in columns (2), (3), and (4) show the coefficient on the triple-interaction term remains negative and statistically significant after including industry, industry-times-year, and firm fixed effects, respectively.

1.3.5 Sub-Sample Tests

In this section, I report the results of three sub-sample tests to test Hypothesis 2 using regression specification (1.2). First, I divide the sample into three groups sorted by the number of analysts following the firm. Hypothesis 2 predicts the effect of reputational concerns on turnover-performance sensitivity is greater for firms that are followed by fewer analysts. Table 1.7 presents the results of regression equation (1.2) for firms in the bottom tercile in column (1) and for firms in the top tercile in column (2). The coefficient on the interaction term is negative and significant only for firms in the bottom tercile. The results suggest the increase in turnover-performance sensitivity after a director's promotion is mostly driven by firms with a fewer number of analysts following.

Second, I divide the firm-years into three groups sorted by the market capitalization of the firm. Hypothesis 2 predicts the effect of reputational concerns on turnover-performance sensitivity is greater for smaller firms. Table 1.7 presents the results of regression equation (1.2) for firms in the bottom tercile in column (3) and for firms in the top tercile in column (4). The coefficient on the interaction term is negative and significant only for firms in the bottom tercile. The results suggest the increase in turnover-performance sensitivity after a director's promotion is mostly driven by smaller firms.

Finally, I divide the sample into three groups sorted by institutional ownership.

Hypothesis 2 predicts the effect of reputational concerns on turnover-performance sensitivity is greater for firms with low institutional ownership. Table 1.7 presents the results of regression equation (1.2) for firms in the bottom tercile in column (5) and for firms in the top tercile in column (6). The coefficient on the interaction term is negative and significant only for firms in the bottom tercile. The results suggest the increase in turnover-performance sensitivity after a director's promotion is mostly driven by firms with low institutional ownership.

Overall, the results from the sub-sample tests suggest that when publicly available information about the CEO is less precise relative to the board's private information, the effect of reputational concerns on turnover-performance sensitivity is greater.

1.3.6 Director Promotions and Future Firm Performance

In this section, I estimate the regression model to test Hypothesis 3 and report the results. To test Hypothesis 3, I need to compare the difference in future firm performance of the treated firms before and after the promotion, relative to the same difference in the future firm performance of the control firms, given that the manager is retained. For future firm performance, I calculate the average ROA across years $t+1$ to year $t+3$ for every firm i and year t.

I examine the effect of a promotion of a director on ex-post performance using the following linear regression model:

$$\begin{aligned} ROA_{it+1,t+3} = & \eta_t + \eta_i + \eta_1 CEO\ Retained_{it} + \eta_2 Post_{it} + \eta_3 CEO\ Retained_{it} \times Post_{it} \\ & + \eta_4 Treat_{it} + \eta_5 Treat_{it} \times CEO\ Retained_{it} + \eta_6 Treat_{it} \times Post_{it} \\ & + \eta_7 Treat_{it} \times Post_{it} \times CEO\ Retained_{it} + \eta_8 X_{it} + \epsilon_{it}\ , \end{aligned} \tag{1.3}$$

where the dependent variable $ROA_{it+1,t+3}$ is the average ROA from years $t+1$ to $t+3$. η_i represents firm fixed effects, η_t represents year fixed effects, η_j represents industry fixed effects, and η_{jt} represents industry-times-year fixed effects. $CEO\ Retained_{it}$ is an indicator variable that takes the value of one if the CEO of firm i is retained in year t. $Treat_{it}$ is an indicator variable that takes the value of one for firm i from year $t-4$ to year $t+3$, where the promotion happened in year t, and takes the value of zero for the matching control firm during the years $t-4$ to $t+3$. $Post_{it}$ is an indicator variable that takes the value of one for both control and treatment firms from year t to year $t+3$, where t is the year of a promotion. X_{it} represents a vector of controls including CEO age, CEO tenure, board size, firm size (measured by logarithm of Sales), book leverage, board's busyness, fraction of non-executive directors on the board, and directors' past experience. All variables are defined in Table 1.1 in the appendix. The main coefficient of interest is η_7 which estimates the difference in average future profitability of the retained manager for the treated firms over a four-year period before and after the promotion, relative to the same difference for the control firms where no such promotion occurs.

Table 1.8 presents the results of this regression. In column (1), the coefficient η_1 is positive and significant at the 1% level. It shows that relative to the years in which the CEO is fired, firm profitability is higher in the years when the CEO is retained. In column (2), I present the results of regression equation 1.3 by comparing the average future performance of the treated and control firms. The coefficient η_5 on $Treat_{it} \times CEO\ Retained_{it}$ is insignificant. It suggests that if the CEO is retained, the future performance of the treated firms in which a promotion occurs is not statistically different from the future performance of the control firms. In column (3), I present the results of the overall regression model. The coefficient η_3 is statistically insignificant. It suggests the future performance of the retained manager for control firms does not change after the year of the promotion in treated firms. The coefficient on the triple-interaction term (η_7) is negative and significant at the 5% level. It suggests that if the manager is retained, the future firm performance declines after the promotion for the treated firms relative to the matching control firms. In terms of economic significance, a promotion in the treatment firms, relative to control firms, is associated with a 0.89% decline in the average future profitability over a four-year period.

The results in column (1), (2), and (3) include firm fixed effects, so the effect of promotions on future firm performance is relative to the average firm performance across the sample period. However, the average firm performance across the sample period includes the performance by the retained CEO as well as the performance of other CEOs who worked with that firm. Therefore, in column (4), instead of firm fixed effects, I control for CEO fixed effects, which enables me to capture the effect of promotions on future firm performance relative to the average firm performance by the same CEO. The results remain the same.

1.3.7 Other Results

In this section, I study the effect of reputational concerns on turnover-performance sensitivity using alternative ways to capture the reputational concerns of the board of directors. First, I use the equity compensation of the directors as a proxy for how much they care about shareholder value. The motivation for using this measure is based on the agency view: shareholders provide incentives in the form of equity compensation to align the interests of the board with those of the shareholders. Following the assumption about the board's payoff in the model, one minus the fraction of the directors' equity compensation captures the director's reputational concerns (parameter β in the model). The equity compensation of the directors for a firm i in year t is calculated using the average of the proportion of equity compensation to total compensation across all directors on the board.

I study the relation between the equity compensation of the directors and turnover-performance sensitivity by estimating the linear probability regression model specified in equation 1.1. Table 1.9 presents the results of this regression. The results suggests the effect of performance on CEO dismissal is weaker when the board's equity compensation is high. In terms of economic significance, a one standard deviation change in equity compensation is associated with a 65% change in turnover-performance sensitivity. The results are robust to including year, industry, industry-times-year, and firm fixed effects.

Second, I use the tenure on the board as an inverse proxy for a director's reputational concerns. The motivation for using this proxy is that in the early years of their tenure on the board, directors have greater reputational concerns than in the later years. The reason is that the board's decisions in the early years of their tenure have a greater impact on their future payoffs through additional board seats and possibly more compensation on those board seats. Board tenure is calculated using the average tenure across all directors on the board.

I use the linear probability regression model in equation 1.1 to study the relation between board tenure and turnover-performance sensitivity. Table 1.10 presents the results of this regression. The results suggests that in the later years of the director's tenure, turnover-performance sensitivity becomes weaker. In terms of economic significance, a one standard deviation change in the director's tenure is associated with an 83% change in turnover-performance sensitivity. The results are robust to including year, industry, industry-times-year, and firm fixed effects.

Directors who are new to the board or new to the role might be selected into the board because the current directors have stronger ties with the CEO and have become entrenched. Hence, the arrival of new directors decreases the average board entrenchment. In that case, in the early years of a director's tenure, turnover-performance sensitivity is stronger because the board's entrenchment is low. I correct for this bias using director deaths as an exogenous shock to directors' tenure on the board. After a director's death, the average tenure of directors decreases. The identifying assumption is that the decrease in average board tenure is caused by a director death and not by the selection of new directors to an entrenched board.

I analyze how turnover-performance sensitivity changes from five years before a director's death to five years after a director's death.[7] Suppose at least one director death occurs in firm i in year t. I construct an indicator variable Post Death that equals one for firm i from year $t+1$ to year $t+5$ and equals 0 from year $t-4$ to year t. Using this variable, I estimate the following linear probability regression model:

$$\begin{aligned} CEO\ Turnover_{it} =& \eta_t + \eta_i + \eta_1 ROA_{it} + \eta_2 Post\ Death_{it} \\ &+ \eta_3 Post\ Death_{it} \times ROA_{it} + \eta_4 X_{it} + \epsilon_{it} \ , \end{aligned} \tag{1.4}$$

Table 1.11 presents the results of this regression. In column (1), the coefficient on the interaction term is negative and significant at the 5% level. The results suggest turnover-performance sensitivity increases after a director's death. The results are robust to including year, industry, and industry-times-year fixed effects.

1.4 Conclusion

In this paper, I study how reputational concerns affects a board's incentives and therefore, the internal governance of the firm. I develop a model in which the board of directors cares about shareholder value and the labor market's perception of its decision. Because the market's information about the CEO is inferior to that of the board, it perceives the board's decision to fire (retain) in response to poor (good) firm performance as favorable. Therefore, the board may rely more on firm performance for the firing decision, to signal better decision-making to the market. As a result, CEO turnover-performance sensitivity increases when the board of directors cares more about its reputational payoff. Importantly, this effect of reputational concerns

[7] The results are similar if I use the sample during the four-year period before and after a director's death.

on turnover-performance sensitivity holds only if the board's private information is more precise than the public information about the CEO. Further, this inefficient decision by the board culminates in a decline in future firm performance.

I test the predictions of the model using the number of years a director has served in a role on the board (years-in-role) as an inverse proxy for their reputational concerns. Specifically, I use a director's promotions as a shift in the board's reputational concerns. This approach rules out some of the other factors that are correlated with years-in-role and affect turnover-performance sensitivity. Relative to matched control firms, I find a promotion increases the turnover-performance sensitivity by 28% over a four-year period. Moreover, I find the effect of promotions on turnover-performance sensitivity is stronger when public information about the CEO is less precise, that is, for firms that are smaller, are followed by fewer analysts, and have lower institutional ownership. Finally, I find the future firm performance declines if the manager is retained when the board has greater reputational concerns.

The study has implications for the design of directors' incentive schemes. The findings of this paper suggest a director's career concerns may not necessarily act as a substitute to explicit incentives. Instead, the labor market for directors may have unintended consequences for a board's behavior. In addition, the study has implications for the labor market for CEOs. That good CEOs are sometimes fired may deter the entry of good CEOs and encourage the entry of bad CEOs. As a result, the average CEO quality may go down. Furthermore, this paper contributes to the debate on director tenure or board "refreshment". It highlights an advantage of increasing tenure of the board. A board with a longer tenure may have lower reputational concerns, and their interests may be better aligned with those of the shareholders. The greater alignment of incentives may improve the quality of the board's decisions. More broadly, this paper provides a novel perspective for analyzing CEO dismissal in response to bad luck or adverse shocks. The main findings suggest the increase in turnover-performance sensitivity perhaps reflects a board's catering to the market's demand. Therefore, researchers and shareholders need to be cautious in interpreting CEO dismissal in response to firm performance.

1.5 Variable Construction

Table 1.1: Variable Definitions

Variable	Definition
Director Characteristics	
Tenure	The number of years director has been on the board.
Years-in-role	The number of years director has been in a role on the board.
Busy Directors	Indicator that equals one if the director sits on three or more boards.
Director Experience	The number of boards of publicly listed firms that the director has been on in the past.
Director Compensation	Equity compensation as a proportion of total compensation based on the closing stock price of the annual report date in that year.
Director Promotion	Indicator that equals one if the director's role changes to a Lead Independent Director or a Chairman and zero otherwise.
Board and Firm Characteristics	
Busy Board	Indicator that equals one if more than half the directors on the board sit on three or more boards and zero otherwise.
% NED Directors	Fraction of non-executive directors on the board.
Board Size	The number of directors on a board.
Board Experience	The average of director experience across all directors on the board.
Board Compensation	The average of director compensation across all directors on the board.
Years-in-role	The average years-in-role across all directors on the board.
Tenure	The average director tenure across all directors on the board.
Promotion	Indicator that equals one if at least one promotion occurs in the fiscal year and zero otherwise.
ROA	Earnings before interest, taxes, depreciation, and amortization divided by total assets.
Stock Return	Stock returns in the last fiscal year.
Sales	Annual sales, in millions of dollars.
Assets	End of fiscal year assets, in millions of dollars.
Book Leverage	Book value of debt divided by the book value of debt and the book value of equity.
Market Capitalization	Market value of equity computed as close price at the end of fiscal year times the number of shares outstanding.

1.6 Supplementary Figures and Tables

Table 1.2: Summary Statistics
The table below reports the summary statistics of the variables used in the regression models. All variables are defined in Table 1.1 in the appendix.

	N	Mean	SD	p50
All Turnover	28748	0.11	0.31	0.00
Forced Turnover	28748	0.03	0.17	0.00
CEO Age	28703	55.78	7.53	56.00
CEO Tenure	28748	7.00	7.12	5.00
Assets ($ mil)	28693	8852.55	19428.18	1891.51
Sales ($ mil)	28677	4401.26	8009.69	1253.59
ROA	27583	0.13	0.11	0.12
Stock Return	24632	0.13	0.42	0.10
Directors Equity Compensation	8639	0.60	0.26	0.64
Tobin Q	28177	1.88	1.40	1.45
Board Size	25287	9.37	2.58	9.00
Board Tenure	25280	8.22	3.89	7.88
Years-in-role	25280	6.57	3.14	6.28
log Sales	28673	7.20	1.60	7.13
Book Leverage	28582	0.23	0.20	0.20
Busy Board	25287	0.05	0.22	0.00
% NED Directors	25287	0.83	0.09	0.86

Table 1.3: Promotions

The table below reports the top promotions in the sample.

Top 10 Promotions	Perc	Cum Perc
Independent Director – Lead Independent Director	46.53	46.53
Independent Director – Independent Chairman	25.98	72.51
Independent Director – Presiding Independent Director	10.35	82.86
Lead Independent Director – Independent Chairman	4.14	87.00
Director - SD – Chairman	1.87	88.87
Lead Independent Director – Lead Independent Chairman	1.46	90.33
Director - SD – Lead Independent Director	1.36	91.69
Presiding Independent Director – Lead Independent Director	1.00	92.69
Director - SD – Independent Chairman	0.94	93.63
Independent Director – Lead Independent Chairman	0.93	94.56

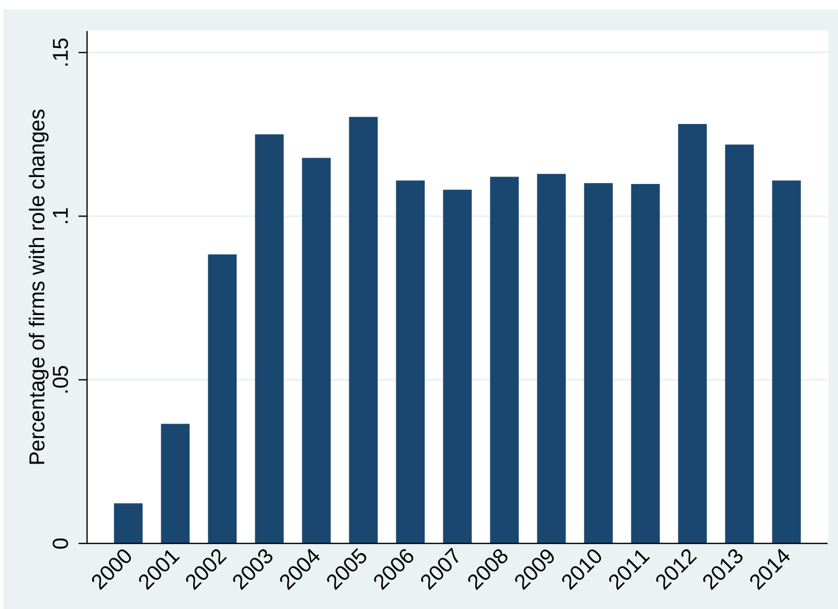

Figure 1.2: This figure shows the percentage of firms with at least one promotion in a year across the sample period 2000-2014.

Table 1.4: Do Years-in-Role Affect CEO Turnover-Performance Sensitivity? The table below reports results from a linear probability model that analyzes the relation between directors' years-in-role and CEO turnover-performance sensitivity. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
Years-in-role	-0.0060***	-0.0060***	-0.0061***	-0.0052**
	(-5.78)	(-5.67)	(-5.76)	(-2.47)
ROA	-0.014***	-0.015***	-0.015***	-0.023***
	(-10.29)	(-10.21)	(-10.14)	(-9.21)
ROA × Years-in-role	0.0050***	0.0048***	0.0047***	0.0051***
	(4.58)	(4.43)	(4.29)	(2.97)
CEO Age	-0.0033***	-0.0030**	-0.0031***	-0.013***
	(-2.87)	(-2.56)	(-2.66)	(-4.25)
CEO Tenure	-0.0018*	-0.0016	-0.0015	0.022***
	(-1.69)	(-1.52)	(-1.38)	(7.10)
Board Size	-0.0065***	-0.0049***	-0.0050***	-0.0048*
	(-4.78)	(-3.48)	(-3.49)	(-1.76)
log Sales	0.0034**	0.0027	0.0027	0.015**
	(2.13)	(1.60)	(1.61)	(2.41)
Book Leverage	0.0024*	0.0038***	0.0036***	0.0066**
	(1.85)	(2.84)	(2.68)	(2.37)
Busy Board	-0.012***	-0.011**	-0.012**	-0.0052
	(-2.69)	(-2.43)	(-2.49)	(-0.87)
% NED Directors	0.0030**	0.0036***	0.0035***	0.0054**
	(2.49)	(2.91)	(2.84)	(2.16)
Board Experience	0.0032**	0.0028*	0.0028*	0.0065
	(2.23)	(1.91)	(1.89)	(1.63)
Adjusted R^2	0.013	0.015	0.015	0.032
Observations	24206	24206	24206	24206
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.5: Matching of Treatment and Control Groups

The table below reports the differences between the sample average of firm, CEO, and board characteristics for the treatment and control group of firms. All variables are defined in Table 1.1 in the appendix. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Before Matching	Control	Treatment	Diff	t-stat
ROA	0.13	0.13	0.0014	(0.68)
Years-in-role	6.57	6.71	0.14**	(2.37)
Board Tenure	8.26	8.36	0.10	(1.37)
log Sales	7.19	7.61	0.42***	(12.6)
log Assets	7.63	8.03	0.40***	(10.9)
CEO Age	55.8	56.3	0.44***	(3.12)
CEO Tenure	7.02	6.67	-0.35***	(-2.68)
Board Size	9.34	9.82	0.48***	(9.79)
Book Leverage	0.24	0.23	-0.0071*	(-1.85)
Busy Board	0.050	0.058	0.0079*	(1.88)
% NED Directors	0.84	0.85	0.013***	(8.29)
Board Experience	3.08	3.23	0.15***	(5.83)
log Market Cap	7.43	7.83	0.40***	(11.6)

Panel B: After Matching	Control	Treatment	Diff	t-stat
ROA	0.13	0.13	-0.00063	(-0.26)
Years-in-role	6.62	6.68	0.062	(0.88)
Board Tenure	8.26	8.34	0.076	(0.87)
log Sales	7.61	7.62	0.015	(0.40)
log Assets	7.97	7.99	0.016	(0.38)
CEO Age	56.2	56.2	0.013	(0.078)
CEO Tenure	6.66	6.66	-0.0012	(-0.0077)
Board Size	9.83	9.83	-0.0041	(-0.070)
Book Leverage	0.22	0.22	0.00054	(0.13)
Busy Board	0.057	0.060	0.0035	(0.65)
% NED Directors	0.85	0.85	0.00082	(0.46)
Board Experience	3.22	3.24	0.017	(0.56)
log Market Cap	7.79	7.80	0.0041	(0.11)

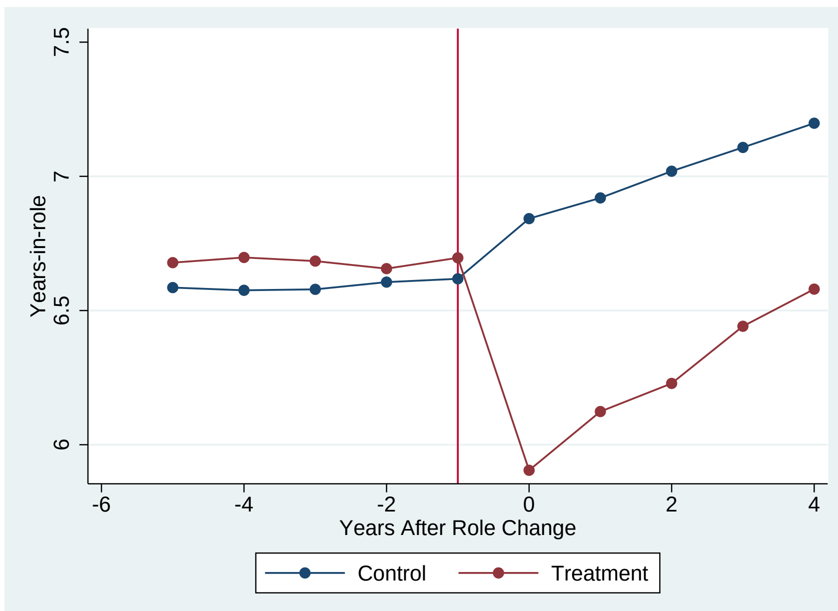

Figure 1.3: This figure shows the average years-in-role of the board before and after the promotion in the treatment group and control group firms.

Table 1.6: Do Director Promotions Affect CEO Turnover-Performance Sensitivity? The table below reports results from a linear probability regression model that analyzes how a director's promotion affects the CEO turnover-performance sensitivity for treatment firms relative to control firms. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
ROA	-0.013***	-0.014***	-0.014***	-0.026***
	(-7.08)	(-7.53)	(-7.32)	(-8.22)
Post Promotion	0.00099	0.00088	0.0010	-0.0017
	(0.70)	(0.63)	(0.72)	(-1.21)
ROA × Post Promotion	-0.0012	-0.0013	-0.0022	-0.0015
	(-0.78)	(-0.81)	(-1.45)	(-1.02)
Treat	0.0021	0.0021	0.0021	-0.0017
	(1.09)	(1.12)	(1.09)	(-1.02)
ROA × Treat	0.000094	0.00017	0.00024	-0.000061
	(0.05)	(0.09)	(0.13)	(-0.03)
Post Promotion × Treat	0.0076***	0.0076***	0.0077***	0.0098***
	(2.71)	(2.72)	(2.74)	(3.42)
ROA × Post Promotion × Treat	-0.011***	-0.011***	-0.011***	-0.0074**
	(-3.10)	(-3.06)	(-2.98)	(-2.16)
Adjusted R^2	0.014	0.017	0.023	0.11
Observations	77202	77202	77202	77202
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.7: Does Public Information about the CEO Matter?

The table below reports results from a regression model that analyzes how a director's promotion affects the CEO turnover-performance sensitivity across different sub-samples. In columns (1) and (2), firms are sorted into three groups by number of analysts following the firm. In columns (3) and (4), firms are sorted into three groups by firm size (measured by market capitalization). In columns (5) and (6), firms are sorted into three groups by institutional ownership. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1) Less Analysts	(2) More Analysts	(3) Small Firms	(4) Large Firms	(5) Low I.O.	(6) High I.O.
ROA	-0.021***	-0.0074**	-0.019***	-0.0075***	-0.017***	-0.0099***
	(-5.49)	(-2.48)	(-5.27)	(-2.72)	(-5.10)	(-3.11)
Post Promotion	0.0027	-0.00079	0.0019	0.00044	0.0047*	-0.00021
	(1.09)	(-0.31)	(0.62)	(0.20)	(1.71)	(-0.09)
ROA × Post Promotion	-0.0024	-0.0021	-0.0028	-0.00081	-0.00057	-0.0042*
	(-0.70)	(-0.87)	(-0.86)	(-0.37)	(-0.17)	(-1.79)
Treat	0.0042	0.0024	0.0088**	0.0013	0.0044	0.00041
	(1.19)	(0.75)	(2.30)	(0.41)	(1.47)	(0.13)
ROA × Treat	0.0035	-0.0022	0.0044	-0.00072	0.000068	0.00093
	(0.93)	(-0.73)	(1.08)	(-0.25)	(0.02)	(0.28)
Post Promotion × Treat	0.011*	0.0027	0.0061	0.0059	0.0012	0.0089*
	(1.95)	(0.59)	(1.04)	(1.43)	(0.24)	(1.88)
ROA × Post Promotion × Treat	-0.022***	-0.0020	-0.021***	-0.0047	-0.015**	0.00060
	(-2.75)	(-0.48)	(-2.86)	(-1.33)	(-2.27)	(0.10)
Adjusted R^2	0.051	0.028	0.049	0.026	0.052	0.029
Observations	23819	26975	24790	26220	21507	22607
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes

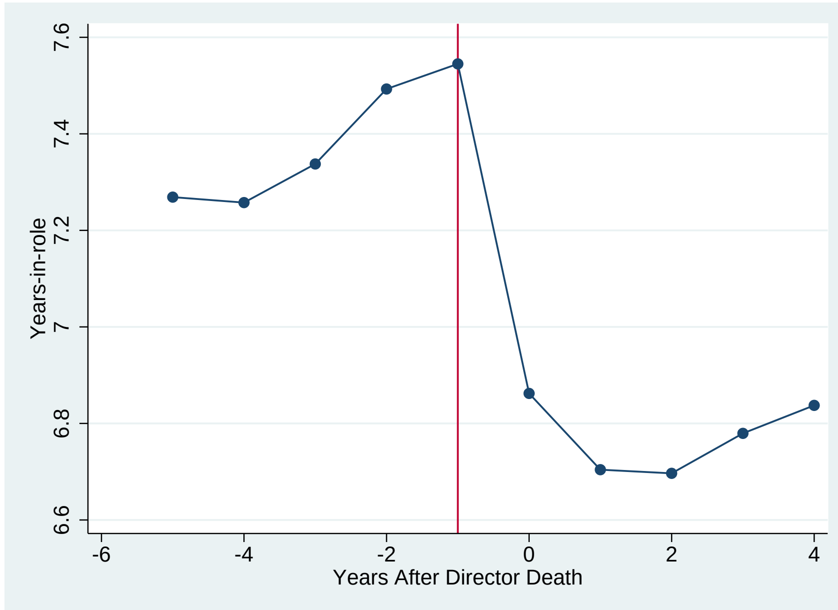

Figure 1.4: This figure shows the average years-in-role of the board before and after a director's death.

Table 1.8: Firm Profitability from (t+1) to (t+3) Years after the Firing Decision
The table below reports results from a regression model that analyzes how a director's promotion affects the ex-post firm performance of the retained manager for treatment firms relative to control firms. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: $ROA_{it+1,t+3}$	(1)	(2)	(3)	(4)
CEO Retained	0.011***	0.014***	0.014***	0.0041
	(4.20)	(4.33)	(4.63)	(1.18)
Post Promotion			0.0012	-0.0022
			(0.54)	(-1.18)
CEO Retained × Post Promotion			-0.0015	0.0020
			(-0.64)	(0.99)
Treat		0.0034	-0.0018	-0.0046
		(1.07)	(-0.49)	(-1.33)
CEO Retained × Treat		-0.0045	0.000091	0.0033
		(-1.43)	(0.03)	(0.92)
Post Promotion × Treat			0.010**	0.014***
			(2.34)	(3.39)
CEO Retained × Post Promotion × Treat			-0.0089**	-0.013***
			(-2.02)	(-3.12)
Adjusted R^2	0.80	0.80	0.80	0.86
Observations	67664	67664	67664	67664
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	No
Year FE	Yes	Yes	Yes	Yes
CEO FE	No	No	No	Yes

Table 1.9: Does Equity Compensation of Directors Affect CEO Turnover-Performance Sensitivity?

The table below reports results from a linear probability model that analyzes the relation between equity-based compensation of directors and CEO turnover-performance sensitivity. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
% equity	-0.0078***	-0.0084***	-0.0083***	-0.014***
	(-4.29)	(-4.60)	(-4.54)	(-3.84)
ROA	-0.012***	-0.013***	-0.013***	-0.021***
	(-6.01)	(-6.22)	(-6.07)	(-4.88)
ROA × % equity	0.0051**	0.0051**	0.0051**	0.0086**
	(2.45)	(2.42)	(2.44)	(2.55)
Adjusted R^2	0.0098	0.012	0.012	0.022
Observations	8319	8319	8319	8319
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.10: Does a New Board Affect CEO Turnover-Performance Sensitivity? The table below reports results from a linear probability model that analyzes the relation between board tenure and CEO turnover-performance sensitivity. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
Board Tenure	-0.0048***	-0.0049***	-0.0050***	-0.0032
	(-4.32)	(-4.39)	(-4.47)	(-1.28)
ROA	-0.014***	-0.015***	-0.015***	-0.024***
	(-10.19)	(-10.15)	(-10.08)	(-9.19)
ROA × Board Tenure	0.0040***	0.0039***	0.0037***	0.0045**
	(3.78)	(3.63)	(3.50)	(2.48)
Adjusted R^2	0.012	0.014	0.014	0.032
Observations	24206	24206	24206	24206
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.11: Do Director Deaths Affect CEO Turnover-Performance Sensitivity? The table below reports results from a linear probability model that analyzes how the death of a director affects the CEO turnover-performance sensitivity. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
ROA	-0.0075	-0.0096	-0.012	-0.016
	(-0.77)	(-0.97)	(-1.11)	(-1.48)
Post Death	-0.0021	-0.0024	-0.0017	0.00017
	(-0.44)	(-0.50)	(-0.35)	(0.03)
ROA × Post Death	-0.012**	-0.012**	-0.011**	-0.0086
	(-2.40)	(-2.40)	(-2.33)	(-1.23)
Lagged ROA	-0.0018	-0.0037	-0.0027	-0.011
	(-0.17)	(-0.36)	(-0.25)	(-0.89)
Adjusted R^2	0.011	0.015	0.016	0.039
Observations	5808	5808	5808	5808
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.12: Sub-sample Tests - Does the Number of Analysts Following Matter?

The table below shows the effect of a director's promotion on CEO turnover-performance sensitivity across firms that are sorted into terciles by the number of analysts. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
A. Firms in the bottom tercile of the number of analysts following				
ROA	-0.020***	-0.021***	-0.021***	-0.031***
	(-5.38)	(-5.55)	(-5.49)	(-4.62)
Post Promotion	0.0022	0.0022	0.0027	-0.0034
	(0.86)	(0.87)	(1.09)	(-1.36)
ROA × Post Promotion	-0.0016	-0.0010	-0.0024	-0.00064
	(-0.47)	(-0.30)	(-0.70)	(-0.21)
Treat	0.0040	0.0045	0.0042	-0.0014
	(1.12)	(1.27)	(1.19)	(-0.46)
ROA × Treat	0.0033	0.0031	0.0035	0.0051
	(0.87)	(0.82)	(0.93)	(1.32)
Post Promotion × Treat	0.011*	0.011**	0.011*	0.010*
	(1.95)	(2.01)	(1.95)	(1.90)
ROA × Post Promotion × Treat	-0.023***	-0.023***	-0.022***	-0.021***
	(-2.91)	(-2.86)	(-2.75)	(-2.81)
Adjusted R^2	0.029	0.032	0.051	0.16
Observations	23819	23819	23819	23819
B. Firms in the top tercile of the number of analysts following				
ROA	-0.0065**	-0.0070**	-0.0074**	-0.024***
	(-2.33)	(-2.43)	(-2.48)	(-4.66)
Post Promotion	0.000032	-0.00035	-0.00079	-0.0016
	(0.01)	(-0.13)	(-0.31)	(-0.68)
ROA × Post Promotion	-0.0012	-0.0014	-0.0021	-0.00098
	(-0.49)	(-0.57)	(-0.87)	(-0.42)
Treat	0.0032	0.0030	0.0024	-0.00037
	(0.97)	(0.92)	(0.75)	(-0.13)
ROA × Treat	-0.0026	-0.0027	-0.0022	-0.0023
	(-0.83)	(-0.88)	(-0.73)	(-0.93)
Post Promotion × Treat	0.0021	0.0023	0.0027	0.0052
	(0.44)	(0.49)	(0.59)	(1.09)
ROA × Post Promotion × Treat	-0.0028	-0.0024	-0.0020	0.00024
	(-0.67)	(-0.56)	(-0.48)	(0.05)
Adjusted R^2	0.0094	0.013	0.028	0.14
Observations	26975	26975	26975	26975
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.13: Sub-sample Tests - Does Firm Size Matter?

The table below shows the effect of a director's promotion on CEO turnover-performance sensitivity across firms that are sorted into terciles by the firm size. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
A. Firms in the bottom tercile of Market Capitalization				
ROA	-0.019***	-0.020***	-0.019***	-0.030***
	(-5.00)	(-5.34)	(-5.27)	(-4.77)
Post Promotion	0.0025	0.0022	0.0019	-0.0050*
	(0.85)	(0.73)	(0.62)	(-1.74)
ROA × Post Promotion	-0.0011	-0.0012	-0.0028	-0.0018
	(-0.34)	(-0.37)	(-0.86)	(-0.60)
Treat	0.0078*	0.0081**	0.0088**	0.0010
	(1.96)	(2.10)	(2.30)	(0.30)
ROA × Treat	0.0039	0.0043	0.0044	0.0030
	(0.92)	(1.02)	(1.08)	(0.72)
Post Promotion × Treat	0.0068	0.0073	0.0061	0.012**
	(1.15)	(1.24)	(1.04)	(2.10)
ROA × Post Promotion × Treat	-0.023***	-0.023***	-0.021***	-0.016**
	(-3.12)	(-3.05)	(-2.86)	(-2.32)
Adjusted R^2	0.031	0.033	0.049	0.19
Observations	24790	24790	24790	24790
B. Firms in the top tercile of Market Capitalization				
ROA	-0.0070**	-0.0075***	-0.0075***	-0.024***
	(-2.50)	(-2.76)	(-2.72)	(-4.19)
Post Promotion	0.00039	0.00038	0.00044	0.00020
	(0.17)	(0.16)	(0.20)	(0.09)
ROA × Post Promotion	-0.00035	-0.0010	-0.00081	-0.0029
	(-0.16)	(-0.47)	(-0.37)	(-1.27)
Treat	0.0015	0.0014	0.0013	-0.0018
	(0.45)	(0.44)	(0.41)	(-0.61)
ROA × Treat	-0.00048	-0.00091	-0.00072	-0.00021
	(-0.16)	(-0.31)	(-0.25)	(-0.07)
Post Promotion × Treat	0.0059	0.0059	0.0059	0.0074*
	(1.40)	(1.40)	(1.43)	(1.66)
ROA × Post Promotion × Treat	-0.0051	-0.0044	-0.0047	-0.0036
	(-1.38)	(-1.20)	(-1.33)	(-0.87)
Adjusted R^2	0.0099	0.015	0.026	0.11
Observations	26220	26220	26220	26220
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 1.14: Sub-sample Tests - Does Institutional Ownership Matter?

The table below shows the effect of a director's promotion on CEO turnover-performance sensitivity across firms that are sorted into terciles by the institutional ownership. All variables are defined in Table 1.1 in the appendix. The standard errors reported are robust and clustered at the firm level. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CEO Turnover	(1)	(2)	(3)	(4)
A. Firms in the bottom tercile of Institutional Ownership				
ROA	-0.014***	-0.016***	-0.017***	-0.025***
	(-4.59)	(-5.01)	(-5.10)	(-4.11)
Post Promotion	0.0034	0.0035	0.0047*	0.0011
	(1.20)	(1.24)	(1.71)	(0.42)
ROA × Post Promotion	-0.00076	-0.0011	-0.00057	-0.0027
	(-0.23)	(-0.34)	(-0.17)	(-0.98)
Treat	0.0041	0.0045	0.0044	0.0013
	(1.37)	(1.48)	(1.47)	(0.45)
ROA × Treat	-0.00096	-0.00097	0.000068	0.0010
	(-0.29)	(-0.30)	(0.02)	(0.34)
Post Promotion × Treat	0.0018	0.0013	0.0012	0.0062
	(0.35)	(0.26)	(0.24)	(1.24)
ROA × Post Promotion × Treat	-0.015**	-0.014**	-0.015**	-0.0079
	(-2.15)	(-2.08)	(-2.27)	(-1.26)
Adjusted R^2	0.023	0.030	0.052	0.21
Observations	21507	21507	21507	21507
B. Firms in the top tercile of Institutional Ownership				
ROA	-0.0084***	-0.0097***	-0.0099***	-0.022***
	(-2.63)	(-3.10)	(-3.11)	(-3.62)
Post Promotion	0.00076	0.000056	-0.00021	-0.0022
	(0.31)	(0.02)	(-0.09)	(-0.99)
ROA × Post Promotion	-0.0039	-0.0041*	-0.0042*	-0.0040*
	(-1.62)	(-1.67)	(-1.79)	(-1.80)
Treat	0.00024	0.00032	0.00041	-0.0039
	(0.07)	(0.10)	(0.13)	(-1.46)
ROA × Treat	0.00050	0.00067	0.00093	-0.0030
	(0.14)	(0.20)	(0.28)	(-1.00)
Post Promotion × Treat	0.0090*	0.0090*	0.0089*	0.011**
	(1.86)	(1.87)	(1.88)	(2.29)
ROA × Post Promotion × Treat	0.00061	0.00042	0.00060	0.0022
	(0.10)	(0.07)	(0.10)	(0.35)
Adjusted R^2	0.015	0.019	0.029	0.19
Observations	22607	22607	22607	22607
Controls	Yes	Yes	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

1.7 Proofs

Proof of Lemma I.1. This proof shows the existence of a pooling equilibrium in which the board retains the manager upon receiving signal s_g or signal s_b in state H. In this equilibrium, firing is an off-equilibrium decision. In state H, the equilibrium labor market's beliefs are $\mu(g|r) = \psi$. Suppose the off-equilibrium beliefs are such that given that the manager is fired, the board must be A_b (have signal s_b). The off-equilibrium belief in state H is $\mu(b|f) = \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}$. This off-equilibrium belief is less than 0.5 because $\alpha < \psi$. Board A_g and A_b's equilibrium payoffs by retaining after signal s_g and s_b are:

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) \ ,$$
$$(1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

The board's payoff from deviation to firing is $(1-\beta)(0.5) + \beta\mu(b|f)$. Notice that $\mu(g|s_g) > \mu(g|s_b)$, so the payoff from project by retaining after signal s_g is greater than the payoff by retaining after signal s_b. Further, $\mu(g|r) = \psi > 0.5 > \mu(b|f)$. Therefore, the pooling equilibrium is sustained with the off-equilibrium beliefs that the board has signal s_b given that the manager is fired.

Similarly, in state L, a pooling equilibrium exists in which the board fires the manager upon receiving signal s_g or signal s_b. In this equilibrium, retaining is an off-equilibrium decision. This pooling equilibrium is sustained with the off-equilibrium beliefs that the board has signal s_g given that the manager is retained. The board does not have an incentive to deviate to retaining, because both the payoff from the project and the reputational payoff are greater by firing the manager. ■

Proof of Proposition I.2. First, I show the existence of a separating equilibrium. In this equilibrium, the labor market beliefs $\mu(g|r)$ and $\mu(b|f)$ are:

$$\mu(g|r) = \frac{\psi\alpha}{\psi\alpha + (1-\psi)(1-\alpha)} \ ,$$
$$\mu(b|f) = \frac{(1-\psi)\alpha}{\psi(1-\alpha) + (1-\psi)\alpha} \ .$$

To sustain this equilibrium, board A_g and A_b's payoffs need to satisfy the following conditions:

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) > (1-\beta)(0.5) + \beta\mu(b|f) \ ,$$
$$(1-\beta)(0.5) + \beta\mu(b|f) > (1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

It is optimal for board A_g to retain the manager, because $\mu(g|s_g) > 0.5$ and $\mu(g|r) > \mu(b|f)$. The no-deviation condition for the board with signal s_b can be simplified to:

$$(1-\beta)(\alpha-\psi)(2\psi-1) > 2\beta\alpha(1-\alpha)\frac{\psi^2-(1-\psi)^2}{\psi\alpha+(1-\psi)(1-\alpha)} \ .$$

Denote the solution to the above equation as β_s. Therefore, the separating equilibrium is sustained if $\beta < \beta_s(\alpha, \psi)$.

Next, I show a hybrid equilibrium exists in which A_g retains the manager and A_b fires the manager with probability δ_h and retains the manager with probability $1-\delta_h$. In this equilibrium, market beliefs are

$$\mu(g|r) = \frac{\psi(\alpha + (1-\alpha)(1-\delta_h))}{\psi(\alpha + (1-\alpha)(1-\delta_h)) + (1-\psi)(\alpha(1-\delta_h) + (1-\alpha))} \ ,$$
$$\mu(b|f) = \frac{(1-\psi)\alpha}{\psi(1-\alpha) + (1-\psi)\alpha} \ .$$

Notice that $\mu(g|r)$ in this equilibrium is lower than $\mu(g|r)$ in the separating equilibrium, because board A_b sometimes retains the manager in this equilibrium. To sustain this equilibrium, the board's payoff must satisfy the following conditions:

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) > (1-\beta)(0.5) + \beta\mu(b|f) ,$$

$$(1-\beta)(0.5) + \beta\mu(b|f) = (1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) .$$

Suppose the second condition holds; that is, board A_b is indifferent between firing and retaining the manager. Then, it follows that board A_g's payoff from retaining the manager is strictly greater than its payoff from firing the manager. Because the payoff from firing for both boards are the same, by firing, board A_g will receive as much as A_b's payoff: that payoff is smaller than board A_g's payoff from retaining. The indifference condition for board A_b can be simplified to:

$$(1-\beta)(\alpha-\psi)(2\psi-1) = 2\beta(\psi(1-\alpha) + (1-\psi)\alpha)(\mu(g|r) - \mu(b|f)) .$$

Observe that $\mu(g|r)$ is increasing in δ_h. If the board is more likely to fire the manager when its signal is poor, the value of retention as a signal of good information increases. Because $\mu(g|r)$ is increasing in δ_h, the equilibrium firing probability is decreasing in β. Let the threshold of β at which $\delta_h = 0$ be β_p. β_p is solved using the following equation:

$$(1-\beta)(\alpha-\psi)(2\psi-1) = 2\beta(\psi(1-\alpha) + (1-\psi)\alpha)(\psi - \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}) .$$

This threshold for β between hybrid and pooling equilibria exists when $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$. When $\alpha = \frac{\psi^2}{\psi^2+(1-\psi)^2}$, $\delta_h = 0$ at $\beta = 1$. Therefore, the hybrid equilibrium exists if $\beta \in [\beta_s(\alpha,\psi), \beta_p(\alpha,\psi)]$ and $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$. When $\alpha > \frac{\psi^2}{\psi^2+(1-\psi)^2}$, the hybrid equilibrium exists when $\beta \in [\beta_s(\alpha,\psi), 1]$.

Next, I show the existence of a pooling equilibrium in which board retains the manager upon receiving signal s_g or signal s_b. In that equilibrium, firing is an off-equilibrium decision. The equilibrium belief $\mu(g|r) = \psi$. Suppose the off-equilibrium beliefs are such that when the market observes firing, the board must have signal s_b. Hence, $\mu(b|f) = \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}$. The board's equilibrium payoff from retaining after signal s_g and s_b is

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) \ ,$$

$$(1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

The board receives $(1-\beta)(0.5)+\beta\mu(b|f)$ if it deviates to firing. Notice that $\mu(g|s_g) > \mu(g|s_b)$, so the board's payoff from retaining after signal s_g is greater than the payoff from retaining after signal s_b. Thus, for the pooling equilibrium to sustain, the board should not deviate to firing upon receiving signal s_b. The no-deviation condition for board A_b can be simplified to

$$(1-\beta)\frac{\psi-\alpha}{2(\psi(1-\alpha)+\alpha(1-\psi))}(2\psi-1) + \beta\left(\psi - \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}\right) > 0 \ .$$

If $\alpha < \psi$, both the firm payoff and reputational payoff are strictly greater from retaining the manager after s_b. In other words, if the board's information is worse than the information in output, the board follows the output and retains the manager after state H. If $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$, firing the manager is value maximizing. However, the reputational payoff is greater from retaining the manager. The board retains the manager if β is large enough such that the reputational payoff dominates the loss in value from retaining the manager. Specifically, if $\beta > \beta_p$, the board retains the manager upon receiving s_b. This completes the proof of existence of pooling equilibrium.

■

Proof of Proposition I.3. First, I show the existence of a separating equilibrium in state L. In this equilibrium, the board retains after signal s_g and fires after signal s_b.

The equilibrium beliefs $\mu(g|r)$ and $\mu(b|f)$ are:

$$\mu(g|r) = \frac{(1-\psi)\alpha}{(1-\psi)\alpha + \psi(1-\alpha)} \ ,$$
$$\mu(b|f) = \frac{\psi\alpha}{\psi\alpha + (1-\psi)(1-\alpha)} \ .$$

To sustain this equilibrium, the board's payoff needs to satisfy the following conditions:

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) > (1-\beta)(0.5) + \beta\mu(b|f) \ ,$$
$$(1-\beta)(0.5) + \beta\mu(b|f) > (1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

Board A_b's payoff from firing is strictly greater than its payoff from retaining, because $\mu(g|s_b) < 0.5$ and $\mu(b|f) > \mu(g|r)$. The no-deviation condition for board A_g can be simplified to

$$(1-\beta)(\alpha-\psi)(2\psi-1) > 2\beta\alpha(1-\alpha)\frac{\psi^2-(1-\psi)^2}{\psi\alpha+(1-\psi)(1-\alpha)} \ .$$

Observe that the solution to this equation is given by β_s. The threshold β beyond which board A_g chooses to fire the manager with a non-zero probability is equal to the threshold in state H beyond which the board A_b chooses to fire the manager with a non-zero probability. Therefore, the separating equilibrium exists if $\beta < \beta_s(\alpha, \psi)$.

Next, I show the existence of a hybrid equilibrium in which board A_g fires the manager with probability δ_l and retains the manager with probability $1-\delta_l$. A_b fires the manager with probability one. In this equilibrium , market beliefs are

$$\mu(g|r) = \frac{(1-\psi)\alpha}{\psi(1-\alpha) + (1-\psi)\alpha} \ ,$$
$$\mu(b|f) = \frac{\psi(\alpha + (1-\alpha)\delta_l)}{\psi(\alpha+(1-\alpha)\delta_l) + (1-\psi)(\alpha\delta_l + (1-\alpha))} \ .$$

Because board A_g sometimes fires the manager, $\mu(b|f)$ in this equilibrium is lower than $\mu(b|f)$ in the separating equilibrium. To sustain this equilibrium, the board's payoff must satisfy the following conditions:

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) = (1-\beta)(0.5) + \beta\mu(b|f) \ ,$$
$$(1-\beta)(0.5) + \beta\mu(b|f) > (1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

Suppose the first condition holds. Then, it follows that board A_b's payoff from firing the manager is as much as board A_g's payoff from retaining. Because $\mu(g|s_g) > \mu(g|s_b)$, board A_g's payoff from retaining is greater than board A_b's payoff from retaining. Therefore, it is optimal for board A_b to fire the manager. The indifference condition for board A_g can be simplified to

$$(1-\beta)(\alpha-\psi)(2\psi-1) = 2\beta(\psi(1-\alpha)+(1-\psi)\alpha)(\mu(b|f)-\mu(g|r)) \ .$$

Notice that $\mu(b|f)$ is decreasing with δ_l. Therefore, the equilibrium firing probability is increasing with β. The threshold of β at which $\delta_l = 1$ (defined by β_p) is solved using the following equation:

$$(1-\beta)(\alpha-\psi)(2\psi-1) = 2\beta(\psi(1-\alpha)+(1-\psi)\alpha)(\psi - \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}) \ .$$

This threshold is the same as β_p solved in the hybrid equilibrium in state H. This threshold for β between the hybrid and pooling equilibria exists when $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$. When $\alpha = \frac{\psi^2}{\psi^2+(1-\psi)^2}$, $\delta_l = 1$ at $\beta = 1$. Therefore, the hybrid equilibrium exists if $\beta \in [\beta_s(\alpha,\psi), \beta_p(\alpha,\psi)]$ and $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$. When $\alpha > \frac{\psi^2}{\psi^2+(1-\psi)^2}$, the hybrid equilibrium exists when $\beta \in [\beta_s(\alpha,\psi), 1]$.

Next, I show the existence of a pooling equilibrium in which the board fires upon receiving both signals s_g and s_b. In this case, retaining is off-equilibrium. The equilibrium belief $\mu(b|f) = \psi$. Suppose the off-equilibrium beliefs are such that when the market sees retention, the board's information must be good (it received s_g). Therefore, $\mu(g|r) = \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}$. The board's payoff from firing after signal s_g and s_b is

$(1-\beta)(0.5) + \beta\mu(b|f)$. Board A_g and A_b's off-equilibrium payoffs from retaining are

$$(1-\beta)(\mu(g|s_g)\psi + (1-\mu(g|s_g))(1-\psi)) + \beta\mu(g|r) \ ,$$
$$(1-\beta)(\mu(g|s_b)\psi + (1-\mu(g|s_b))(1-\psi)) + \beta\mu(g|r) \ .$$

Notice that $\mu(g|s_g) > \mu(g|s_b)$, so board A_g's payoff from retaining is greater than board A_b's payoff from retaining. Thus, for the pooling equilibrium to sustain, board A_g should not deviate to retaining. The no-deviation condition for board A_g can be simplified to

$$(1-\beta)\frac{\psi-\alpha}{2(\psi(1-\alpha)+\alpha(1-\psi))}(2\psi-1) + \beta\left(\psi - \frac{(1-\psi)\alpha}{\psi(1-\alpha)+(1-\psi)\alpha}\right) > 0 \ .$$

If $\alpha < \psi$, both the firm value and reputational payoff are strictly greater from firing the manager. If the board's information is worse than the information in output, the board relies on the output and fires in state L. If $\alpha \in [\psi, \frac{\psi^2}{\psi^2+(1-\psi)^2}]$, it is value maximizing for A_g to retain the manager. However, the reputational payoff is greater from firing the manager. If $\beta > \beta_p$, board A_g fires the manager. This completes the proof of the existence of pooling equilibrium.

■

CHAPTER II

Do Equity Analysts Matter for Debt Contracts?

2.1 Introduction

Jensen and Meckling (1976) argue that security analysts employed by institutional investors and brokers play a large role in monitoring activities. The security analysts employed by these intermediaries have access to private information, and specialised skills and ability to interpret and process that information. They interact with the managers of a firm directly and question them in the earnings release conference calls. They can reveal any managerial misbehavior, and unravel any accounting shenanigans ex-post, thus posing a threat to the manager and preventing the manager from taking actions which are detrimental to the shareholders ex-ante. Dyck et al. (2010) find that analysts play an important role in the external governance mechanisms and are often the first to detect managerial misbehavior.

The security analysts by putting a check on the actions of the manager increase the value of the firm not only by reducing the agency costs of equity, but also by reducing the agency costs of debt. If the manager engages in private benefit or takes inefficient actions, the value of the claims to the creditors as well as the shareholders is affected. The two effects on the value of the debt and equity are not mutually exclusive and difficult to disentangle. Leland (1994) shows that the value of debt depends on the leverage and the asset risk. Thus, if the riskiness of the assets decreases due to the monitoring by security analysts, it will also affect the value of debt. Similarly, the actions of the manager detrimental to the creditors can reduce the value of the firm by reducing the value of debt as well as the value of equity. Chava and Roberts (2008) show that debt covenant violations lead to a decrease in capital investment, which would decrease the value of the firm.

The goal of this paper is to study the effect of a decrease in analyst coverage on the agency costs of debt. A decrease in analyst coverage causes a decrease in the monitoring of the firms which is expected to lead to an increase in the agency cost of debt. All else equal, this decrease in analyst coverage may lead to an increase in the probability of default and thus increase the cost of debt and reduce the value of the firm. However, I also expect that the creditors of the firms will take relatively more precautionary measures to reduce the increasing riskiness of debt by making the debt contracts more restrictive. The contracts are expected to be more likely to include covenants and a larger number of them. All else equal, the increased restrictiveness of the contracts is expected to reduce the costs of debt. However, it remains an empirical question whether the decrease in the costs of debt due to an increase in the number of covenants is more than enough to compensate for the increase in the costs of debt due to an increase in the agency costs.

Covenants can be thought of as mechanisms, which by imposing a credible threat to the managers, reduce the agency costs of debt (see Jensen and Meckling (1976) and Smith and Warner (1979)). The breach of a covenant in the debt contract is taken to be a signal of poor performance. Aghion and Bolton (1992) and Dewatripont and Tirole (1994) show that the debt contracts in which control rights are transferred to the creditors after poor performance are the optimal financial contracts in mitigating inefficient management decisions and reducing managerial moral hazard problem. Empirically, it has been observed that cost of debt is lower for bonds which include covenants. Chava et al. (2009), Reisel (2014) and Goyal (2005) find that covenants reduce the cost of issuing public debt. Bradley and Roberts (2015) find the same for private debt.

It is challenging to cleanly identify the effect of analyst monitoring on the debt covenants due to confounding factors that may drive debtholders' behavior. An increase in the number of covenants could be driven by an increase in the opaqueness of the firm or a change in manager's investment behavior. For example, the manager may choose to invest in risky projects and that may result in an increase in restrictiveness of debt contracts. Due to these concerns, estimating the effect of a reduction in the number of analysts following the firm on the debt contracts using a simple OLS could be biased.

In order to cleanly identify the effect of a decrease in monitoring by the security analysts on the debt contracts, I use the merger of 14 brokerage houses between 1984 and 2005 (Hong and Kacperczyk (2010)), as a quasi-natural experiment which led to a decrease in the amount of coverage because some redundant analysts had to leave post-merger. The reduced coverage has been shown to increase the agency costs of equity and decrease the value of the firm (see Kelly and Ljungqvist (2012)). As discussed above, it should also adversely affect the value of the firm by increasing the agency costs of debt and decreasing the value of debt. It is plausibly an exogenous source of decrease in the analyst coverage, because it seems unlikely that an increase in the agency costs of debt would cause an ex-ante reduction in analyst coverage. Also, since the merger is staggered during a long period of about 20 years, it is unlikely that other events occurring at the same time as the brokerage houses merger will be affecting the agency costs of debt.

I use difference-in-difference technique to establish a causal effect of decrease in analyst coverage on the inclusion of debt covenants and the cost of debt. The firms which were covered by both brokerage houses before the merger and only by the merged broker after the merger form the treatment group. The remaining firms which were unaffected by the brokerage houses merger form the control group. The identifying assumption is that any confounding factor that drives the characteristics of the debt contracts affects the treatment and the control group in the same manner. For instance, it is possible that the brokerage houses prefer to cover firms that are larger and therefore the treatment firms, that are followed by fewer analysts after the merger, are smaller. However, matching the treatment firms to set of control firms that are similar in size and other characteristics (that may drive the ownership of the firm's debt or equity by the brokerage firm) suggests that the assumption holds.

Moreover, as argued above, the reduced coverage due to the brokerage houses merger should increase the agency costs of debt only for treatment group firms. Thus, firms which were covered by both brokerage houses pre-merger should have higher agency costs of debt as compared to firms which were unaffected by the merger. Therefore, the creditors should be more likely to include covenants and increase the number of covenants for debt issued after the merger for the firms in the treatment group. Also, the role of covenants in reducing the agency costs of debt should be of greater importance for the firms in the treatment group in post-merger period.

First, I study the effect of covenants in reducing the agency costs of debt. Smith and Warner (1979) argue that covenants reduce the agency costs of debt by restricting the actions of the manager. I find that, on average, the cost of debt is 14bps lower if there is at least one covenant in the bond. The covenants which restrict the investment actions and the event-driven covenants play an important role in reducing the costs of debt. However, the financing and the payout covenants impose restrictions which may negatively affect the probability of payment to the creditors. Thus, they infact diminish the effect of investment and event-driven covenants and increase the costs of debt.

Further, using the merger of brokerage houses as an exogenous decrease in the analyst coverage, I find that the likelihood of including the covenants in bonds increases, the number of covenants included in the bonds increases and the cost of debt decreases, upon a decrease in the analyst coverage. I find that the odds of including the covenants are about 1.6-2.3 times larger for the treatment firms after the merger. Also, on average, the number of covenants increases by about 1.03-1.22 for the treatment firms after the merger. I find that all four categories of covenants increase upon a decrease in the analyst coverage. I also find weak evidence of an increase in the effectiveness of the covenants in reducing the costs of debt.

2.2 Literature Review

Smith and Warner (1979) argue that covenants reduce the agency costs of debt by restricting the actions of the manager and giving him incentives to maximize the value of the firm, instead of shareholder's wealth. Billett et al. (2007) find that covenant protection diminishes the negative relationship between growth opportunities and leverage for high growth firms, by reducing the agency costs of debt. Gamba and Triantis (2014) find that debt covenants mitigate losses due to agency costs and makes investment and financing policies closer to first-best. Leland (1994) finds that positive net-worth covenants makes both debt and equity a concave function of the firm value, and reduces the incentive of shareholders to take excessive risk. He also finds that "increasing risk lowers equity value as well as debt value". Chava et al. (2009), Reisel (2014) and Goyal (2005) while studying the role of covenants in public debt issues find that including covenants reduce the cost of debt. Bradley and Roberts (2015) examine private debt and supports the role of covenants in reducing the cost of debt.

Besides covenants, researchers have studied other mechanisms which reduce the agency costs of debt. Diamond (1989) and Hirshleifer and Thakor (1992) show that the problem of agency costs of debt is attenuated if managers, out of reputational concerns, favor relatively safe projects. Green (1984) finds that issuing convertible bonds and warrants reduce the agency costs of debt by reversing the convex shape of levered equity over the upper range of the firm's earnings. In this paper, I examine the effect of decrease in analyst coverage on the agency costs of debt and the effectiveness of the covenants in overcoming the increase in agency costs.

Researchers have also studied various incentive schemes to overcome the agency problem. Equity ownership structure reduces the manager-shareholder conflict by aligning the interests of the manager with that of the shareholders (Morck et al. (1988), McConnell and Servaes (1990)). The effect of ownership on agency costs of debt is mixed. Brander and Poitevin (1992) and Anderson et al. (2003) find that ownership structure is associated with reducing the agency costs of debt besides the usual manager-shareholder agency conflict. On the other hand, Bagnani et al. (1994) find that increase in managerial ownership structure increases the agency costs of debt, when ownership is low. The increase in managerial ownership aligns the manager's incentives with that of shareholders, which increases the agency costs of debt. However, they find a non-positive relationship when the ownership is large (over 25 percent).

Another strand of literature focuses on the reasons and effects of covenant violations. Dichev and Skinner (2002) find that covenant violations are quite high because the constraints on the covenants are quite tight relative to the financial condition of the firm at the time they are written. Roberts and Sufi (2009) find that net debt issuing activity reduces after covenant violations. Chava and Roberts (2008) show that debt covenant violations lead to a decrease in capital investment. Nini et al. (2009) find that covenant violations lead to a decrease in acquisitions and capital expenditures, increase in CEO turnover and a decrease in leverage and shareholder payouts. Thus, covenants play an important role in reducing the agency problem and thus protecting the interests of the creditors and the value of the firm.

There are several papers which have used the brokerage house mergers as an exogenous shock to information asymmetry and studied its effect on reporting bias (Hong and Kacperczyk (2010)) credit ratings (Fong et al. (2014)) and innovation (He and Tian (2013)). Purnanandam and Rajan (2018) show that an increase in the information asymmetry increases the intensity of the signal inherent in the growth option conversion. Kelly and Ljungqvist (2012) find an increase in the cost of equity and a decrease in the value of the firm. However, they find that the channel that links information asymmetry to prices is liquidity. Irani and Oesch (2013) and Balakrishnan et al. (2014) investigate the effect of analyst monitoring on corporate disclosure. Derrien and Kecskés (2013) find that firms decrease investment and financing due to an increase in the information asymmetry. They show that a decrease in analyst coverage increases the information asymmetry which increases cost of capital.

In a related contemporaneous study, Derrien et al. (2016) show that with an increase in information asymmetry the cost of debt and the rate of credit events (such as defaults) increases. They suspect information asymmetry affects debt-holders through two channels. The direct channel is by the transfer of information from the stock market to the bond market. The indirect channel is through the price of equity, since it is an important determinant in the price of debt (Merton (1974)). Unlike Derrien et al. (2016), I find that the cost of debt decreases as the amount of analyst coverage reduces. The channel is due to an increase in the likelihood of inclusion of covenants and an increase in the number of covenants in the bonds issued after the decrease in the analyst coverage.

2.3 Hypothesis and Empirical Design

Covenants protect the interests of the creditors by imposing constraints on the actions of the manager which may be detrimental to the creditors. The managers may make large dividend payments, raise additional financing and thereby, dilute the claim of the creditors. They may engage in risk shifting, which increases the probability of default on the bond. The managers may forgo investment in some positive net present value projects (Myers (1977)) and may participate in mergers and acquisitions which might adversely affect the claim of the creditors (Warga and Welch (1993)). However, covenants limit the discretion of the manager and help to reduce the risk of default by increasing the probability of repayment of the debt. Therefore, the cost of debt is lower for bonds which include covenants.

I measure the inclusion of covenants in two ways: i) I create dummy variable CovFlag which measures the presence or absence of covenants, ii) I count the number of covenants included in each bond, and estimate the effect of a marginal increase in the number of covenants on the cost of debt.

Security analysts, apart from making a buy-sell recommendation on the equity of the firm, provide details about the firm and the competition in the industry in their reports. They provide sales and margin analysis, which are also relevant for the creditors and the institutional investors. The projections about the sales, gross margin and operating margin provide information about the ability of the firm to pay its debt obligations. Since the managers are ex-ante aware that creditors and institutional investors consume the reports published by the security analysts, it deters them from making decisions which might deteriorate the value of debt. Thus ex-post monitoring by the security analysts reduces the agency costs of equity as well as agency costs of debt by disciplining the manager ex-ante.

Therefore, if there is an exogenous shock which decreases the coverage by security analysts then it will adversely affect the agency costs of debt. Thus, the bonds will be more likely to include covenants to protect the interest of the creditors. Also, the creditors should include more number of covenants to deter the manager from taking actions detrimental to the creditors.

Hypothesis 1: With a decrease in analyst coverage, the likelihood of including covenants in a bond increases, and the number of covenants included in a bond increases.

I test the above hypothesis against the null hypothesis that the analyst coverage has no effect on the likelihood of including the covenants in bonds and the number of covenants in the bonds. I use 14 mergers of brokerage houses during 1984-2005 as an exogenous shock which adversely affected the analyst coverage. I assign firms into the treatment group if they were followed by both brokerage houses before the merger and only by the merged entity after the merger. I use matching by industry and size as well as propensity score matching (using all firm specific control variables) to match the control firms with the treatment firms.

Since the number of covenants increases for the bonds of the treatment firms, the cost of debt should be marginally lower for those bonds. As the first hypothesis states that covenants are an effective mechanism which reduce managerial misbehavior and thus lower the cost of debt, more covenants should decrease the cost of debt. However, with a decrease in monitoring by the security analysts and with an increase in information asymmetry, the cost of debt goes up. It remains an empirical question to test whether the effect of covenants in reducing the cost of debt dominates the adverse effect of a decrease in analyst coverage on the cost of debt.

Hypothesis 2: The cost of debt is lower after a decrease in monitoring by the analysts.

I test the above hypothesis against the null hypothesis that the analyst coverage has no effect on the cost of debt. I use the same dataset as described in Hypothesis 1. I use both industry-size as well as propensity score matching to match the control firms with the treatment firms.

2.4 Data

2.4.1 Covenants and Cost of Debt

Chava et al. (2009), Reisel (2014), Goyal (2005), and Billett et al. (2007) in their studies use the sample of debt issues from Fixed Investment Securities Database (FISD), which has detailed information on over 130,000 public debt issues spread across different countries and includes, among others, Corporate bonds, US government bonds, and foreign bonds. FISD dataset includes only those debt issues which mature after 1989, thus there are few debt issues prior to 1981, which marks the start of my sample. I do not include any of the government bonds, foreign bonds, bonds denominated in foreign currency in the sample. I exclude bond issues for which "subsequent data" flag in FISD dataset is "N". This flag is "Y" if the issue has proceeded beyond the initial input phase and whether FISD records subsequent data from a prospectus, pricing supplement or other more detailed document or source. This leaves us with a sample of about 23,672 public debt issues spanning from 1981-2012, out of which 64% of the issues includes covenants, about 89% of the issues are corporate debentures, and about 7% are corporate convertibles.

Further I match the bond issuers with the Compustat dataset and obtain information about other firm specific variables, such as the Issuer Ratings, Leverage, Size, Tangibility and Profitability of the firm. However, I am able to match only 11,464 bond issues for 2516 issuers with the information about the financial statement variables from the Compustat database. Table 2.2 shows the summary statistics of these debt issues and also the information on firm specific variables of the firm-bond observations. The median debt has a maturity of 10 years and offering yield of 6.63%. Each bond issue in the sample has the information of about 50 possible covenants for creditor protection and restriction on the issuer's actions. Following, Billett et al. (2007), I group the covenants into 15 broad categories. I further cluster these categories into

4 major groups.

The covenants in the first group are the *Payout Restriction Covenants* which limit the issuer from paying the shareholders. The two covenants in this group limit the dividend payments and other forms of payment to the shareholders and others. About 8% of the issues have dividend payment restrictions and about 6% of the issues have restrictions on other forms of payment to shareholders. The next seven categories limits the financing activities of the issuer. *FunDebtR* restricts the issuer from issuing additional funded debt. Funded debt is any debt with a maturity of 1 year or longer. The following three covenants restrict the issuer from raising additional subordinate, senior and secured debt. About 44% of the bond issues include the secured debt covenant. *LevTest* includes a group of covenants placing restrictions on the leverage. *SalesLB* covenant limits the issuer from selling and then leasing back the assets. *StockIss* covenant limits the issuance of additional common or preferred stock.

The next set of covenants are the *Event-driven covenants*. These covenants automatically trigger certain provisions of the bond after an event specified in the covenant occurs. For instance, if the issuer's rating or net worth declines below a certain threshold, then certain provisions of the bond are triggered (such as put provision of the bond in case of rating decline). In the event of default under any debt of the firm, the *CrossDef* provision will trigger the event of the default in the issue that includes the CrossDef covenant. *CrossDef* covenant also includes the Cross Acceleration provision which triggers the acceleration of the debt, incase any other debt has been accelerated due to an event of default. It is included in 45% of the bond issues in the sample. *PosionPut* covenant allows the creditors to have the option of selling the bond back to the issuer upon a change in control.

The last set of covenants restrict the investment activities of the issuer. *AssetSale* clause requires the issuer to use the proceeds from the asset sales to redeem the bonds at par or at a premium. It does not limit the right to sell assets. *Inv* restricts the issuer's investment policy to prevent risky investments. *MergerR* restricts a consolidated merger of the issuer with another entity. There is only 1% of the bond issues which include the *Inv* covenant, while 62% of the bond issues have an asset sale covenant. Also, the correlation between asset sale covenant and merger covenant is 99%, therefore if a bond issue has an asset sale covenant, it is almost certain to have a merger restriction covenant as well.

I create a dummy variable $CovFlag$ which indicates the presence/absence of covenants. In the FISD/Compustat matched sample, 74% of the bond issues have covenants, higher than the unmatched FISD sample in which about 64% of the issues included covenants. Therefore , it seems that some of the bond issuers are private, and public debt raised by them is less likely to include covenants. It could be because the financial information is less verifiable for private firms, thus it is hard to write covenants on the financial variables of the firm. Also, the accounting variables are more subject to manipulation by the manager, therefore even if the bond includes the covenants, their enforcement will be ineffective.

I create 15 dummy variables for each covenant and consolidate those 15 variables into 4 variables for each group of covenant. *CovIndex* is calculated as the sum of all 15 covenant dummy variables. Table 2.2 also presents the summary statistics of other firm specific variables obtained from Compustat. Instead of using issue rating, I use issuer rating since FISD has rating information about the issue only since April 1995. However, the issuer rating is a huge determinant in assigning an issuer rating. The correlation between issue rating and the issuer rating is about 94% during the time period when both are present. The variables are defined in the Appendix.

2.4.2 Analyst Coverage

I follow Hong and Kacperczyk (2010) and use the merger of brokerage firms as an exogenous shock to the analyst coverage. I use the IBES database and get the detailed history about the earnings estimates by the security analysts. Each analyst has a unique identifier through which I can follow the analyst across time. I can identify the firms which are followed by the analyst as well as the brokerage firms with which the analyst was employed during different periods of time. I use 14 mergers between brokerage firms spanned during 1984-2005.[1]

A firm is considered to be treated if it was covered by both brokerage houses before merger and with the merged brokerage house after the merger. If not, then that firm will be a control firm. I choose 4 time windows before and after the merger to observe the early and late effects of the merger on the use of debt covenants. The first three time windows are denoted by *1yr*, *2yr* and *3yr*, while the fourth time window is anytime before or after the merger in the sample, and is denoted by *Nyr*. For instance, consider the merger on May 31, 1997. If any firm is covered by both brokerage firms, which were involved in the merger, during the period May 31,1996 to May 31,1997 and only by the merged entity during the period May 31,1997 to May 31,1998 then this firm will be included in the 1yr time-window sample. Similarly, I do it for 2yr, 3yr and Nyr time window samples.

Now, during the period of 1981-2012, a firm may be affected by more than one merger. If there is a overlap between the time-windows of the two mergers, there will be a dilemma in the post merger status of the firm. To illustrate, suppose there is a firm which is affected by two mergers, one in 1997 and second in 1999. Now, the year 1998 will be treated as post merger observation for merger 1 while a pre-merger observation for merger 2. To avoid this dilemma, in this paper, I consider only the most recent merger which affected the firm and ignore all the earlier mergers. Using this process, I obtain 1,167 treated firms and 18,590 control firms which were not affected by the merger. Similarly, for 2yr, 3yr, Nyr window, I find 1,322 firms, 1,407 firms and 1,595 firms to be affected by the mergers. Upon, considering different time

[1]Detailed information about the mergers can be obtained from the appendix in Hong and Kacperczyk (2010).

windows, on average, there are about 12-16 control firms for each treatment group. On average, every year 13.3 analysts follow the group of firms covered by 1yr window. The 2yr, 3yr and Nyr window has about 12-13 analysts covering a firm every year. The treated firms in these windows are covered by around 15-16 analysts while the control firms are covered by 8-9 analysts.

2.5 Effect of Covenants on Cost of Debt

In this section, I analyse whether the inclusion of covenants in a bond reduces the costs of raising debt. I control for all possible factors which may affect the cost of raising debt. I use year fixed effects to control for any changes in the market environment, which affects all firms in a particular year. I control for firm specific variables which affect the cost of debt. If the leverage of a firm is high, then the risk of default is also high, thus raising the cost of debt for highly levered firms. I also control for the growth opportunities of the firm. Firms with more growth opportunities have been known to issue equity to raise financing, and are negatively related to leverage. Thus, cost of debt is lower for firms with higher growth opportunities. I use the market-to-book ratio as a proxy for the growth opportunities.

First, I analyse the effect of the presence of covenants on the cost of raising debt. I run the following regression:

$$\begin{aligned} CostofDebt_{itb} =& \alpha + \gamma_i + \delta_t + \beta_1 CovFlag_{itb} + \beta_2 Term_{itb} \\ &+ \beta_3 Firm\,Controls_{it} + \epsilon_{itb} \ , \end{aligned} \tag{2.1}$$

where $CostofDebt_{itb}$ is the yield offered by firm i on bond b issued in year t. γ and δ control for firm and year fixed effects. $CovFlag$ is a dummy variable which equals 1 if the bond issue includes at least one covenant. $Term$ denotes the maturity of the bond. $Firm\,Controls$ denote the time-varying firm specific control variables (defined in the Appendix). I run 4 regressions with different subsets of the above control variables. The results are reported in detail in Table 2.3. The full regression (Model 4 in the table) shows that the cost of debt for bonds which includes covenants is 14 bps lower than the bonds which do not include covenants. If the rating decreases by one notch, the cost of debt increases by 23 bps. Also, the cost of debt increases with an increase in leverage, and decreases with an increase in market-to-book ratio. Upon comparing the results for regression models (3) and (4), I find that many of the other firm level controls become insignificant after controlling for firm fixed effects. It implies there is not enough variation within firms for R&D expenses, advertising expenses, capital expenditure and cash. Also, there are only about 4.5 firm-bond observations for each firm during the period 1981-2012.

Next, I analyse the contribution of a marginal increase in the number of covenants in decreasing the cost of debt. I run the following regression:

$$
\begin{aligned}
CostofDebt_{itb} =& \alpha + \gamma_i + \delta_t + \sum_j \beta_{1j} CovIndexDummmy(=j)_{itb} + \beta_2 Term_{itb} \\
&+ \beta_3 Firm\,Controls_{it} + \epsilon_{itb}\ ,
\end{aligned}
\tag{2.2}
$$

where $CovIndexDummy(=j)$ is a dummy variable which equals 1 if the number of covenants in a bond issue is equal to j. I again run 4 regressions as before. The results are reported in Table 2.4. As the number of covenants increases the cost of debt decreases. The cost of debt is the least for bonds with 4 covenants. However, as the number of covenants begin to increase beyond 7 the cost of debt begins to increase. This implies that the marginal benefit of an increase in the number of covenants diminishes as the number of covenants increases. Once the number of covenants is greater than 7, further increase in the number of covenants increases the cost of debt.

Now, I divide the covenants into different categories and analyse the source of the decrease in the cost of debt. I run a regression similar to the the previous one but with a different set of dummy variables indicating the different categories of covenants.

$$
\begin{aligned}
&CostofDebt_{itb} = \alpha + \gamma_i + \delta_t + \sum_j \beta_{1j} PayoutRestriction(=j)_{itb} \\
&+ \sum_j \beta_{2j} FinancingRestriction(=j)_{itb} + \sum_j \beta_{3j} InvestmentRestriction(=j)_{itb} \\
&+ \sum_j \beta_{4j} EventDriven(=j)_{itb} + \beta_5 Term_{itb} + \beta_6 Firm\ Controls_{it} + \epsilon_{itb} \ ,
\end{aligned} \tag{2.3}
$$

where the dummy variable, $PayoutRestriction(=j)$ equals 1 if there are j payout covenant restrictions for a bond. The other 3 dummy variables are similarly related to the other 3 categories of covenants.

Table 2.5 presents the results of this regression. The covenants which restrict the investment policy of the firm and the event-driven covenants are the ones which reduce the cost of debt. While the payout restriction covenants and the financing restriction covenants increase the cost of debt. Upon comparing these results with those of Table 2.4, I infer that the event driven covenants and the investment restriction covenants are the first ones to be included in a bond issue. This is so because these covenants have a negative effect on the cost of debt; and a smaller number of covenants is also associated with lower cost of debt (Table 2.4). Whereas the payout restriction covenants and the financing restriction covenants must be the ones which are included in the debt after the investment and the event driven covenants are already included, since the payout restriction covenants and the financing restriction covenants are positively related to the cost of debt (Table 2.5), which increases if the number of covenants increases beyond 7 (Table 2.4).

It seems surprising that the addition of payout and financing restriction covenants should be associated with higher cost of debt. One plausible explanation of this result is that firms issuing bonds with large number of covenants and payout and financing covenants are the ones with low creditworthiness, and thus they have a higher cost of debt compared to the others.

As seen above the investment and event-driven covenants seem to be the ones which are included first in the bonds and they play an important role in reducing the cost of debt. This may be so because these types of covenants are more effective in reducing the agency costs of debt than the financing or payout covenants. The investment restriction group of covenants include the asset sale, investment and merger covenants. In the absence of the asset sale covenant, the manager may sell the asset and not use the proceeds to redeem the bonds, which jeopardizes the principal amount of debt for the creditors. If any of the thresholds in the event driven covenant is breached, then it automatically triggers certain provisions of the bond. *CrossDef* covenant will trigger the event of default/acceleration of the debt in case any other bond faced an event of default/acceleration.

Payout and financing restriction covenants do not pose such strong restrictions as event driven covenants. For instance, for a financing covenant, in case the borrower issued additional debt and breached a covenant. This breach increases the probability of bankruptcy since leverage has increased. However, if the additional financing is invested in positive net present value projects with low risk, the probability of repayment should increase and the probability of default should decrease instead. Second, the payout covenants restrict the manager from paying dividends to the shareholders. However, the dividends can be paid only from the net income after paying the interest payments to the creditors. Therefore, the payout and the financing restriction covenants do not jeopardize the principal outstanding for the debt issue as the investment restriction covenants. They also do not impose automatic trigger of default/acceleration or put provision of the debt as the event-driven covenants.

2.6 Effect of Brokerage Firms Merger on Debt Contracts

In this section, I use the merger of brokerage firms to establish a causal relationship between the analyst coverage and the debt contracts. Before that, I replicate (using only the IBES brokerage house dataset) the results of Hong and Kacperczyk (2010) who find that when brokerage firms merge, a redundant analyst is fired. This provides a quasi-natural experiment to measure a decrease in the analyst monitoring of the firm. I match the treatment firms with control firms which were followed by exactly the same number of analysts as the treatment firm before the merger. For each treatment firm I match upto 5 control firms. I do the same exercise for all 4 time windows 1yr, 2yr, 3yr and Nyr. I run the following regression:

$$NumAnalyst_{it} = \beta_1 Treat + \beta_2 Post + \beta_3 TreatXPost + \epsilon_{it} \ , \qquad (2.4)$$

where $NumAnalyst$ represent the number of analysts following firm i in year t. The results are shown in Table 5. The coefficient of interest is β_3 which is the difference-in-difference estimate of the effect of brokerage house merger on the analyst coverage. I run the above regression with treatment firms estimated in three different ways. As described in the data section, the regression for 1yr under column 1 and 2 correspond to the treatment variable estimated using 1 year time window before and after the merger. Similarly, the 2yr and 3yr columns correspond to two year and three year time windows before and after the merger. The coefficient β_3 is negative and significant at 1% level for all three regression specifications.

2.6.1 Effect of Decrease in Analyst Coverage on Bond Covenants

I use the IBES analyst dataset as described in the data section and merge it with the Compustat/FISD dataset. Out of the 11,464 bond issues in the FISD/Compustat dataset, I could find 9,629 bond issues whose issuers were followed by security analysts at some point of time in the sample. I include the remaining firms which were not covered by security analysts (remaining 1,835 out of 11,464) but have bond issues, into the group of control firms as well. Thus, the final FISD/Compustat/IBES merged dataset consists of 11,464 bonds issued by 2516 issuers during the period 1981-2012. I partition these bond issues into treatment and control group where the groups are assigned based on 4 different time windows. I assign firms into the treatment group if they were followed by both brokerage houses before the merger and only by the merged entity after the merger. For each treated firm, I find control firms through matching by industry and size; and through propensity scores. The results are qualitatively similar in both cases and I report only those obtained though matching based on the propensity score. There are 4367 treatment firm-bond observations using a 1 year time window, while 4737, 4935, 5289 firm-bond treatment observations using a 2yr, 3yr, Nyr time window. The summary statistics of the covenant and the financial statement variables for the treatment and control firm-bond observations using a 3yr window are in Table 2.7.

I estimate the effect of merger of brokerage firms on the debt covenants. I run the following logistic regression model:

$$\begin{aligned} CovFlag_{itb} =& \alpha + \gamma_j + \delta_t + \beta_1 Treat + \beta_2 NewDebtPostMerger \\ & \beta_3 Treat\ X\ NewDebtPostMerger + \beta_4 Firm\ Controls + \epsilon_{itb}\ , \end{aligned} \tag{2.5}$$

where $CovFlag_{itb}$ is a dummy variable which indicates the presence of covenants in bond b for firm i in year t. I run the above regression for 4 different time-window specification, as described in the data section. $Treat$ equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 1yr, 2yr, 3yr and Nyr time-windows $NewDebtPostMerger$ equals 1 for firm-bond observations 1 year, 2 year, and 3 year and all remaining years in the sample after the merger. $NewDebtPostMerger$ equals 0 for all firm-bond observations before the merger. There is not enough within-firm variation amongst the bonds in the data to analyse the data at the within-firm level. On average there are only 4.5 bond issues by a firm during the sample period of 31 years. I use industry fixed effects γ_j to control for any factors particular to an industry which may effect the probability of including covenants in bonds.

I also control for financial statement variables of the issuer which may affect the presence of covenants in the bond issues. Malitz (1986) and Begley (1994) identify that firm size and capital structure play a role in the use of covenants in the bond. Nash et al. (2003) and Billett et al. (2007) find that growth options play a role in influencing the use of bond covenants. Following the literature, I use market-to-book ratio as a proxy for growth options.

The results of the above regression are in Table 2.8. The coefficient of interest is β_3 which represents the difference in difference estimate of the probability of issuing a bond with covenants for treatment firms after the merger. It is positive and significant at 1% level for all time-windows. It implies that the bonds issued by the treatment firms after the merger are more likely to include covenants. Thus, I reject the hypothesis that monitoring by the equity analysts have no effect on the bond contracts. I find that the creditors are more likely to include bond covenants after an exogenous decrease in the monitoring by analysts.

Now, I test whether the brokerage house merger has any effect on the number of covenants in the bonds which are issued after the merger. I run the following regression model:

$$\begin{aligned}CovIndex_{itb} =& \alpha + \gamma_j + \delta_t + \beta_1 Treat + \beta_2 NewDebtPostMerger \\ & \beta_3 Treat\ X\ NewDebtPostMerger + \beta_4 FirmControls + \epsilon_{itb}\ ,\end{aligned} \tag{2.6}$$

where $CovIndex$ measures the total number of covenants included in the bond. The coefficient of interest is β_3 which represents the difference in difference estimate of the number of bond covenants for treatment firms after the merger. The coefficient is positive and significant at 1% level for all regression specifications, implying that the bonds issued post merger include more number of covenants for the treated firms. The results are reported in Table 2.9. On average, the number of covenants in the new bond issued post merger by the treated firms is higher by 1.03-1.22.

I further investigate the source of increase in the bond covenants. I find that all categories of covenants increase after the merger. The results are reported in Table 2.10. The results hold for all time windows and are statistically significant at 1% level. These results are in contrast with Chava et al. (2009) who find that likelihood of including investment related and merger related covenants increases while that of payout and financing related covenants decreases once managerial entrenchment increases.

I also analyse the relative proportion of increase in different categories of covenants. I run the following regression on proportion of all 4 covenants:

$$\begin{aligned}Proportion_{itb} =& \alpha + \gamma_j + \delta_t + \beta_1 Treat + \beta_2 NewDebtPostMerger \\ & \beta_3 Treat\ X\ NewDebtPostMerger + \beta_4 FirmControls + \epsilon_{itb}\ ,\end{aligned} \tag{2.7}$$

where $Proportion$ is the relative proportion of covenants. I use all four categories of covenants as the dependent variable in 4 separate regressions. The results are presented in Table 2.11. This analysis is limited to those bonds which include at least one covenant, so that proportion of different categories of covenants can be estimated. This explains the decrease in the number of observations in the regressions in this particular table. I find that the proportion of payout covenants and event-driven covenants increases, while the proportion of investment restriction covenants decreases for the bonds issued after the merger by the treated firms. The results are statistically significant at 1% level.

2.7 Effect of Decrease in Analyst Coverage on Cost of Debt

Now, I estimate the effect of a decrease in the analyst coverage on the cost of raising new debt. Specifically I run the following regression:

$$\begin{aligned} CostofDebt_{itb} = &\alpha + \gamma_j + \delta_t + \beta_1 Treat + \beta_2 NewDebtPostMerger \\ &\beta_3 Treat\ X\ NewDebtPostMerger + \beta_4 FirmControls + \epsilon_{itb} , \end{aligned} \tag{2.8}$$

where $CostofDebt$ is the yield offered on a bond. The results are reported in Table 2.12. The difference in difference estimate of the effect of a decrease in analyst coverage on the cost of debt is captured by β_3. As can be seen from the table, β_3 is negative and statistically significant at 1% level for the 1year, 2yr and 3yr windows. The coefficient for the N year window is statistically significant at 5% level with a t-stat of -2.54. It implies that the cost of debt is lower for the new bonds issued by the firms which were affected by the merger.

Therefore as the number of analysts following a firm reduce, the number of covenants in the new debt increases as well as the cost of debt reduces. This provides an evidence of the role of covenants in reducing the cost of debt for the new debt issued.

2.8 Discussion

It is puzzling to note that the cost of debt goes down when there are fewer analysts following a firm. However, this result can be justified in a world in which the decrease in analyst coverage results in worse shareholder monitoring. Because of the worse monitoring, manager chooses to remain passive and do nothing. Thus, the manager chooses low risk projects and therefore the cost of debt is lower.

Alternatively, assume a world in which the manager's behavior is disciplined only by security analysts and debt covenants. The security analysts produce information about the manager's actions and the covenants put restrictions on the manager's behavior. Further, the cost of debt is only a function of debt covenants. Before the merger of brokerage houses, the number of covenants on the debt contracts and the security analysts covering the firm are optimal. After the merger of brokerage houses, the firm faces an exogenous shock to its analyst coverage. In order to to substitute for the loss of information produced by the analysts, the debt holders increase the number of covenants. The increase in the restrictions put forth by the covenants results in a change in manager's behavior. The manager chooses low risk projects and that results in a lower cost of debt.

2.9 Conclusion

In this paper, I analyse the overlap between the agency costs of equity and agency costs of debt. I study and connect the effects of covenants and security analysts in reducing these agency costs. On one hand, covenants play an important role in protecting the interests of the creditors. They impose constraints on the actions of the manager and the shareholders ex-post, and thus reduce the agency cost of debt ex-ante. On the other hand, information intermediaries act as agents of the shareholders and prevent the manager from taking inefficient actions detrimental to the shareholders. However, since any sub-optimal action of the manager will effect the value of the equity as well as the value of debt, information intermediaries, in the process of reducing the agency costs of equity, indirectly reduce the agency costs of debt as well, and protect the interests of the creditors. If there is an exogenous decrease in monitoring by the information intermediaries, it should increase the agency costs of equity as well as the agency costs of debt. Creditors, by increasing the likelihood of inclusion of covenants and the number of covenants, are expected to take measures to reduce the increase in the agency costs of debt.

I find that the inclusion of covenants in the bond contracts reduce the cost of debt. The covenants which restrict the investment actions and the event-driven covenants are strong and play an important role in reducing the cost of debt. However, the financing and the payout covenants impose restrictions which may negatively affect the probability of payment to the creditors. Thus they infact diminish the effect of investment and event-driven covenants and increase the costs of debt. Further, I use the merger of brokerage houses during the period 1984-2005 as an exogenous decrease in the analyst coverage and study its effect on the debt contracts. I find that the likelihood of including the covenants increases, the number of covenants included in the bonds increases and the cost of debt decreases, upon a decrease in the analyst coverage. I find that all four categories of covenants increase upon a decrease in the analyst coverage.

2.10 Variable Construction

Table 2.1: Variable Definitions

Variable	Definition
Tangibility	Plant, Property and Equipment / Total Assets, both at time t
Profitability	EBITDA between $t-1$ and t / Total Assets at t -1
Capx_Assets	Capital Expenditure between $t-1$ and t / Total Assets at $t-1$
RD_PPE	R&D Expenditure between $t-1$ and t / PPE at t. Set missing observations to 0 to maintain sample size.
Adv_PPE	Advertising Expenditure between $t-1$ and t / PPE at t. Set missing observations to 0 to maintain sample size.
M/B Ratio	(Total Assets - Book value of equity + Market value of equity) / Total Assets, all at time t.
Cash_Assets	Cash and Short Term Investments / Total Assets at t
Leverage	(Long Term Debt + Debt in Current Liabilities)/(Total Assets - Book value of equity + Market value of equity)
ROA	Income Before Extraordinary items / Total Assets at $t-1$ * 100
Issuer Rating	Number coding from 1 to 22 for S&P Domestic Long Term Issuer Credit Rating 1=AAA, 22=D
DivPmtR	Equals 1 if there is covenant limiting the dividend payments of the issuer or a subsidiary of the issuer.
ShareRepR	Equals 1 if there is a covenant limiting the issuer to make payments (other than dividend payments) to shareholders and others.
FundDebtR	Equals 1 if there is covenant preventing the issuer and/or the subsidiary from issuing additional debt with a maturity of 1 year or longer.
SubDebtR	Equals 1 if there is a covenant preventing the issuer from issuing additional subordinate debt.
SenDebtR	Equals 1 if there is a covenant preventing the issuer from issuing additional senior debt.
SecDebtR	Equals 1 if there is a covenant preventing the issuer from issuing additional secured debt.
LevTest	Equals 1 if i) there is a covenant restricting leverage of the issuer of the issuer and/or subsidiary and/or ii) there is covenant specifying issuer to maintain minimum net worth and/or iii) there is a covenant specifying issuer to maintain minimum ratio of earnings to fixed charges.
SalesLB	Equals 1 if there is covenant restricting the issuer and/or subsidiary from selling and then leasing back assets that provide security to the debtholder.
StockIss	Equals 1 if there is a covenant restricting the issuer and/or subsidiary from issuing additional common or preferred stock.
RatingNWT	Equals 1 if there is covenant under which certain provisions are triggered if either the credit rating or the net worth of the issuer falls below a specified level.
CrossDef	Equals 1 if there is a covenant under which default or acceleration is triggered in the issue when default or acceleration occurs in any other debt issue.
PoisonPut	Equals 1 if there is a covenant under which bondholders have the option of selling the issue back to the issuer (poison put) upon a change in control of the issuer.
AssetSale	Equals 1 if there is a covenant requiring the issuer and/or subsidiary to use the net proceeds from the sale of certain assets to redeem the bonds at par or at a premium.
Inv	Equals 1 if there is a covenant restricting the issuer and/or subsidiary from investing in risky assets.
MergerR	Equals 1 if there is a covenant restricting the issuer from a consolidated merger with another entity.

2.11 Supplementary Tables

Table 2.2: Summary Statistics

The table below presents the summary statistics of the debt issues by 2516 firms using 11,464 firm-bond observations during 1981-2012. All variables are defined in the Appendix.

	N	Mean	p50	SD	Min	Max
Yield	11464	6.65	6.63	2.33	0.12	20.35
Term	11464	12.83	10.00	9.94	0.00	100.00
Payout Restriction Covenants						
DivPmtR	11464	0.08	0.00	0.27	0.00	1.00
ShareRepR	11464	0.06	0.00	0.23	0.00	1.00
Financing Restriction Covenants						
FundDebtR	11464	0.02	0.00	0.13	0.00	1.00
SubDebtR	11464	0.01	0.00	0.12	0.00	1.00
SenDebtR	11464	0.00	0.00	0.04	0.00	1.00
SecDebtR	11464	0.44	0.00	0.50	0.00	1.00
LevTest	11464	0.16	0.00	0.37	0.00	1.00
SalesLB	11464	0.29	0.00	0.45	0.00	1.00
StockIss	11464	0.05	0.00	0.23	0.00	1.00
Event-Driven Covenants						
RatingNWT	11464	0.01	0.00	0.11	0.00	1.00
CrossDef	11464	0.45	0.00	0.50	0.00	1.00
PoisonPut	11464	0.21	0.00	0.41	0.00	1.00
Investment Restriction Covenants						
AssetSale	11464	0.62	1.00	0.49	0.00	1.00
Inv	11464	0.01	0.00	0.09	0.00	1.00
MergerR	11464	0.62	1.00	0.49	0.00	1.00
Aggregate Variables						
CovFlag	11464	0.74	1.00	0.44	0.00	1.00
CovIndex	11464	3.04	3.00	2.53	0.00	12.00
Payout Restrictions	11464	0.14	0.00	0.46	0.00	2.00
Financing Restrictions	11464	0.98	1.00	1.09	0.00	5.00
Event Driven	11464	0.67	1.00	0.76	0.00	3.00
Investment Restrictions	11464	1.24	2.00	0.98	0.00	3.00
Firm Level Controls						
logAssets	11464	9.06	9.06	1.70	4.20	14.82
logSales	11450	8.26	8.39	1.67	-2.30	13.01
Tangibility	10952	0.40	0.37	0.30	0.00	0.97
Profitability	10868	0.13	0.12	0.12	-1.89	2.39
RD_PPE	10875	0.13	0.00	1.02	0.00	54.67
Adv_PPE	10875	0.05	0.00	0.27	0.00	14.66
Capx_Assets	10812	0.08	0.05	0.13	-0.03	3.34
ROA	11274	3.46	3.51	10.00	-306.44	90.11
Cash_Assets	11457	0.08	0.03	0.12	0.00	0.95
Leverage	9154	0.25	0.22	0.16	0.00	0.95
MBRatio	9185	1.54	1.30	0.90	0.53	27.09
IssuerRating	10726	8.31	8.00	3.27	1.00	21.33

Table 2.3: Effect of Presence of Covenants on Cost of Debt

The table below reports the effect the presence of covenants on the cost of debt using 11,464 firm-bond observations during 1981-2012. The number of observations in Models (3) and (4) are less due to some missing values for firm control variables in the merged FISD/Compustat dataset. The dependent variable is the offering yield on the bond. *CovFlag* is a dummy variable which equals 1 if there is at least one covenant in the bond. All other variables are defined in the Appendix. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: Cost of Debt	(1)	(2)	(3)	(4)
CovFlag	-0.84***	-0.22***	-0.43***	-0.14***
	(-20.51)	(-5.59)	(-9.15)	(-2.60)
Term	0.0083***	0.027***	0.023***	0.030***
	(4.83)	(19.47)	(12.39)	(18.01)
IssuerRating			0.22***	0.23***
			(25.52)	(13.94)
logAssets			-0.30**	-0.71**
			(-2.56)	(-2.26)
logAssets_Sq			0.0094	0.023
			(1.59)	(1.42)
logSales			0.051	0.69**
			(0.49)	(2.43)
logSales_Sq			-0.00094	-0.028*
			(-0.16)	(-1.72)
Tangibility			-0.031	-0.087
			(-0.37)	(-0.29)
Profitability			-0.11	0.033
			(-0.50)	(0.13)
RD_PPE			-0.58***	-0.32**
			(-9.51)	(-2.32)
Adv_PPE			-0.092	0.26**
			(-1.36)	(2.17)
Capx_Assets			0.29*	-0.18
			(1.75)	(-0.69)
ROA			-0.0030	-0.014***
			(-1.24)	(-3.81)
Cash_Assets			-0.89***	0.31
			(-4.31)	(0.85)
Leverage			1.82***	2.29***
			(12.69)	(7.93)
MBRatio			-0.14***	-0.096**
			(-4.62)	(-2.32)
Adjusted R^2	0.42	0.74	0.57	0.73
Observations	11464	11464	7513	7513
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 2.4: Effect of Marginal Increase in Covenants on Cost of Debt

The table below reports the effect of marginal increase in the number of covenants on the cost of debt using 11,464 firm-bond observations during 1981-2012. The number of observations in Models (3) and (4) are less due to some missing values for firm control variables in the merged FISD/Compustat dataset. The dependent variable is the offering yield on the bond. *Covenants*(#*j*) is a dummy variable which equals 1 if there are *j* covenants in the bond, otherwise 0. All other variables are defined in the Appendix. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: Cost of Debt	(1)	(2)	(3)	(4)
Covenants(#1)	-0.35***	-0.10	-0.10	0.020
	(-4.79)	(-1.53)	(-1.20)	(0.21)
Covenants(#2)	-0.90***	-0.25***	-0.63***	-0.38***
	(-14.59)	(-4.24)	(-7.10)	(-4.07)
Covenants(#3)	-1.20***	-0.38***	-0.89***	-0.30***
	(-21.72)	(-6.73)	(-13.11)	(-4.00)
Covenants(#4)	-1.17***	-0.56***	-0.83***	-0.50***
	(-24.08)	(-11.05)	(-14.26)	(-7.74)
Covenants(#5)	-0.85***	-0.37***	-0.61***	-0.26***
	(-15.85)	(-6.65)	(-10.29)	(-3.82)
Covenants(#6)	-0.86***	-0.32***	-0.65***	-0.14*
	(-11.79)	(-4.52)	(-8.49)	(-1.69)
Covenants(#7)	-0.59***	-0.13	-0.51***	0.0078
	(-5.92)	(-1.35)	(-5.23)	(0.07)
Covenants(#8)	1.53***	1.00***	0.65***	0.96***
	(10.85)	(7.05)	(4.55)	(6.08)
Covenants(#9)	2.20***	1.14***	1.11***	1.05***
	(18.46)	(9.30)	(9.01)	(7.51)
Covenants(#10)	2.31***	0.96***	1.01***	0.77***
	(17.27)	(6.94)	(7.44)	(5.00)
Covenants(#11)	2.24***	0.96***	0.93***	0.69**
	(8.46)	(3.39)	(3.32)	(2.17)
Covenants(#12)	2.38**	2.15*		
	(2.03)	(1.72)		
Term	0.015***	0.028***	0.025***	0.031***
	(9.21)	(20.40)	(13.89)	(18.67)
Adjusted R^2	0.50	0.75	0.60	0.74
Observations	11464	11464	7513	7513
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 2.5: Effect of Different Categories of Covenants on Cost of Debt

The table below reports the effect of different categories of covenants on the cost of debt using 11,464 firm-bond observations during 1981-2012. The dependent variable is the offering yield on the bond. $PayoutRestrictions(\#j)$, $FinancingRestrictions(\#k)$, $InvestmentRestrictions(\#l)$, $EventDriven(\#m)$ are dummy variables which equal 1 if there are j, k, l, m payout covenants, financing covenants, investment covenants, and event driven covenants in the bond, otherwise 0. All other variables are defined in the Appendix. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: Cost of Debt	(1)	(2)	(3)	(4)
Payout Restrictions(#1)	0.58***	0.49***	0.71***	0.83***
	(7.31)	(5.84)	(6.18)	(6.00)
Payout Restrictions(#2)	3.13***	1.56***	1.86***	1.42***
	(30.70)	(14.57)	(17.60)	(11.44)
Financing Restrictions(#1)	-0.055	0.16***	0.48***	0.55***
	(-1.10)	(3.19)	(7.79)	(7.79)
Financing Restrictions(#2)	0.17***	0.41***	0.70***	0.78***
	(3.43)	(7.59)	(12.35)	(11.55)
Financing Restrictions(#3)	0.11	0.40***	0.66***	0.78***
	(1.43)	(5.04)	(8.29)	(8.28)
Financing Restrictions(#4)	0.63***	0.72***	0.81***	0.90***
	(4.51)	(5.06)	(5.94)	(5.76)
Financing Restrictions(#5)	0.13	1.04**	0.44	1.36**
	(0.28)	(2.06)	(0.99)	(2.44)
Investment Restrictions(#1)	-0.79***	-0.52**	-0.96***	-0.96***
	(-3.17)	(-2.57)	(-3.50)	(-3.94)
Investment Restrictions(#2)	-0.66***	-0.24***	-0.65***	-0.42***
	(-14.99)	(-5.69)	(-12.03)	(-7.17)
Investment Restrictions(#3)	-0.69***	-0.65***	-0.53**	-0.55**
	(-3.63)	(-3.57)	(-2.13)	(-2.01)
Event Driven(#1)	-0.32***	-0.33***	-0.37***	-0.32***
	(-7.98)	(-8.35)	(-8.52)	(-6.41)
Event Driven(#2)	-0.55***	-0.82***	-1.00***	-0.90***
	(-8.94)	(-12.88)	(-15.40)	(-11.87)
Event Driven(#3)	0.35**	-0.48***	-0.45**	-0.83***
	(2.11)	(-2.77)	(-2.48)	(-4.04)
Term	0.013***	0.028***	0.025***	0.031***
	(8.12)	(20.65)	(14.05)	(19.44)
Adjusted R^2	0.49	0.75	0.61	0.75
Observations	11464	11464	7513	7513
Controls	No	No	Yes	Yes
Firm FE	No	No	No	Yes
Industry FE	No	Yes	No	No
Year FE	Yes	Yes	No	Yes
Industry X Year FE	No	No	Yes	No

Table 2.6: Effect of Brokerage Firms Merger on Coverage by Analysts

The table below reports the effect of the merger of brokerage firms on the number of analysts following a firm using IBES database during the period 1981-2012. The dependent variable is the number of analysts following a firm in a given firm-year. There are three sets of regressions for three different time windows before and after the merger. *Treat* equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 1yr, 2yr, and 3yr time-windows *Post* equals 1 for observations 1 year, 2 year, and 3 year after the merger. *Post* equals 0 for observations 1 year, 2 year, and 3 year before the merger.

Dep Var: # of Analysts	(1)	(2)	(3)	(4)	(5)	(6)
Treat	7.59***		7.77***		7.93***	
	(25.59)		(29.50)		(31.18)	
Post	-1.73***	-2.89***	-0.68***	-2.29***	-1.00***	-2.05***
	(-5.91)	(-7.17)	(-3.20)	(-8.34)	(-4.89)	(-11.02)
Treat × Post	-0.84***	-0.91***	-1.52***	-1.56***	-1.88***	-1.83***
	(-3.63)	(-3.47)	(-6.64)	(-6.62)	(-8.25)	(-8.25)
Adjusted R^2	0.21	0.81	0.20	0.76	0.20	0.75
Observations	7527	7527	13116	13116	17759	17759
Firm FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.7: Summary Statistics

The table below presents the summary statistics of the 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The firm-bond observations are in the treatment group if that firm was followed by both brokerage houses before the merger, while only by the merged entity after the merger. All remaining firms are in the control group. The statistics presented in the table are for the treatment group which was obtained using a 3 year time-window before and after the merger.

	N	Mean	p50	SD	Min	Max
Treatment Group						
Yield	4935	6.43	6.54	2.26	0.12	20.35
Term	4935	13.26	10.00	11.04	1.00	100.00
CovFlag	4935	0.82	1.00	0.38	0.00	1.00
CovIndex	4935	3.47	4.00	2.30	0.00	12.00
Payout Restrictions	4935	0.09	0.00	0.38	0.00	2.00
Financing Restrictions	4935	1.24	1.00	1.06	0.00	5.00
Event Driven	4935	0.67	1.00	0.76	0.00	3.00
Investment Restrictions	4935	1.47	2.00	0.89	0.00	3.00
logAssets	4935	9.63	9.52	1.56	4.95	14.60
logSales	4933	9.02	9.08	1.41	3.86	13.01
Tangibility	4797	0.35	0.31	0.27	0.00	0.96
Profitability	4819	0.14	0.14	0.13	-1.89	2.39
RD_PPE	4795	0.12	0.00	0.46	0.00	11.16
Adv_PPE	4795	0.06	0.00	0.30	0.00	14.66
Capx_Assets	4614	0.08	0.05	0.13	0.00	3.34
ROA	4901	4.46	4.26	9.49	-294.46	54.58
Cash_Assets	4933	0.08	0.04	0.10	0.00	0.87
Leverage	4744	0.24	0.20	0.16	0.00	0.86
MBRatio	4756	1.62	1.35	0.96	0.59	27.09
IssuerRating	4815	7.57	7.00	3.06	1.00	21.33
Control Group						
Yield	6529	6.81	6.74	2.37	0.25	19.00
Term	6529	12.50	10.00	9.01	0.00	100.00
CovFlag	6529	0.68	1.00	0.47	0.00	1.00
CovIndex	6529	2.71	2.00	2.65	0.00	12.00
Payout Restrictions	6529	0.18	0.00	0.50	0.00	2.00
Financing Restrictions	6529	0.78	0.00	1.07	0.00	5.00
Event Driven	6529	0.68	1.00	0.76	0.00	3.00
Investment Restrictions	6529	1.07	2.00	1.01	0.00	3.00
logAssets	6529	8.63	8.60	1.67	4.20	14.82
logSales	6517	7.67	7.75	1.62	-2.30	12.33
Tangibility	6155	0.43	0.45	0.31	0.00	0.97
Profitability	6049	0.12	0.12	0.11	-1.41	1.44
RD_PPE	6080	0.13	0.00	1.31	0.00	54.67
Adv_PPE	6080	0.05	0.00	0.25	0.00	6.68
Capx_Assets	6198	0.09	0.05	0.13	-0.03	3.11
ROA	6373	2.69	3.18	10.30	-306.44	90.11
Cash_Assets	6524	0.08	0.03	0.12	0.00	0.95
Leverage	4410	0.27	0.25	0.16	0.00	0.95
MBRatio	4429	1.46	1.25	0.81	0.53	19.72
IssuerRating	5911	8.91	9.00	3.31	1.00	20.80

Table 2.8: Effect of Brokerage Firms Merger on New Debt Issue Covenants (Probability of Presence of Covenants)

The table below reports the effect of a decrease in analyst coverage on the probability of presence of covenants using 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The dependent variable $CovFlag$ is a dummy variable which equals 1 if there is at least one covenant in the bond, otherwise 0. There are four sets of regressions for four different time windows before and after the merger. $Treat$ equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 1yr, 2yr, 3yr and Nyr time-windows $NewDebtPostMerger$ equals 1 for firm-bond observations 1 year, 2 year, and 3 year and all remaining years in the sample after the merger. $NewDebtPostMerger$ equals 0 for all firm-bond observations before the merger. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CovFlag	(1)	(2)	(3)	(4)
	1Yr	2Yr	3Yr	NYr
Treat	0.30	0.11	0.054	0.072
	(1.55)	(0.59)	(0.30)	(0.44)
New Debt Post Merger	-0.55*	-0.13	-0.27	-0.31
	(-1.75)	(-0.45)	(-1.09)	(-1.38)
Treat × New Debt Post Merger	0.77***	0.84***	0.78***	0.48***
	(2.60)	(3.39)	(3.53)	(2.74)
Pseudo R^2	0.39	0.38	0.37	0.29
Observations	2763	3180	3617	7510
Firm Level Controls	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 2.9: Effect of Brokerage Firms Merger on New Debt Issue Covenants (Covenant Index)
The table below reports the effect of a decrease in analyst coverage on the number of covenants using 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The dependent variable $CovIndex$ equals the number of covenants included in a bond. There are four sets of regressions for four different time windows before and after the merger. $Treat$ equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 1yr, 2yr, 3yr and Nyr time-windows $NewDebtPostMerger$ equals 1 for firm-bond observations 1 year, 2 year, and 3 year and all remaining years in the sample after the merger. $NewDebtPostMerger$ equals 0 for all firm-bond observations before the merger.***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: CovIndex	(1)	(2)	(3)	(4)
	1Yr	2Yr	3Yr	NYr
Treat	0.20*	0.18	0.12	-0.43***
	(1.67)	(1.51)	(1.01)	(-3.61)
New Debt Post Merger	-0.89***	-0.86***	-0.65***	-0.97***
	(-3.27)	(-3.56)	(-3.03)	(-4.60)
Treat × New Debt Post Merger	1.03***	1.22***	1.17***	1.11***
	(4.24)	(6.17)	(6.88)	(8.36)
Adjusted R^2	0.29	0.27	0.25	0.19
Observations	2814	3206	3639	7513
Firm Level Controls	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 2.10: Effect of Brokerage Firms Merger on New Debt Issue Covenants (Different Categories of Covenants)

The table below reports the effect of a decrease in analyst coverage on the number of covenants for all categories using 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The dependent variables are the number of covenants in the payout, financing, investment and event-driven covenants represented by Pay, Fin, Inv, and EDC headers in the table. There are three sets of regressions for three different time windows before and after the merger. *Treat* equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 2yr, 3yr and Nyr time-windows *PostDebt* equals 1 for firm-bond observations 2 year, and 3 year and all remaining years in the sample after the merger. *PostDebt* equals 0 for all firm-bond observations before the merger. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: # Covenants	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Payout	Fin	Inv	EDC	Payout	Fin	Inv	EDC	Payout	Fin	Inv	EDC
	2 yr	2 yr	2 yr	2 yr	3 yr	3 yr	3 yr	3 yr	N yr	N yr	N yr	N yr
Treat	-0.04	0.09*	0.2***	-0.06*	-0.05**	0.10*	0.2***	-0.09***	-0.2***	-0.1**	0.1**	-0.2***
	(-1.6)	(1.8)	(4.3)	(-1.7)	(-2.3)	(1.9)	(3.8)	(-2.6)	(-8.4)	(-2.1)	(2.3)	(-7.1)
PostDebt	-0.1***	-0.3***	-0.2***	-0.2***	-0.08*	-0.1	-0.2**	-0.2***	-0.2***	-0.3***	-0.2**	-0.3***
	(-2.7)	(-2.8)	(-2.8)	(-2.7)	(-1.9)	(-1.5)	(-2.3)	(-4.1)	(-5.2)	(-3.9)	(-2.0)	(-4.5)
Treat × Post Debt	0.2***	0.4***	0.3***	0.3***	0.2***	0.4***	0.3***	0.4***	0.2***	0.4***	0.1**	0.4***
	(4.3)	(4.7)	(4.9)	(5.0)	(6.1)	(4.8)	(4.3)	(7.2)	(9.3)	(6.3)	(2.4)	(10.8)
Adjusted R^2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2
Observations	3206	3206	3206	3206	3639	3639	3639	3639	7513	7513	7513	7513
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.11: Effect of Brokerage Firms Merger on New Debt Issue Covenants (Proportion of Different Categories of Covenants)

The table below reports the effect of a decrease in analyst coverage on the proportion of covenants for all categories using 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The dependent variables are the proprotion of covenants in the payout, financing, investment and event-driven covenants represented by Pay, Fin, Inv, and EDC headers in the table.There are three sets of regressions for three different time windows before and after the merger. *Treat* equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 2yr, 3yr and Nyr time-windows *PostDebt* equals 1 for firm-bond observations 2 year, and 3 year and all remaining years in the sample after the merger. *PostDebt* equals 0 for all firm-bond observations before the merger. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: # Covenants	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Payout	Fin	Inv	EDC	Payout	Fin	Inv	EDC	Payout	Fin	Inv	EDC
	2 yr	2 yr	2 yr	2 yr	3 yr	3 yr	3 yr	3 yr	N yr	N yr	N yr	N yr
Treat	-0.01**	0.04***	0.03**	-0.06***	-0.01***	0.04***	0.03***	-0.06***	-0.04***	0.02**	0.06***	-0.05***
	(-2.4)	(4.3)	(2.4)	(-5.7)	(-3.0)	(4.6)	(2.7)	(-6.1)	(-9.6)	(2.4)	(5.2)	(-4.1)
PostDebt	-0.02*	0.02	0.02	-0.03	-0.01	0.05**	0.03	-0.07***	-0.04***	0.01	0.06***	-0.03
	(-1.8)	(1.0)	(1.0)	(-1.2)	(-1.1)	(2.4)	(1.5)	(-3.5)	(-6.0)	(0.6)	(2.9)	(-1.4)
Treat × PostDebt	0.02***	-0.02	-0.05**	0.04**	0.03***	-0.02	-0.08***	0.07***	0.04***	0.0006	-0.05***	0.02
	(2.8)	(-0.8)	(-2.5)	(2.2)	(3.9)	(-1.1)	(-4.3)	(4.0)	(9.1)	(0.0)	(-4.4)	(1.2)
Adjusted R^2	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Observations	2519	2519	2519	2519	2763	2763	2763	2763	5628	5628	5628	5628
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.12: Effect of Decrease in Analyst Coverage on Cost of Debt

The table below reports the effect of a decrease in analyst coverage on the cost of debt using 11,464 firm-bond observations obtained from the FISD/Compustat/IBES merged dataset during 1981-2012. The dependent variable is the offering yield on the bond. There are four sets of regressions for four different time windows before and after the merger. $Treat$ equals 1 for a firm if it was followed by both brokerage houses before the merger, while only by the merged entity after the merger for that particular time-window. In the regression specifications for 1yr, 2yr, 3yr and Nyr time-windows $NewDebtPostMerger$ equals 1 for firm-bond observations 1 year, 2 year, and 3 year and all remaining years in the sample after the merger. $NewDebtPostMerger$ equals 0 for all firm-bond observations before the merger. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Dep Var: Cost of Debt	(1)	(2)	(3)	(4)
	1 Yr	2 Yr	3 Yr	N Yr
Treat	-0.055	-0.047	-0.055	-0.0019
	(-0.88)	(-0.74)	(-0.82)	(-0.03)
New Debt Post Merger	0.24*	0.35***	0.45***	0.21
	(1.65)	(2.70)	(3.70)	(1.59)
Treat × New Debt Post Merger	-0.55***	-0.47***	-0.55***	-0.21**
	(-4.27)	(-4.40)	(-5.67)	(-2.54)
Adjusted R^2	0.54	0.54	0.57	0.59
Observations	2814	3206	3639	7513
Firm Level Controls	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

CHAPTER III

Managerial Learning and Feedback Effects

3.1 Introduction

Trading in the financial markets aggregates the information of various speculators and arbitrageurs into market prices. Hence, market prices may serve as a useful source of information about fundamentals that can be utilised by managers in the resource allocation decisions of a firm. For instance, Luo (2005) provides evidence of use of information in stock prices in acquisition decisions of the firm. Chen et al. (2007) document that the information in price affects the investment decisions of the firm. Considering these findings, it may appear optimal for a manager to extract useful information from prices in order to enrich her information set and take efficient decisions. However, a more careful analysis suggests that the manager's decisions, in particular, manager's use of information to take those decisions, may affect the information that the prices are supposed to reflect in the first place. For instance, Dow et al. (2017) and Faure-Grimaud (2002) show that manager's use of information in price reduces the incentives of the informed trader to collect information about the state.

In this paper, we model a firm whose value depends on uncertain exogenous fundamentals and the actions of its manager. The manager decides how much to invest in an uncertain technology. The fundamentals can be interpreted as the return to the technology. The manager does not know this return, but gathers some private information about it. In addition, the stock price of the firm reflects the private information of an informed trader, and serves as another source of information. We model price formation through trading in the secondary market as in Kyle (1985).

The manager can learn about the fundamentals in two ways: (i) from the stock price of the firm and (ii) by gathering her own private information. The uncertainty about her action increases the uncertainty about the firm value. The greater uncertainty affects the payoffs of the informed trader, market maker and liquidity traders in the financial market, whose strategies, in turn, affect the information reflected in the stock price. There is a feedback effect: The stock price affects the manager's learning, and hence affect the amount of uncertainty generated by her action.

We analyze two compensation contracts. The first contract does not provide incentives to the manager to learn about fundamentals (from either channel) before taking action. The alternative incentive contract induces the manager to take a high action in the good state of the world, and take a low action in the bad state of the world. We exploit the difference in the two incentive structures to illustrate the effects of manager's learning on financial markets.

The main result of the paper is that the manager acquiring private information and the manager learning from the stock price have different effects on the expected profits of the informed trader. Both channels of learning increases the informational advantage to the informed trader. However, the greater informational advantage leads to greater expected profits to the informed trader only due to the manager acquiring private information. The feedback from price does not affect the expected profits of the informed trader.

The reason is that greater information asymmetry exposes the market maker to greater adverse selection risk. The market maker, anticipating this, increases the price impact, which results in greater price illiquidity and greater price volatility. By setting a higher price impact, the market maker completely unwinds the effects of information asymmetry created by the feedback from price, resulting in no net benefit to the informed trader. However, the market maker cannot undo the informational advantage to the informed trader that results from the manager acquiring private information, because the informed trader has better knowledge about the fundamentals than the market maker does. Thus, only the manager acquiring private information creates a wealth transfer from uninformed liquidity traders to the informed trader.

The second result of the paper is that neither of the learning channels affects the trading volume or how informative the price is about the fundamentals. One might expect that a strategic informed trader would increase his trading intensity to utilise his informational advantage, which would result in an increase in trading volume. The higher trading intensity would also imply greater price informativeness. However, we show that the increase in price impact, set by the market maker, forces the informed trader to lower the quantity he trades, in a manner that completely offsets the former increase in trading volume. In other words, in equilibrium, the trading volume is unaffected by the manager's learning. Consequently, the price informativeness about the fundamentals is also unaffected by the manager's learning.

It has been suggested in the literature that if liquidity traders are the original shareholders of the firm, they would offer a lower price ex-ante to compensate for their losses (see Holmström and Tirole (1993)). In our model, when the manager gathers private information with greater precision, *ceteris paribus*, it decreases her learning from the stock price, thereby increasing the losses to liquidity traders. The increase in losses will be compensated by greater underpricing in the IPOs. So, the model suggests that underpricing will be greater when the manager has better private information about fundamentals.

Our model generates implications for the incentives of the informed trader to acquire information. The precision of the informed trader's information has two effects on his expected profits. First, there is a direct effect: Better information of the informed trader increases his information advantage over uninformed liquidity traders, which increases his expected profits. Second, better information of the informed trader increases the equilibrium price informativeness. As a result, in choosing her action, the manager relies more on the stock price than on her private information. This effect lowers the equilibrium expected profits to the informed trader. We show that overall the first effect dominates.

We extend the model to study the effect of competition amongst informed traders on the manager's learning. We show that, with competition, the price is more informative. As a result, the manager learns more from the price and less from her private information. This lowers the expected profits of the informed trader. Thus, we provide another channel through which the profits of the informed trader decrease beyond the direct effects of market competition.

The rest of the paper is organized as follows. In Section 3.3 we describe the model and define equilibrium. In Section 3.4 and Section 3.5 we solve the equilibrium strategies for a passive and an active manager. In Section 3.6 we solve the model when there is competition between informed traders. We conclude in Section 3.7.

3.2 Related Literature

The paper contributes to a growing literature on feedback effects of financial markets (see Bond et al. (2011) for a survey). Several papers studying the feedback effects of financial markets show that when the manager learns from price to guide her real decisions, it reduces price informativeness about the fundamentals (see for example, Bond et al. (2010), Dow et al. (2017), Bond and Goldstein (2015)). However, they ignore the strategic behavior of the informed trader, which might affect the price informativeness. In our paper, the informed trader is strategic and takes into account the effect of his order on price, and consequently on manager's learning and firm value. We show that manager's learning does not reduce the informativeness of the price.

The model in our paper is closest to the model in Edmans et al. (2015) who also study feedback with a strategic informed trader. They show that the feedback effect results in an asymmetric effect on trading volume, price impact, price informativeness and expected profits of the informed trader. That is, the informed trader has greater profits when the fundamentals are high, while lower profits when the fundamentals are low. Instead, in this paper, we show that, both when the fundamentals are high or low, the feedback effect increases the price impact, while it does not affect trading volume, price informativeness and the expected profits of the informed trader.

In both papers, the role of feedback effect is to reduce the difference between the information sets of market maker and the manager. In their paper, the feedback effect eliminates the difference between the information sets of the market maker and the manager. That is, due to feedback, the market maker can exactly predict the actions of the manager. But the market maker has imperfect knowledge about the fundamentals due to noise trading by liquidity traders, which results in a net advantage to the informed trader. In our paper, the feedback effect reduces, but does not eliminate, the difference between the information set of the market maker and the manager. Overall, the manager has better information about fundamentals than the market maker, due to her private information. This results in an informational advantage to the informed trader, since his information about fundamentals is useful in predicting manager's actions.

The key difference between their paper and ours is the effect of manager's action on firm value. In their paper, the optimal action of the manager makes the firm value a convex function of the fundamentals, which is the main driver of their results. Due to convexity, market maker faces greater risk when manager takes higher action. Conversely, when manager takes low action, market maker faces lower risk. This results in asymmetric price impact. It also implies that the informed trader receives greater profits when the fundamentals are high, and lower profits when the fundamentals are low. In our paper, the firm value is a linear function of the fundamentals, which implies that the risk faced by the market maker is symmetric, implying that the increase in price impact is symmetric. Moreover, the risk faced by the market maker is greater due to manager's learning from her private information. This results in an informational advantage to the informed trader, and hence he receives greater profits both when fundamentals are high and when they are low.

Put differently, both papers show that manager's learning increases the profits of the informed trader because knowing the state benefits the informed trader. But the mechanism is different. In our paper, the benefit of the informed trader in superior knowledge of the state is useful in predicting manager's action, which leads to greater expected profits. In their paper, the informed trader's superior knowledge about the state leads to greater profits when the fundamentals are high because the value is convex in fundamentals.

Dow and Gorton (1997), Dow et al. (2017) and Faure-Grimaud (2002) show that feedback effect reduces the incentives of the informed trader to collect information about the state. The idea is that when the firm learns that the state is bad, it does not invest, which lowers the profitability and the incentives of the informed trader to collect information. However, in our paper, the manager learns from price and from her private information, resulting in a net informational advantage to the informed trader as his information is useful in predicting manager's action. This results in greater incentives to gather precise information.

Our paper also contributes to the literature on underpricing of the IPOs. The asymmetric information based models of underpricing in IPOs (see Rock (1986), Ritter (1984) and Beatty and Ritter (1986)) suggest that the underpricing is greater for firms with greater ex-ante uncertainty in value. In this paper, we show that con-

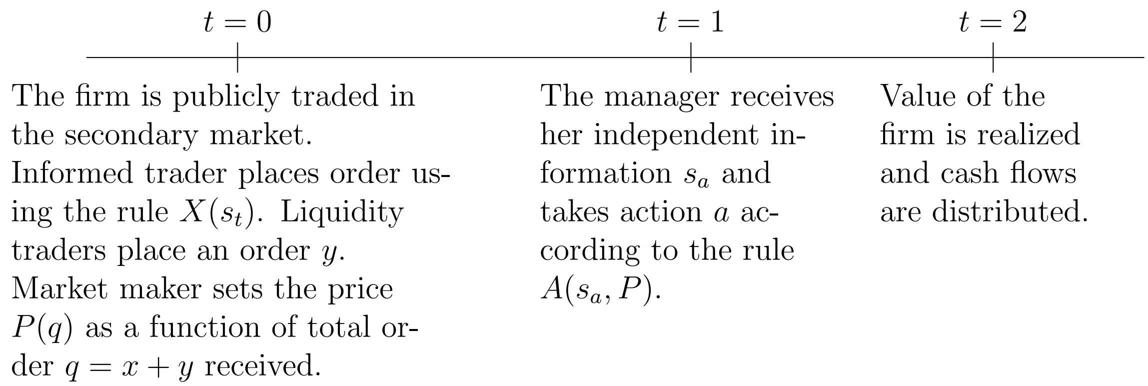

Figure 3.1: This figure shows the timing of the model

ditional on ex-ante uncertainty, manager's incentives to learn about fundamentals increases the uncertainty about the firm value which increases the losses to uninformed traders and aggravates underpricing. It implies that firms with lower ex-ante uncertainty but with better informed managers may underprice their stock listing the same as firms with higher ex-ante uncertainty and uninformed managers.

3.3 Model

3.3.1 Timing

There are three dates in the model $t = 0, 1, 2$. There is one firm run by a manager whose actions affect the value of the firm. At $t = 0$, the firm is traded in the secondary market consisting of an informed trader, liquidity traders and a market maker. The price formation takes place in the first period in two stages. In the first stage, the informed trader and the liquidity traders place their orders to the market maker. In the second stage, the market maker upon receiving the total order flow from the informed trader and the liquidity traders sets the price P. At $t = 1$, the manager of the firm uses the price P and her own private information to take an action which affects the value of the firm. Once the action is taken, the value of the firm is realized and the cash flows are distributed.

3.3.2 Firm

The value of the firm depends on uncertain exogenous fundamental θ and the action a chosen by the manager. θ can be interpreted as the returns to technology or the set of investment opportunities or future industry profitability. At $t = 0$, agents in the economy do not know θ. They have a prior that θ follows a normal distribution with mean θ_0 and variance σ_θ^2. We assume the value of the firm to be linear and additively separable[1] in θ and a. We assume a linear form to disentangle the effect due to feedback on the financial markets from the effect due to a non-linear value function (for example, Edmans et al. (2015) model a firm such that manager's optimal action makes the firm value a convex function of fundamentals).

$$V = \theta + a$$

The manager of the firm incurs a cost $C(a)$ upon taking action a (We assume $C'(.) > 0$ and $C''(.) > 0$). The action a can be interpreted as the amount of investment in the technology and $C(a)$ can be interpreted as the cost of financing the investment. The owners of the firm cannot observe the action taken by the manager. They set up a contract with the manager which pays $w(V)$. We assume that $w(V)$ is exogenously given (satisfying $w' > 0$ and $w'' \geq 0$) and instead focus on the manager's use of information to maximize her payoff.[2] The payoff received by the manager at $t = 2$ is $w(V) - C(a)$. The manager chooses action a at $t = 1$ to maximize her payoff as

[1] An alternative way to model the firm can be when the owners are choosing the action a (resources added to the firm) instead of the manager. In an Empire-Building example, where the manager is entrenched and derives status in running a larger firm, Hermalin and Weisbach (2012) show that the owners would prefer to learn about the fundamentals and add more resources to the firm when the fundamentals are high. That formulation will be consistent with the value function postulated in this paper.

[2] Note that, we have not analyzed the owner's payoff and whether ex-ante it is optimal to give the compensation contract $w(V)$ to the manager. The results of the paper are conditional on a given w.

follows:

$$\max_a E[w(V) - C(a)|\mathcal{I}] \ . \tag{3.1}$$

We assume ($w'' < C''$) so that there exists an interior solution to the optimization problem. The manager's information set $\mathcal{I}$ consists of her own private information s_a and price P. The private information s_a is noisy signal about θ ($s_a = \theta + \varepsilon_a$ where $\varepsilon_a \sim N(0, \sigma_a^2)$) and the price of the firm P is determined through trading in the secondary market at $t = 0$.

3.3.3 Secondary Market

We follow Kyle (1985) and model the secondary market with an informed trader, liquidity traders and a market maker. The informed trader is a monopolistic trader who has private information $s_t = \theta + \varepsilon_t$ where $\varepsilon_t \sim N(0, \sigma_t^2)$. In our setting, his private information is useful to make inference about the actions of the manager, in addition to the fundamentals θ. The informed trader chooses his order x to solve:

$$\max_x E[(V - P)x|s_t, x] \ .$$

Besides the informed trader, the liquidity traders put an order $y \sim N(0, \sigma_y^2)$ for exogenous reasons. The market maker receives the total order flow (q) coming from the informed trader (x) and the liquidity traders (y). Since the market maker is in a competitive industry, he sets the price of the firm equal to expected value of the firm conditional on the order flow, thereby making 0 expected profits. The price set by the market maker is:

$$P(q) = E[V|q = x + y] \ .$$

Note, the market maker sets the price before the manager takes action a but knows the decision rule of the manager. When he sets the price, he also incorporates the effect of price on the value of the firm through its effect on manager's actions. In section 3.6 below, we extend the model with N informed traders competing in quantities.

3.3.4 Equilibrium

We now define the equilibrium.

Definition III.1. An equilibrium consists of a trading strategy of the informed trader $X(s_t) : \mathbb{R} \to \mathbb{R}$, market maker's pricing rule $P(q) : \mathbb{R} \to \mathbb{R}$, and manager's decision rule $A(\mathcal{I}) : \mathbb{R}^2 \to \mathbb{R}$ such that

i. for informed trader, $x = \arg\max E[(V - P)x|s_t, x]$,

ii. market maker's sets the price $P(q) = E[V|q = x + y]$; and

iii. manager's action is $a = \arg\max E[w(V) - C(a)|\mathcal{I}]$.

We use the following strategy to solve the model. At $t = 1$ the manager chooses to take action a using the rule $A(\mathcal{I})$. At $t = 0$, the informed trader places an order $x(s_t) = \gamma_0 + \gamma_1 s_t$ to maximize his expected profits given the manager's decision rule and the market maker's pricing rule. The market maker sets the price P using the pricing rule $P(q) = \alpha_0 + \alpha_1 q$ given the manager's decision rule and the informed trader's order strategy. We then solve the manager's optimal decision given the order $x(s_t)$ from the informed trader and the market price P set by the market maker. We also refer to the tuple (γ_0, γ_1) as γ and (α_0, α_1) as α in the paper.

3.3.5 Manager's Incentives

In this section, we solve the manager's problem. In our paper, the compensation contract $w(V)$ is a way to provide incentives to the manager to induce her to learn about fundamentals. The payoff received by the manager at $t = 2$ is $w(V) - C(a)$. The manager is choosing action a to maximize her expected payoff at $t = 1$ conditional on her information set $\mathcal{I} = \{s_a, P\}$. The optimal action a^* solves the following first order condition:

$$E[w'(\theta + a^*)|\mathcal{I}] - C'(a^*) = 0 \ .$$

We assume $w'(.)$ as a linear function of its parameters, which enables us to characterize the optimal action only as a function of conditional expectation of θ. Let μ denote the conditional expectation $E[\theta|\mathcal{I}]$. We denote the optimal solution as $a^*(\mu)$. It can be easily shown that the optimal action a^* is increasing with μ and

$$\frac{\partial a^*}{\partial \mu} = \frac{w''}{C'' - w''} = k_1 \geq 0 \ . \tag{3.2}$$

The magnitude of k_1 depends on the convexity of the compensation contract w''. It implies that manager's actions vary with μ more if her contract has greater pay-for-performance sensitivity. While, if the contract is linear ($w'' = 0$), then the manager's action will be unaffected by μ. This gives us the following lemma.

Lemma III.2. *The manager's optimal action a^* is increasing with μ if the compensation contract is strictly convex ($w'' > 0$) while it is unaffected by μ if the contract is linear ($w'' = 0$).*

We assume the cost function to be quadratic, which immediately gives us the following equation as the optimal action rule of the manager when $w'' > 0$.

$$a^*(\mu) = k_0 + k_1 \mu \ . \tag{3.3}$$

Thus, a convex compensation contract induces the manager to take higher action if μ is higher. Next, we show that the manager's ex-ante expected payoff is higher when her information $\mathcal{I}$ is of greater precision. We write the expected payoff to the manager as:

$$\pi(\mu, \sigma^2) = E[w(\theta + a^*(\mu)) - C(a^*(\mu))|\mathcal{I}] \ .$$

where $\sigma^2 = V[\theta|\mathcal{I}]$. Since the information structure and the fundamental θ is jointly normal, the expected payoff only depends on the conditional mean and conditional variance. We show that the manager's expected payoff is increasing in the precision of her information set as long as the compensation contract w is strictly convex.

Proposition III.3. *The manager's ex-ante expected payoff $E[\pi]$ is increasing with the precision of her information $\mathcal{I}$ if the compensation contract is strictly convex $w'' > 0$. Whereas the manager's ex-ante expected payoff is unaffected by the precision of her information if the compensation contract is linear ($w'' = 0$).*

The proposition suggests that ex-ante the manager would prefer to gather information with greater precision in order to take efficient actions. It validates the idea that the manager would prefer to use additional information about θ from market price, in addition to her private information, to increase the precision of her information set which increases her expected payoff.

The proposition also suggests that the benefit of having precise information is greater if the manager receives high pay-for-performance sensitivity contract. In summary, the compensation contract creates incentives for the manager such that her actions are more sensitive to her prediction about θ as well as induces the manager to gather precise information ex-ante.

3.4 Passive Manager Equilibrium

In this section, we consider a benchmark case when the manager is given a linear compensation contract. In this case, as shown in Lemma III.2 above, the optimal action a taken by the manager does not depend on μ. Moreover, as shown in Proposition III.3 a linear compensation contract does not provide any incentives to learn about the fundamentals. We label the manager to be "Passive".

The passive manager's action do not add any additional uncertainty in the value of the firm beyond the uncertainty due to fundamentals θ. Thus the price formation process through trading in the secondary market follows Kyle (1985). The trading intensity, price impact and price informativeness obtained in the equilibrium with a passive manager serve as a benchmark to illustrate the effects of manager's learning on the financial markets with an active manager in section 3.5 below.

We solve the equilibrium strategies of all agents as follows. Given the manager's decision, we first solve for informed trader's trading intensity. At $t = 0$ the informed trader places his order $x(s_t)$ to maximize his expected profits $E[(V - P)x|s_t]$ given the pricing rule of the market maker. The informed trader chooses the trading intensity as:

$$\gamma_1^P = \frac{1}{2\alpha_1^P} \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_t^2} . \tag{3.4}$$

The informed trader trades with a greater intensity if his information is precise (σ_t^2 low) or if the price impact α_1^P is low. Since the manager is passive, her actions do not add any additional uncertainty about the firm value. Thus, the informed trader's information about the fundamental θ is useful to predict the overall firm value. Put differently, in the case of a passive manager, her actions do not affect the trading intensity of the informed trader.

Given the trading intensity, the market maker chooses the price impact to make zero expected profits. The market maker upon observing the total order flow q cannot distinguish between the orders coming from informed trader or liquidity traders. Thus, in order to minimize the adverse selection risk, he sets the price $P = E[V|q]$

such that his expected losses $E[(P-V)q]$ equal 0. The price impact α_1^P set by the market maker is:

$$\alpha_1^P = \frac{\gamma_1^P \sigma_\theta^2}{(\gamma_1^P)^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_y^2} \ . \tag{3.5}$$

The price impact is non-linear in trading intensity γ_1^P and increasing in informed trader's precision $1/\sigma_t^2$, while it is decreasing in the amount of noise trading σ_y^2. The price impact also does not depend on the manager's action, since a passive manager's action do not add any uncertainty to the firm value (beyond the fundamental uncertainty about θ).

Next, we solve for the equilibrium trading intensity and the price impact given the manager is passive. We find the trading intensity and the price impact as

$$\gamma_1^P = \left[\frac{\sigma_y^2}{\sigma_\theta^2 + \sigma_t^2}\right]^{1/2} \ , \tag{3.6}$$

$$\alpha_1^P = \frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} \ . \tag{3.7}$$

We plot the informed trader's trading intensity as a function of price impact and the market maker's price impact as a function of trading intensity in figure 3.2. When the manager is passive, the equilibrium values of (γ_1^P,α_1^P) are shown at point A. Note, point A corresponds to the maximum α_1^P for all possible values of γ_1^P, implying that the market maker chooses the highest possible price impact given trading intensity γ_1^P.

Next, we calculate the price informativeness, price volatility and the expected profits of the informed trader for this benchmark case. In our setting the market price, not only provides information about the value of the firm, but also serves as a signal about θ, which the manager may find useful to learn about the fundamental. Thus, we define price informativeness about fundamental as the amount of reduction in uncertainty about θ.

$$PI = \frac{V[\theta] - V[\theta|P]}{V[\theta]} \ .$$

We obtain the equilibrium price informativeness and price volatility as:

$$PI = \frac{\sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)} \ , \tag{3.8}$$

$$V(P) = \frac{(\sigma_\theta^2)^2}{2(\sigma_\theta^2 + \sigma_t^2)} \ . \tag{3.9}$$

Note in this equilibrium, since the manager is passive, her actions do not affect the price impact, price informativeness and price volatility. The reason is that the passive manager's action does not increase uncertainty about the firm value. This also implies that the price informativeness about the firm value is equal to the price informativeness about the fundamental. We show later that, in the case of an active manager, the price informativeness about the firm value is different from the price informativeness about the fundamental.

We also calculate the equilibrium expected profits of the informed trader. It can be easily shown that the expected profits of the informed trader are:

$$E[\pi(s_t)] = \frac{\sigma_y \sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \ . \tag{3.10}$$

We summarize the results of this section in the following proposition.

Proposition III.4. *There exists a unique linear equilibrium when the manager is passive. In the equilibrium the market maker sets the price impact α_1^P as:*

$$\alpha_1^P = \frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} \ .$$

The informed trader's trading intensity γ_1^P is:

$$\gamma_1^P = \left[\frac{\sigma_y^2}{\sigma_\theta^2 + \sigma_t^2}\right]^{1/2} .$$

The price volatility is:

$$V(P) = \frac{(\sigma_\theta^2)^2}{2(\sigma_\theta^2 + \sigma_t^2)} .$$

When the manager is passive, the trading intensity, price impact, price informativeness and price volatility are the same as in a Kyle setting. In the next section, we modify the model such that the manager has incentives to use her information $\mathcal{I}$ to take optimal actions which affect the price formation process in the secondary market.

3.5 Active Manager Equilibrium

In this section, we consider the case when manager is given a strictly convex compensation contract. Thus, as Proposition III.3 shows, the manager has incentives to use her information set to take the optimal action. We label the manager to be "Active". The optimal action rule of the manager is given by equation (3.3). Using the assumption of normality on the information structure we obtain the optimal action rule as a linear function of s_a and P as follows:

$$A(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P , \tag{3.11}$$

where β_0, β_1, β_2 are functions of k_0 and k_1. β_1 is interpreted as the manager's use of her private information while β_2 is interpreted as the learning from the price. We also refer (β_0, β_1, β_2) as β in the paper.

The informed trader places his order by taking into account the effect of his order on the price and subsequently, the effect of price on manager's action. The market maker sets the price by incorporating the effect of price on manager's action and thus the value of the firm. Thus, in this case the manager's use of private information and market price to take optimal action also affects the price which in turn affects the optimal learning by the manager.

3.5.1 Trading Intensity and Market Liquidity Given Manager's Decision

First, we solve for the optimal trading strategy for the informed trader, given the pricing rule of the market maker and the decision rule of the manager. We obtain the trading intensity of the informed trader as:

$$\gamma_1 = \frac{(1+\beta_1)}{(1-\beta_2)} \frac{\sigma_\theta^2}{2\alpha_1(\sigma_\theta^2 + \sigma_t^2)} \ . \tag{3.12}$$

Given the pricing rule of the market maker, the trading intensity is greater than the trading intensity in equation (3.4) by a factor of $\frac{1+\beta_1}{1-\beta_2}$. It increases with manager's use of her private information β_1 and learning from the prices β_2. When the manager is active, her actions increase the uncertainty associated with the value of the firm. This gives an informational advantage to the informed trader since the informed trader's information about θ is useful in predicting the value of the firm by i) directly predicting θ and ii) predicting the actions of the manager. Thus, the informed trader trades with a greater intensity when the manager is active.

Next, we solve for the optimal pricing rule of the market maker, given the order of the informed trader and the decision rule of the manager. We obtain the price impact α_{1A} as:

$$\alpha_1 = \frac{1+\beta_1}{1-\beta_2} \frac{\gamma_1 \sigma_\theta^2}{\gamma_1^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_y^2} \ . \tag{3.13}$$

The price impact when manager is active is greater than the price impact when the manager is passive (equation (3.5)) by a factor of $\frac{1+\beta_1}{1-\beta_2}$. The price impact is increasing in β_1 and β_2. To see the reason, first note that the market maker's objective to get 0 expected profits can be interpreted as minimizing the variance of $V - P$ conditional on his information set. When the manager is active, there is additional uncertainty in the firm value due to manager's actions. Accordingly, the market maker increases the price impact given trading intensity γ_1 and manager's decision rule β.

It is important to note here that the price impact is greater because of greater uncertainty in firm value and not because of greater trading intensity. The reason is that the manager's learning affects the objectives of the informed trader and the market maker separately. The market maker, in anticipation of manager's learning, increases price impact to recoup his losses given the order flow.

Next, we use equations (3.12) and (3.13) to solve for the equilibrium of the game between the informed trader and the market maker, given manager's decision rule. We calculate γ_1 and α_1 as:

$$\gamma_1 = \left[\frac{\sigma_y^2}{\sigma_\theta^2 + \sigma_t^2}\right]^{1/2} , \tag{3.14}$$

$$\alpha_1 = \frac{1+\beta_1}{1-\beta_2}\frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} . \tag{3.15}$$

See appendix for γ_0 and α_0. Note, the trading intensity in (3.14) is independent of manager's action and is equal to the trading intensity in the case of a passive manager. The reason is that when the manager is active, the market maker increases the price impact due to greater uncertainty in the firm value, which in turn decreases the trading intensity. In other words, when the manager is active, it increases the informational advantage to the informed trader which in turn increases the trading intensity, but it also leads to an increase in price impact by the market maker which reduces the trading intensity. The outcome of the game between the informed trader and the market maker given manager's decision results in a higher price impact with

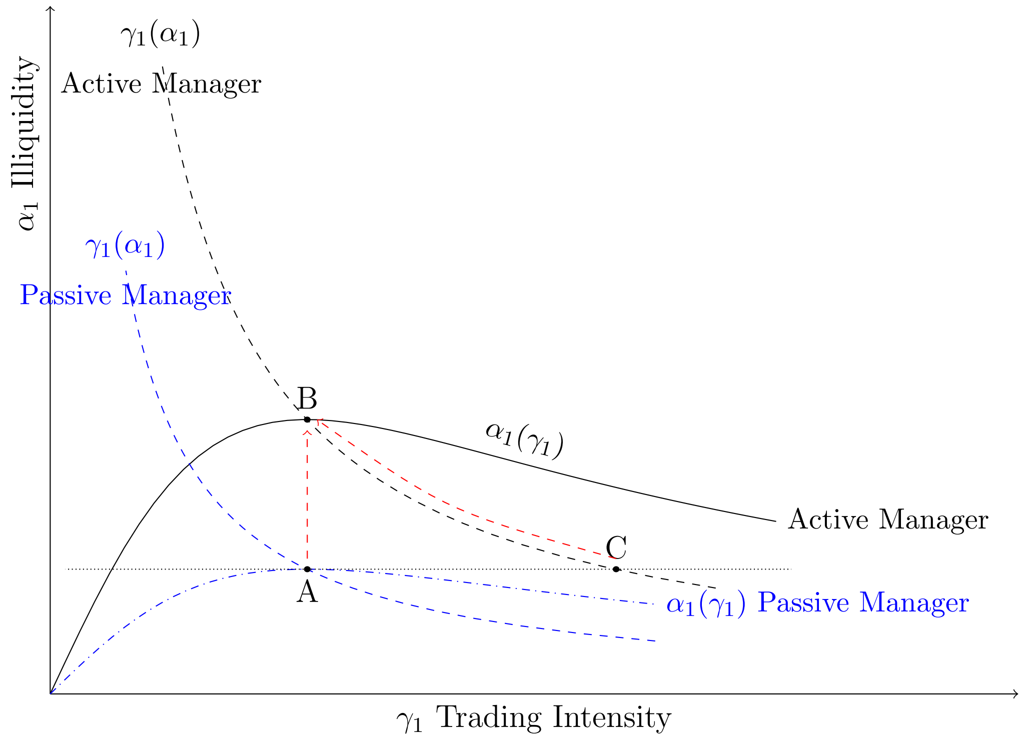

Figure 3.2: This figure shows the trading intensity and market illiquidity in two cases i) when the manager is passive and ii) when manager is active

no effect on trading intensity. This gives us the following Lemma.

Lemma III.5. *When the manager is active, her learning, both from her private information and from prices, increases the risk faced by the market maker. The market maker, in anticipation, increases the price impact, which exactly offsets the effect of manager's learning on the trading intensity of the informed trader, such that it is equal to the trading intensity with a passive manager.*

We can see the results of this Lemma in figure 3.2. The figure shows the informed trader's order strategy as a function of market illiquidity ($\gamma_1(\alpha_1)$) and market illiquidity as a function of informed trader's strategy ($\alpha_1(\gamma_1)$) given the manager's decision rule. We plot $\gamma_1(\alpha_1)$ and $\alpha_1(\gamma_1)$ for passive and active manager to highlight the role of manager's action on trading intensity and price impact.

Point C shows informed trader's order intensity when the manager uses her information, but the market maker keeps the price impact as if the manager is passive (at point A). Note the trading intensity increase from A to C. This increase corresponds to the relation of $\gamma_1(\beta_1, \beta_2)$ in (3.12) above. The intuition is that the use of information by the manager increases the informational advantage of the informed trader. Thus, he increases trading intensity.

In turn, the market maker being exposed to greater uncertainty in the firm value adjusts the price impact from A to B. Accordingly, the informed trader decreases the trading intensity from C to B. Note B is directly above A, which implies that the increase in price impact is just enough so that the trading intensity is independent of manager's use of information. The best response trading strategy γ_1 and best response price impact α_1 given the active manager's decision rule are shown at point B.

By increasing the price impact, market maker decreases the price liquidity and increases the price volatility. The price informativeness and price volatility given active manager's decision rule are:

$$PI = \frac{\sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)} , \tag{3.16}$$

$$V(P) = \left(\frac{1+\beta_1}{1-\beta_2}\right)^2 \frac{(\sigma_\theta^2)^2}{2(\sigma_\theta^2 + \sigma_t^2)} . \tag{3.17}$$

Note price informativeness when the manager is active is equal to the price informativeness when the manager is passive (equations 3.8). The reason is that the price informativeness is only dependent on trading intensity. Since in the case of active manager, the market maker increases the price impact such that the trading intensity is unaffected by the manager's decision rule (Lemma III.5). Consequently, the price informativeness is also unaffected by the manager's decision rule.

However, the price impact and price illiquidity when the manager is active is greater than when the manager is passive (equation 3.7 and 3.9). The reason is because the active manager's use of information increases the uncertainty in the firm value, to which the market maker responds by increasing the price impact. This results in greater illiquidity and higher price volatility.

3.5.2 Expected Profits of the Informed Trader Given Manager's Decision

In this section, we solve for the expected profits of the informed trader, given the manager's decision rule. We show above that the market maker increases the price impact when the manager is active, which in turn reduces the trading intensity of the informed trader such that it is unaffected by the manager's use of information. In this section, we show that, when the manager is active, despite the fact that the informed trader trades at the same intensity as when the manager is passive, he gets higher expected profits (as compared to equation (3.10)).

The expected profits $E[\pi(s_t)] = E[(V - P)x(s_t)]$ can be easily shown to be equal to:

$$E[\pi(s_t)] = (1 + \beta_1) \frac{\sigma_y \sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \ . \tag{3.18}$$

Note the expected profits are higher if β_1 is higher but they do not depend on β_2, manager's feedback from the price. This gives us the following proposition.

Proposition III.6. *The expected profits of the informed trader are increasing in the manager's use of her private information, and are unaffected by the feedback from the prices.*

In order to gain intuition for this result we breakdown the expected profits to the market maker in the following way. We know that the market maker, in order to achieve 0 expected profits, sets the price such that $V - P$ is orthogonal to q. i.e. $Cov(V - P, q) = 0$. We expand the total order flow and re-write the expected losses to the market maker as:

$$Cov(V - P, q) = \gamma_1 Cov(V - P, s_t) + Cov(V - P, y) \ . \tag{3.19}$$

Note the first term in equation (3.19) is equal to the expected profits of the informed trader, and the second term is equal to the expected profits to the liquidity traders. In equilibrium, the market maker would set price impact such that the expected profits of the informed trader are equal to the expected losses to the liquidity traders. Thus, we can write the equilibrium expected profits of the informed trader as:

$$E[\pi(s_t)] = Cov(P - V, y) \ . \tag{3.20}$$

When the manager is passive, the firm value is uncorrelated with liquidity trading y, thus the expected losses to liquidity traders, or equivalently the expected profits to the informed trader, are $Cov(P, y) = \alpha_1^P \sigma_y^2$.

However, the manager's learning from price gives an advantage to the liquidity traders. The feedback from the price induces a positive correlation between firm value and the liquidity trading, which reduces the expected losses to the liquidity traders. The expected losses to the liquidity traders are:

$$Cov(P - V, y) = \alpha_1 (1 - \beta_2) \sigma_y^2 \ . \tag{3.21}$$

Note the key difference between the effect of manager's learning from her own private information and from the market price on the expected losses to liquidity traders. If the manager uses more of her private information, it does not induce a positive correlation between firm value and liquidity trading, thus the expected losses to the liquidity traders are only affected by β_2.

We show in Lemma III.5 that the equilibrium price impact is higher by a factor of $\frac{1+\beta_1}{1-\beta_2}$. Note the greater price impact exactly cancels out the benefit to liquidity traders due to manager's learning from price resulting in greater expected losses to the liquidity traders, or equivalently greater expected profits to the informed trader only due to manager's learning from her private information.

The results of Lemma III.5 and Proposition III.6 can be summarised as follows. If the manager uses more of her own information or feedback from the prices to make decisions, the information asymmetry between the informed traders and the liquidity traders increases. This increases the expected profits to the informed trader. However, the manager's learning from price has an additional offsetting effect on the expected profits by inducing a positive correlation between the liquidity trades and firm value, which benefits liquidity traders and lowers the wealth transfer from the liquidity traders to the informed trader. Overall, the increase in expected profits to the informed trader is only due to manager's use of her private information, which increases the expected profits by a factor of $1 + \beta_1$.

3.5.3 Manager's Optimal Decision

In this section, we solve for manager's optimal action given the trading intensity and market liquidity. The manager is taking action a based on her information set (s_a, P). We show in Proposition III.3 above, the active manager would prefer to gather precise information about θ, because it increases her ex-ante expected payoff. This motivates the idea that learning from prices will increase the precision of her information set which increases her expected payoff. Her private information s_a is a noisy signal about θ, while price P contains the information of the informed trader s_t concealed by the order of the liquidity traders y.

In other words, having additional information about θ coming from the informed trader's signal helps the manager in predicting θ accurately. Consider the case when θ is the returns to technology. Higher prices indicate that the technology, in which the firm is about to invest, is good. Conditional on her own private information the manager learns from price and invests more. The manager would be under investing if there is lack of feedback from the prices. The same logic applies when prices are low. If the manager does not learn from low prices and update her beliefs about the technology, then she would overinvest.

First, we solve for manager's optimal decision rule when the informed trader's strategy is given and the market maker's pricing rule is best response to manager's decision and informed trader's strategy. The market maker's best response is given by equation (3.13). We show that the manager's use of private information β_1 is decreasing with trading intensity γ_1, while feedback from price β_2 is increasing with trading intensity. The reason is that higher trading intensity increases price informativeness about θ, thus the manager uses more feedback from prices to take optimal action.

Next, we solve for manager's optimal decision rule when the market maker's pricing rule is given and the informed trader's order strategy is a best response to market maker's pricing rule and manager's decision rule. The informed trader's order strategy follows equation (3.12). We show that the manager increases her use of feedback from price when the price impact is low. The reason is that with low price impact, the informed trader trades aggressively, which increases the price informativeness about θ and thus the manager uses more feedback.

Lemma III.7. *The manager uses greater feedback from the prices and lowers use of private information if the trading intensity is high (γ_1 high) or if the market liquidity is high (α_1 low).*

In other words, the manager increases her use of feedback from the price when it is more informative about θ relative to her own private information. The price is more informative when the informed trader is trading at a greater intensity or when the market liquidity is high (α_1 low). Thus, price informativeness in the secondary market affects the manager's action through manager's information set.

The results of Lemma III.7 are further illustrated in figure 3.3. The solid line in the figure shows that β_1 is decreasing and β_2 is increasing with the trading intensity of the informed trader when the market maker's pricing rule follows equation (3.13). The dotted line shows that β_1 is decreasing and β_2 is increasing with market liquidity $1/\alpha_1$ when the informed trader's strategy follows equation (3.12).

3.5.3.1 Manager's Action in Equilibrium

Now, we use the results of Lemma III.5 and Lemma III.7 and show the existence of a unique linear equilibrium.

Lemma III.5 shows that manager's use of information increases the informational advantage to the informed trader and the market maker increases the price impact such that the trading intensity is independent of manager's use of information. Lemma III.7 shows that the manager uses more information from price if the price informativeness is high, which happens when price impact is low. Thus, manager's greater use of information increases the price impact, which reduces the manager's incentives to use information from price. Thus, equilibrium is obtained at a fixed point, where the manager's use of information corresponds to price impact, which in turn corresponds to a trading intensity and price informativeness in order for such use of information to be optimal.

The equilibrium use of information can also be seen in figure 3.3. Note the solid line is plotted to show the effect of varying trading intensity on β_1 and β_2, while incorporating the market maker's response to varying trading intensity. The dotted line is plotted to show the effect of varying price impact, while incorporating the informed trader's response to varying price impact. The intersection of solid line and dotted line shows the equilibrium β_1 and β_2 at which the trading intensity chosen on the solid line and the price impact chosen on the dotted line are best responses to

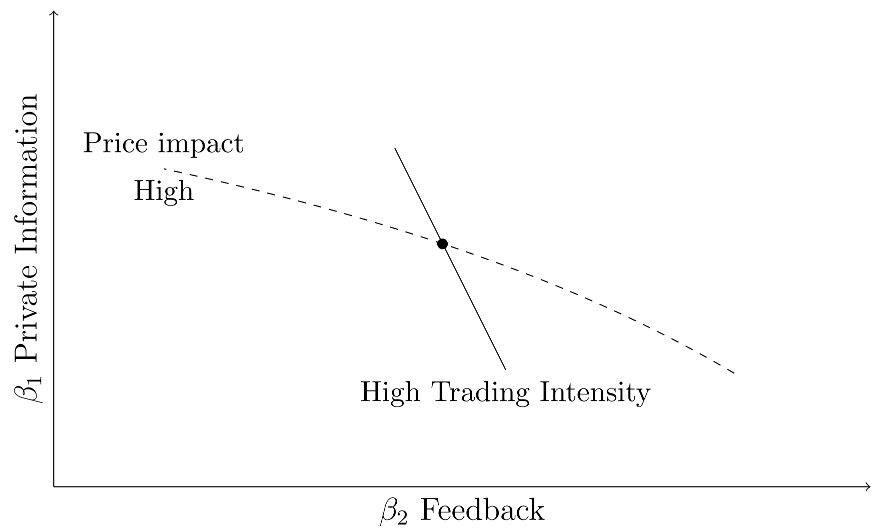

Figure 3.3: This figure shows the equilibrium use of information and the equilibrium trading intensity and market liquidity

each other.

We show the existence of a unique equilibrium and report the equilibrium strategies in Proposition III.8 below.

Proposition III.8. *There exists a unique linear equilibrium when the manager is active. In the equilibrium, the manager's use of her private information and feedback from the price corresponding to action* $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$ *is:*

$$\beta_1 = \frac{k_1}{1+\rho} \ ,$$
$$\beta_2 = \frac{k_1}{1+k_1}\frac{\rho}{1+\rho} \ ,$$

where $\rho = \frac{2\sigma_a^2(\sigma_t^2+\sigma_\theta^2)}{\sigma_\theta^2(2\sigma_t^2+\sigma_\theta^2)}$.

The market maker sets the price impact α_1 *as:*

$$\alpha_1 = (1+k_1)\frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2+\sigma_\theta^2)^{1/2}} \ .$$

The informed trader's trading intensity γ_1 is:

$$\gamma_1 = \left[\frac{\sigma_y^2}{\sigma_\theta^2 + \sigma_t^2}\right]^{1/2}.$$

See the appendix to this chapter for the expressions for β_0, γ_0 and α_0. Recall that $k_1 = \frac{w''}{C''-w''}$ (see equation 3.2). ρ is a measure of precision of price as a signal of θ, relative to the manager's private information. In the limiting case when σ_a^2 goes to infinity, β_1 goes to 0 and β_2 goes to $\frac{k_1}{1+k_1}$. In that case, the model reduces to a standard model with feedback effects.[3] Further, the expected profits of the informed trader (see Proposition III.6) reduce to the profits of the informed trader with a passive manager. It implies that the manager's use of information in price does not affect the profits of the informed trader.

On the other hand, if σ_t^2 is low, then the price is more precise (ρ is high), and the manager's use of the stock price (β_2) is high. Moreover, as price becomes more informative, ceteris paribus, manager decreases her use of private information (β_1 is low). In other words, if the manager does not know much about future investment returns, while the market has more precise information about the fundamental, she will use more information from the price. Therefore, in equilibrium, the manager's use of feedback from price is increasing with quality of information from price and decreasing with her own quality of information.

3.5.4 Equilibrium Price Volatility and Price Informativeness

Proposition III.8 shows that the equilibrium price impact is increasing with k_1. k_1 is determined by the compensation contract provided to the manager. k_1 is high if the compensation has high powered pay-for-performance incentives. Lemma III.2 shows that the manager's compensation contract provides her with incentives to take higher action when her prediction about θ is high. Thus, if k_1 is high, the manager's

[3]See Bond et al. (2011) for a survey paper on the real effects of financial markets.

decision is more sensitive to her prediction about θ. This increases the uncertainty in the firm value and the market maker responds by increasing the price impact.

Note, the equilibrium trading intensity of the informed trader does not depend on k_1. This is because the market maker chooses the price impact (shown earlier in Lemma III.5) so that the trading intensity of the informed trader does not depend on the manager's action. Next, we calculate the equilibrium price informativeness and equilibrium price volatility. The equilibrium price informativeness and price volatility are:

$$PI = \frac{\sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)} \ , \tag{3.22}$$

$$V(P) = (1 + k_1)^2 \frac{(\sigma_\theta^2)^2}{2(\sigma_\theta^2 + \sigma_t^2)} \ . \tag{3.23}$$

The equilibrium price informativeness does not depend on k_1. The reason is, as before, the equilibrium price informativeness only depends on trading intensity, which is unaffected by the manager's actions and thus her compensation contract. However, the equilibrium price volatility is greater if k_1 is high. Again, the reason is if k_1 is high, manager's action is more sensitive to μ, which increases the uncertainty in the firm value, and the market maker raises the price impact, which increases the price volatility.

We use the standard definition of price informativeness about the firm value from the literature.

$$PI_{Firm} = \frac{Var[V] - Var[V|P]}{Var[V]} \ .$$

Using simple algebra, it follows that, in equilibrium, the price informativeness about the firm value is:

$$PI_{Firm} = \frac{\sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)} \frac{(1+k_1)^2 \sigma_\theta^2}{\sigma_\theta^2 + (k_1^2 + 2k_1) Var(\mu)} ,$$

where $Var(\mu) = Var[E[\theta|I]]$. Using the fact that $Var(\mu)$ is smaller than $Var(\theta)$, it follows that the price informativeness about the firm value with an active manager is greater than with a passive manager (see equation 3.8).

The reason is that the active manager's action increases the uncertainty in the firm value which decreases the price informativeness but the increase in uncertainty increases the covariance between V and P, which increases the price informativeness. To see this, note that $Cov(V, P) = Cov(\theta, P) + k_1 Cov(\mu, P)$ and $Cov(\mu, P) = Cov(\theta, P)$ since the information set of the market maker is a subset of the information set $\mathcal{I} = \{s_a, P\}$ of the manager. Thus, the greater uncertainty increases the covariance by a factor of $1 + k_1$, while the total uncertainty in firm value does not increase as much (since $Var(\mu) < \sigma_\theta^2$). Overall, the price informativeness about the firm value is greater when the manager is active. We summarize the results of this section in the following proposition.

Proposition III.9. *Manager's learning in the active manager equilibrium does not affect the price informativeness about the fundamental. However, it leads to greater price informativeness about the firm value. Also, the equilibrium market price is more volatile in active manager equilibrium.*

We use this result to study the effect of an increase in the precision of manager's private information s_a on price informativeness of the fundamental and price informativeness of the firm value. As we show in Lemma III.5, due to an increase in the price impact, the informed trader lowers his trading intensity such that it is unaffected by manager's learning. Thus, when the manager's information is more precise and she learns more from her private information, it does not affect the trading intensity of the informed trader, and consequently does not affect the price informativeness about the fundamental.

Interestingly, ceteris paribus, the price informativeness about the firm value decreases as the precision of manager's private information increases. The reason is that an increase in the precision of manager's private information increases the total uncertainty in firm value, while keeping $Cov(V, P)$ unchanged. Thus, the price informativeness about the firm value decreases.

3.5.5 Equilibrium Expected Profits of the Informed Trader

In this section, we calculate the expected profits of the informed trader in equilibrium. Then, we use the manager's equilibrium use of information to study its effects on the incentives of the informed trader to gather information about fundamentals. Recall from proposition III.6, that the expected profits of the informed trader are high if his information is precise and if manager uses more of her private information. More importantly, the expected profits are unaffected by the manager's use of market price. We use the equilibrium use of private information from proposition III.8 and show that the unconditional expected profits of the informed trader, in equilibrium, are:

$$E[\pi(s_t)] = \left(1 + \frac{k_1}{1+\rho}\right) \frac{\sigma_y \sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \ .$$

This result shows that the expected profits of the informed trader are decreasing with ρ where ρ is a measure of informed trader's information precision relative to manager's private information. It implies that the information precision of the informed trader σ_t^2 affects his profits in two ways, a direct effect and through ρ. The direct effect is obvious. The indirect effect of increasing precision of informed trader's information increases price informativeness, which, in equilibrium, makes the manager use more of price and less of her private information. This benefits the liquidity traders and lowers the wealth transfer from the liquidity traders to the informed traders (Proposition III.6). Overall, the expected profits of the informed trader are greater with greater precision of information. This implies that manager's learning increases the incentives of the informed trader to gather precise information.

Conversely, if the informed trader has poor quality of information, then the extent of losses can be compensated if the manager's private information is of better quality. Ceteris paribus, if the manager's precision of information increases, she learns less from the price, which lowers the benefit to liquidity traders and increases the wealth transfer from the liquidity traders to the informed trader.

Thus, our model sheds light on the incentives of outsiders to gather precise information when the manager is active. In equilibrium, the informed trader's information affects the price informativeness, which affects the amount of learning by the manager, which in turn affects the profit of liquidity traders and net informational advantage to the informed trader. Overall, ex-ante the informed trader has greater expected profits which increases the incentives to gather precise information.

3.6 Competition Between Informed Traders

In this section, we solve the model if there are N informed traders competing in quantities in a Cournot competition. We assume that all traders obtain the same private information s_t. The trading strategy x_i for trader i is obtained by solving :

$$\max_{x_i} E[(V-P)x_i|s_t, x_i] \ . \tag{3.24}$$

The total order flow received by the market maker is $q = \sum x_i + y$, where ,as before, y is order of the liquidity traders. The price set by the market maker to obtain zero expected profits is:

$$P(q) = E[V|q] = \alpha_0 + \alpha_1 q \ . \tag{3.25}$$

In equilibrium since all traders have the same private information, their order are the same. We assume the order to be equal to $\gamma_0 + \gamma_1 s_t$. As before, we first solve for the optimal trading strategy and market maker's optimal pricing rule given the manager's decision rule to be exogenous. The equilibrium values of γ_1, α_1 are:

$$\gamma_1 = \left[\frac{\sigma_y^2}{N(\sigma_\theta^2 + \sigma_t^2)}\right]^{1/2} \ , \tag{3.26}$$

$$\alpha_1 = \frac{\sqrt{N}}{N+1}\frac{1+\beta_1}{1-\beta_2}\frac{\sigma_\theta^2}{\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} \ . \tag{3.27}$$

See Appendix for γ_0 and α_0. Similar to the earlier section with monopolistic informed trader, the market maker increases the price impact to account for the increase in uncertainty in the firm value. However, the increase in price impact is lower than would be in the case of a monopolistic informed trader. Note as N (> 1) increases, the price impact is lower and the trading intensity of each trader is lower. But the aggregate trading intensity increases with N, which reduces the adverse selection risk to the market maker. Thus, he sets lower price impact.

Before solving for the manager's optimal action, we solve for the aggregate expected profits of the informed trader. The aggregate expected profit of informed traders $E[\pi(s_t)] = \sum E[\pi_i(s_t)]$ is:

$$E[\pi(s_t)] = (1+\beta_1)\,\frac{\sigma_y\sigma_\theta^2}{N^{1/2}(\sigma_\theta^2 + \sigma_t^2)^{1/2}}\frac{N}{N+1} \ . \tag{3.28}$$

As a direct consequence of Cournot competition the aggregate profits decrease as the number of informed traders increase. However, the aggregate profits are increasing with β_1. The results of Proposition III.6 hold when there is competition between informed traders. i.e the informational advantage to the informed trader comes only from the manager's use of private information.

Next, we solve for the manager's optimal action given the trading intensity and market liquidity. The manager's optimal decision rule is given by $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$ where $\beta_0(\alpha,\gamma)$, $\beta_1(\alpha,\gamma)$ and $\beta_2(\alpha,\gamma)$ can be seen in the appendix. As with one monopolistic informed trader case analyzed earlier, the manager use of feedback from the prices is greater if price impact is low. Also, the price impact chosen by the market maker is greater when manager's use of information is greater. The equilibrium is obtained as a fixed point, where the manager's use of information corresponds to a price impact, which in turn corresponds to a trading intensity and price informativeness so that such use of information is optimal.

We show the existence of a unique equilibrium in Proposition III.10 below.

Proposition III.10. *There exists a unique equilibrium. In the equilibrium the manager's action is $\beta_0 + \beta_1 s_a + \beta_2 P$ where:*

$$\beta_1 = \frac{k_1}{1+\rho_N} \ ,$$
$$\beta_2 = \frac{k_1}{1+k_1}\frac{\rho_N}{[1+\rho_N]} \ ,$$

where $\rho_N = \frac{(N+1)\sigma_a^2(\sigma_t^2+\sigma_\theta^2)}{\sigma_\theta^2((N+1)\sigma_t^2+\sigma_\theta^2)}$.

The market maker pricing rule is $\alpha_0 + \alpha_1 q$ where:

$$\alpha_1 = \frac{\sqrt{N}}{N+1}(1+k_1)\frac{\sigma_\theta^2}{\sigma_y(\sigma_t^2+\sigma_\theta^2)^{1/2}} \ .$$

The informed trader's trading strategy is $\gamma_0 + \gamma_1 s_t$ where:

$$\gamma_1 = \left[\frac{\sigma_y^2}{N(\sigma_\theta^2+\sigma_t^2)}\right]^{1/2} \ .$$

The expected profits of the informed trader before receiving private information s_t are:

$$E[\pi(s_t)] = \left(1 + \frac{k_1}{1+\rho_N}\right) \frac{\sigma_y \sigma_\theta^2}{N^{1/2}(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \frac{N}{N+1} \ .$$

See Appendix for the expressions for β_0, α_0 and γ_0. In this equilibrium, with multiple traders, the informed traders collectively trade with a greater intensity, which impounds greater information into prices. Thus, the price precision relative to manager's private information ρ_N is greater than ρ. Thus, the manager uses greater feedback from the price, and lowers her use of private information. This increases the correlation between liquidity trading and firm value which benefits liquidity traders and lowers the wealth transfer from liquidity traders to the informed traders. Thus, we provide another channel through which the profits of the informed trader decrease beyond the forces of market competition.

3.7 Conclusion

In this paper, we model the effect of market prices on the real decisions of the manager. We show that the incentives of the manager induce her to learn about the fundamentals from the price, in addition to her private information. The feedback from price improves the information set of the manager, and therefore improves the efficiency of manager's decisions. That is, as the manager's knowledge of the state improves, her actions are more appropriate for the state of the world. Thus, the feedback from the market price affects the manager's learning, and consequently affects her actions and firm value.

However, manager's decision, in particular, manager's learning from prices to improve her information set, affects the price formation process which aggregates the information of the speculators into the prices in the first place. We show that manager's learning, both from her private information and from the prices, increases the price impact and price volatility. On the contrary, manager's learning from her private information and from prices do not affect the trading intensity of the informed trader, and hence price informativeness about the fundamentals. That is, manager's learning does not reduce the discovery aspect of the information content in the prices.

We also show that manager's learning from her private information and from the feedback from market price has opposite effects on the expected profits of the informed trader. Only the manager's learning from her private information increases the expected profits of the informed trader. The reason is that the manager's learning increases uncertainty about her actions which increases the uncertainty in firm value, thereby increasing the informational advantage to the informed trader. On the contrary, the feedback from price affects the manager's learning and her action, but does not affect the expected profits of the informed trader. Because the market maker, by setting a higher price impact, "undoes" the informational advantage created by the feedback from price.

Our model also generates implications for underpricing in the IPOs and incentives of the informed trader in information acquisition. We show that the manager's incentives induce her to gather information before taking actions. When the manager's private information is of greater precision, it increases the expected profits of the informed trader. This increases the incentives of the informed trader to gather precise information. Moreover, it increases the losses to the uninformed liquidity traders and thereby aggravates the underpricing in the IPOs.

3.8 Proofs

Proof of Proposition III.3. The expected payoff to the manager can be written as:

$$\pi(\mu, \sigma^2) = E[w(\theta + a^*(\mu)) - C(a^*(\mu))|\mathcal{I}] ,$$

where $\mathcal{I} = \{s_a, P\}$, and $\sigma^2 = V[\theta|\mathcal{I}]$. In Lemma III.2, we assume that w' is linear and show $a^*(\mu) = k_0 + k_1\mu$. Using that assumption here, we can re-write the expected payoff as:

$$\begin{aligned}\pi(\mu, \sigma^2) &= w(\mu + a^*(\mu)) + w'E[(\theta - \mu)|\mathcal{I}] + \frac{1}{2}w''E[(\theta - \mu)^2|\mathcal{I}] - C(a^*(\mu)) \\ &= w(\mu + a^*(\mu)) + \frac{1}{2}w''\sigma^2 - C(a^*(\mu)) \ ,\end{aligned}$$

where $\sigma^2 = V[\theta|\mathcal{I}]$. Next, we show that expected payoff $E[\pi]$ is increasing in the precision of information set. We write the ex-ante expected payoff by taking expectation and substituting $a^*(\mu) = k_0 + k_1\mu$ as:

$$\begin{aligned}E[\pi] &= E[w(\mu + a^*(\mu)) + \frac{1}{2}w''\sigma^2 - C(a^*(\mu))] \\ &= w(\theta_0 + a^*(\theta_0)) + \frac{1}{2}w''(1 + k_1)^2V(\mu) + \frac{1}{2}w''\sigma^2 - C(a^*(\theta_0)) - \frac{1}{2}C''k_1^2V(\mu) \ .\end{aligned}$$

We use the fact that $\sigma^2 + V(\mu) = \sigma_\theta^2$ and re-write the equation as:

$$E[\pi] = w(\theta_0 + a^*(\theta_0)) + \frac{1}{2}w''\sigma_\theta^2 - C(a^*(\theta_0)) + \frac{1}{2}(w''(k_1^2 + 2k_1) - C''k_1^2)V(\mu) \ .$$

We substitute $k_1 = \frac{w''}{C''-w''}$ and get:

$$E[\pi] = w(\theta_0 + a^*(\theta_0)) + \frac{1}{2}w''\sigma_\theta^2 - C(a^*(\theta_0)) + \frac{1}{2}\frac{(w'')^2}{C'' - w''}V(\mu) \ .$$

As the information set $\mathcal{I}$ is more precise, $V(E[\theta|\mathcal{I}])$ is greater, which increases $E[\pi]$ only if $w'' > 0$. If $w'' = 0$, then $E[\pi]$ is not affected by the precision of information $\mathcal{I}$. ■ ■

Proof of Lemma III.5. We first solve for informed trader's strategy given the pricing rule $P(q) = \alpha_0 + \alpha_1 q$ and the manager's decision rule $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$. The noise in the manager's private information is assumed to be independent of the informed trader's private information. Thus, the optimal order $x(s_t) = \arg\max_x E[(V - P)x|s_t, x]$ for the informed trader is then

$$x(s_t) = \gamma_0 + \gamma_1 s_t = \frac{(1+\beta_1)E[\theta|s_t] + \beta_0 - (1-\beta_2)\alpha_0}{2\alpha_1(1-\beta_2)} , \tag{3.1}$$

where

$$\gamma_0 = \frac{(1+\beta_1)\frac{\sigma_t^2\theta_0}{\sigma_\theta^2+\sigma_t^2} + \beta_0}{2\alpha_1(1-\beta_2)} - \frac{\alpha_0}{2\alpha_1} , \tag{3.2}$$

$$\gamma_1 = \frac{(1+\beta_1)}{2\alpha_1(1-\beta_2)}\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_t^2} . \tag{3.3}$$

Next, we solve for the market maker's pricing rule $P(q) = \alpha_0 + \alpha_1 q$ given the informed trader's trading strategy $x(s_t) = \gamma_0 + \gamma_1 s_t$ and the manager's decision rule $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$. The pricing rule $P(q) = E[V|q = (x+y)] = \alpha_0 + \alpha_1 q$ is then

$$P(q) = \alpha_0 + \alpha_1 q = \frac{1+\beta_1}{1-\beta_2}E[\theta|q] + \frac{\beta_0}{1-\beta_2} , \tag{3.4}$$

where

$$\alpha_0 = \frac{1+\beta_1}{1-\beta_2}\frac{\theta_0(\sigma_t^2 + \frac{\sigma_y^2}{\gamma_1^2}) - \frac{\gamma_0}{\gamma_1}\sigma_\theta^2}{\sigma_t^2 + \frac{\sigma_y^2}{\gamma_1^2} + \sigma_\theta^2} + \frac{\beta_0}{1-\beta_2} , \tag{3.5}$$

$$\alpha_1 = \frac{1+\beta_1}{1-\beta_2}\frac{\frac{\sigma_\theta^2}{\gamma_1}}{\sigma_t^2 + \frac{\sigma_y^2}{\gamma_1^2} + \sigma_\theta^2} . \tag{3.6}$$

Next, we solve for γ_0, γ_1, α_0, α_1 as a function of β_0, β_1, β_2 and the primitives of the model. After simple algebra, it follows that:

$$\gamma_0 = -\theta_0 \frac{\sigma_y}{(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \tag{3.7}$$

$$\gamma_1 = \left[\frac{\sigma_y^2}{\sigma_\theta^2 + \sigma_t^2}\right]^{1/2} \tag{3.8}$$

$$\alpha_0 = \frac{1+\beta_1}{1-\beta_2}\theta_0 + \frac{\beta_0}{1-\beta_2} \tag{3.9}$$

$$\alpha_1 = \frac{1+\beta_1}{1-\beta_2} \frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} \tag{3.10}$$

Thus equations (3.7,3.10) show the effect of manager's decision rule on trading intensity and price impact. ■ ■

Proof of Proposition III.6. Expected Profits of the Informed Trader given manager's decision

Using the equilibrium values of γ, α in (3.7)-(3.10), it can be easily shown that the profits of the informed trader ($\pi(s_t)$) after receiving their private information s_t are:

$$\begin{aligned}
\pi(s_t) &= E[(V-P)x|s_t] \\
&= E[(\theta + \beta_0 + \beta_1 s_a + \beta_2 P - P)(\gamma_0 + \gamma_1 s_t)|s_t] \\
&= (1+\beta_1)\frac{\sigma_y}{(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \frac{\sigma_\theta^2 (s_t - \theta_0)^2}{2(\sigma_t^2 + \sigma_\theta^2)}
\end{aligned}$$

where the third equality is obtained by substituting the equilibrium values of $\gamma(\beta)$ and $\alpha(\beta)$. The expected profits of the informed trader before receiving private information s_t are:

$$E[\pi(s_t)] = (1+\beta_1)\frac{\sigma_y}{(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \frac{\sigma_\theta^2 E(s_t - \theta_0)^2}{2(\sigma_t^2 + \sigma_\theta^2)}$$

$$E[\pi(s_t)] = (1+\beta_1)\frac{\sigma_y \sigma_\theta^2}{2(\sigma_\theta^2 + \sigma_t^2)^{1/2}}$$

This gives us the unconditional expected profits of the informed trader, which are increasing with manager's use of her private information and are unaffected from the manager's learning from prices. ■ ■

Proof of Lemma III.7. We solve for optimal manager's action given the trading intensity and market liquidity. The manager's optimal action $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$ is:

$$a(s_a, P) = k_0 + k_1 E[\theta | s_a, P] \tag{3.11}$$

$$= k_0 + k_1 \frac{\frac{\theta_0}{\sigma_\theta^2} + \frac{s_a}{\sigma_a^2} + \frac{P - \alpha_0 - \alpha_1\gamma_0}{\alpha_1\gamma_1} \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}} \tag{3.12}$$

where

$$\beta_0 = k_0 + k_1 \frac{\frac{\theta_0}{\sigma_\theta^2} + \frac{-\alpha_0 - \alpha_1\gamma_0}{\alpha_1\gamma_1} \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}} \tag{3.13}$$

$$\beta_1 = k_1 \frac{\frac{1}{\sigma_a^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}} \tag{3.14}$$

$$\beta_2 = k_1 \frac{\frac{1}{\alpha_1\gamma_1} \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/\gamma_1^2}} \tag{3.15}$$

First, we solve for β_1 and β_2 given γ_1, while α_1 is endogenous. We can directly observe from equation (3.14) that β_1 is decreasing with γ_1. In order to see the effect of γ_1 on β_2, we substitute for α_1 from equation (3.6). We get β_2 as:

$$\beta_2 = \frac{k_1(1-\beta_2)}{(1+\beta_1)} \frac{\frac{\sigma_a^2}{\sigma_\theta^2 + \sigma_a^2}(\sigma_t^2 + \frac{\sigma_y^2}{\gamma_1^2} + \sigma_\theta^2)}{\sigma_t^2 + \sigma_y^2/\gamma_1^2 + \sigma_\theta^2 \frac{\sigma_a^2}{\sigma_\theta^2 + \sigma_a^2}} \tag{3.16}$$

From the above equation, it directly follows that the manager's learning from price is increasing with trading intensity γ_1. Next, we solve for β_1 and β_2 as a function of α_1 by replacing γ_1 from equation (3.3). We get two nonlinear equations in β_1 and

β_2 which we solve using matlab and show that β_1 is increasing with α_1 while β_2 is decreasing with α_1. ■ ■

Proof of Proposition III.8. We solve for the equilibrium by substituting γ_0, γ_1, α_0, α_1 into the expressions for β_0, β_1, β_2. First, by direct substitution of γ_1, the equilibrium value of β_1 is:

$$\beta_1 = k_1 \frac{\sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2)}{\sigma_a^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2\sigma_a^2} \tag{3.17}$$

$$= k_1 \frac{\sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2)}{2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2)} \tag{3.18}$$

By substituting α_1 and γ_1, the equilibrium value of β_2 is:

$$\beta_2 = \frac{k_1}{\alpha_1\gamma_1} \frac{\sigma_\theta^2\sigma_a^2}{\sigma_a^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2\sigma_a^2} \tag{3.19}$$

$$\beta_2 = \frac{k_1(1-\beta_2)2(\sigma_t^2 + \sigma_\theta^2)}{(1+\beta_1)} \frac{\sigma_a^2}{\sigma_a^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2\sigma_a^2} \tag{3.20}$$

$$\beta_2 = \frac{\frac{k_1}{(1+\beta_1)} \frac{2(\sigma_t^2+\sigma_\theta^2)\sigma_a^2}{\sigma_a^2(2\sigma_t^2+\sigma_\theta^2)+\sigma_\theta^2(2\sigma_t^2+\sigma_\theta^2)+\sigma_\theta^2\sigma_a^2}}{1 + \frac{k_1}{(1+\beta_1)} \frac{2(\sigma_t^2+\sigma_\theta^2)\sigma_a^2}{\sigma_a^2(2\sigma_t^2+\sigma_\theta^2)+\sigma_\theta^2(2\sigma_t^2+\sigma_\theta^2)+\sigma_\theta^2\sigma_a^2}} \tag{3.21}$$

$$\beta_2 = \frac{k_1}{1+k_1} \frac{2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2)}{[2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2)]} \tag{3.22}$$

Next we solve for equilibrium value of β_0 as follows:

$$\beta_0 = k_0 + k_1 \frac{\frac{\theta_0}{\sigma_\theta^2} + \frac{-\alpha_0-\alpha_1\gamma_0}{\alpha_1\gamma_1} \frac{1}{\sigma_t^2+\sigma_y^2/\gamma_1^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2+\sigma_y^2/\gamma_1^2}} \tag{3.23}$$

$$= k_0 + k_1 \frac{\theta_0(2\sigma_t^2 + \sigma_\theta^2)(\sigma_a^2) + \frac{-\alpha_0-\alpha_1\gamma_0}{\alpha_1\gamma_1}(\sigma_a^2\sigma_\theta^2)}{(2\sigma_t^2 + \sigma_\theta^2)\sigma_a^2 + (2\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2 + \sigma_a^2\sigma_\theta^2} \tag{3.24}$$

$$= k_0 - k_1 \frac{\beta_0 2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2)}{2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + (2\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2(1 + k_1)} \tag{3.25}$$

$$= \frac{k_0}{1+k_1}\left[1 + \frac{k_1(2\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2}{2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + (2\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2}\right] \tag{3.26}$$

For simplicity, lets define ρ as:

$$\rho = \frac{2\sigma_a^2(\sigma_t^2 + \sigma_\theta^2)}{\sigma_\theta^2(2\sigma_t^2 + \sigma_\theta^2)} \tag{3.27}$$

Now, β_0, β_1 and β_2 can be written as:

$$\beta_0 = \frac{k_0}{1+k_1}\left[1 + \frac{k_1}{1+\rho}\right] \tag{3.28}$$

$$\beta_1 = \frac{k_1}{1+\rho} \tag{3.29}$$

$$\beta_2 = \frac{k_1}{1+k_1}\frac{\rho}{[1+\rho]} \tag{3.30}$$

We use the above values of β_0, β_1, β_2 to obtain the equilibrium informed trader's order and the equilibrium market price set by the market maker. We have shown above that the informed trader's order does not depend on the manager's action. The equilibrium market price set by the market maker is:

$$\alpha_0 = \theta_0 + k_0 + k_1\theta_0 \tag{3.31}$$

$$\alpha_1 = (1+k_1)\frac{\sigma_\theta^2}{2\sigma_y(\sigma_t^2 + \sigma_\theta^2)^{1/2}} \tag{3.32}$$

The equilibrium order strategy of the informed trader is the same as (3.7,3.8) since it does not depend on β. ■ ■

Proof of Proposition III.10. To solve the model, we first solve for informed trader's strategy given the pricing rule $P(q) = \alpha_0 + \alpha_1 q$ and the manager's decision rule $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$. Thus, the optimal order $x_i(s_t) = \arg\max_{x_i} E[(V - P)x_i|s_t, x_i]$ for the informed trader i is then

$$x_i(s_t) = \gamma_0 + \gamma_1 s_t = \frac{(1+\beta_1)E[\theta|s_t] + \beta_0 - (1-\beta_2)(\alpha_0 + \alpha_1\sum_{j\neq i} x_j)}{2\alpha_1(1-\beta_2)} \tag{3.33}$$

where γ_0 and γ_1 can be easily shown as:

$$\gamma_0 = \frac{2}{N+1}\left(\frac{(1+\beta_1)\frac{\sigma_t^2\theta_0}{\sigma_\theta^2+\sigma_t^2}+\beta_0}{2\alpha_1(1-\beta_2)} - \frac{\alpha_0}{2\alpha_1}\right) \tag{3.34}$$

$$\gamma_1 = \frac{2}{N+1}\frac{(1+\beta_1)}{2\alpha_1(1-\beta_2)}\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_t^2} \tag{3.35}$$

Next, we solve for the market maker's pricing rule $P(q) = \alpha_0 + \alpha_1 q$ given the informed traders trading strategy $\sum x_i(s_t) = N(\gamma_0 + \gamma_1 s_t)$ and the manager's decision rule $a(s_a, P) = \beta_0 + \beta_1 s_a + \beta_2 P$. The pricing rule $P(q) = E[V|q = (\sum x_i + y)] = \alpha_0 + \alpha_1 q$ is then

$$P(q) = \alpha_0 + \alpha_1 q = \frac{1+\beta_1}{1-\beta_2}E[\theta|q] + \frac{\beta_0}{1-\beta_2} \tag{3.36}$$

where

$$\alpha_0 = \frac{1+\beta_1}{1-\beta_2}\frac{\theta_0(\sigma_t^2+\frac{\sigma_y^2}{N^2\gamma_1^2}) - \frac{\gamma_0}{\gamma_1}\sigma_\theta^2}{\sigma_t^2+\frac{\sigma_y^2}{N^2\gamma_1^2}+\sigma_\theta^2} + \frac{\beta_0}{1-\beta_2} \tag{3.37}$$

$$\alpha_1 = \frac{1+\beta_1}{1-\beta_2}\frac{\frac{\sigma_\theta^2}{N\gamma_1}}{\sigma_t^2+\frac{\sigma_y^2}{N^2\gamma_1^2}+\sigma_\theta^2} \tag{3.38}$$

Next, we solve for γ_0, γ_1, α_0, α_1 as a function of β_0, β_1, β_2 and the primitives of the model. After simple algebra, it follows that:

$$\gamma_0 = -\theta_0\frac{\sigma_y}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}} \tag{3.39}$$

$$\gamma_1 = \left[\frac{\sigma_y^2}{N(\sigma_\theta^2+\sigma_t^2)}\right]^{1/2} \tag{3.40}$$

$$\alpha_0 = \frac{1+\beta_1}{1-\beta_2}\theta_0 + \frac{\beta_0}{1-\beta_2} \tag{3.41}$$

$$\alpha_1 = \frac{\sqrt{N}}{N+1}\frac{1+\beta_1}{1-\beta_2}\frac{\sigma_\theta^2}{\sigma_y(\sigma_t^2+\sigma_\theta^2)^{1/2}} \tag{3.42}$$

■

Expected Profits of the Informed Trader given Manager's decision rule

Using the equilibrium values of γ, α given manager's decision rule, it can be easily shown that the profits of the informed trader i ($\pi_i(s_t)$) after receiving their private information s_t are:

$$\pi_i(s_t) = E[(V-P)x_i|s_t] \tag{3.43}$$
$$= E[(\theta+\beta_0+\beta_1 s_a+\beta_2 P-P)(\gamma_0+\gamma_1 s_t)|s_t] \tag{3.44}$$
$$= (1+\beta_1)\frac{\sigma_y}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}}\frac{1}{N+1}\frac{\sigma_\theta^2(s_t-\theta_0)^2}{(\sigma_t^2+\sigma_\theta^2)} \tag{3.45}$$

where the third equality is obtained by substituting the equilibrium values of $\gamma(\beta)$ and $\alpha(\beta)$. The expected profits of the informed trader i before receiving private information s_t are:

$$E[\pi_i(s_t)] = (1+\beta_1)\frac{\sigma_y\sigma_\theta^2}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}}\frac{1}{N+1} \tag{3.46}$$

The total profit of all informed traders $E[\pi(s_t)] = \sum E[\pi_i(s_t)]$is:

$$E[\pi(s_t)] = (1+\beta_1)\frac{\sigma_y\sigma_\theta^2}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}}\frac{N}{N+1} \tag{3.47}$$

Next, we solve for optimal manager's action given the trading intensity and market liquidity. The manager's optimal action $a(s_a,P) = E[k_0+k_1\theta|s_a,P] = \beta_0+\beta_1 s_a+\beta_2 P$ where

$$\beta_0 = k_0 + k_1 \frac{\frac{\theta_0}{\sigma_\theta^2} + \frac{-\alpha_0 - \alpha_1 N \gamma_0}{\alpha_1 N \gamma_1} \frac{1}{\sigma_t^2 + \sigma_y^2/(N^2\gamma_1^2)}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/(N^2\gamma_1^2)}} \tag{3.48}$$

$$\beta_1 = k_1 \frac{\frac{1}{\sigma_a^2}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/(N^2\gamma_1^2)}} \tag{3.49}$$

$$\beta_2 = k_1 \frac{\frac{1}{\alpha_1 N \gamma_1} \frac{1}{\sigma_t^2 + \sigma_y^2/(N^2\gamma_1^2)}}{\frac{1}{\sigma_\theta^2} + \frac{1}{\sigma_a^2} + \frac{1}{\sigma_t^2 + \sigma_y^2/(N^2\gamma_1^2)}} \tag{3.50}$$

Next, we solve for the equilibrium by substituting γ_0, γ_1, α_0, α_1 into the expressions for β_0,β_1, β_2. First, by direct substitution of γ_1, the equilibrium value of β_1 is:

$$\beta_1 = k_1 \frac{\sigma_\theta^2((N+1)\sigma_t^2 + \sigma_\theta^2)}{(N+1)\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2((N+1)\sigma_t^2 + \sigma_\theta^2)} \tag{3.51}$$

By substituting α_1 and γ_1, the equilibrium value of β_2 is:

$$\beta_2 = \frac{k_1}{1+k_1} \frac{(N+1)\sigma_a^2(\sigma_t^2 + \sigma_\theta^2)}{[(N+1)\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + \sigma_\theta^2((N+1)\sigma_t^2 + \sigma_\theta^2)]} \tag{3.52}$$

Note that it gives an interesting relationship between β_1 and β_2 as follows:

$$\beta_1 + \beta_2(1 + k_1) = k_1 \tag{3.53}$$

Next we solve for equilibrium value of β_0 as follows:

$$\beta_0 = \frac{k_0}{1+k_1} \left[1 + \frac{k_1((N+1)\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2}{(N+1)\sigma_a^2(\sigma_t^2 + \sigma_\theta^2) + ((N+1)\sigma_t^2 + \sigma_\theta^2)\sigma_\theta^2} \right] \tag{3.54}$$

For simplicity, lets define ρ_N as:

$$\rho_N = \frac{(N+1)\sigma_a^2(\sigma_t^2 + \sigma_\theta^2)}{\sigma_\theta^2((N+1)\sigma_t^2 + \sigma_\theta^2)} \tag{3.55}$$

Now, β_0, β_1 and β_2 can be written as:

$$\beta_0 = \frac{k_0}{1+k_1}\left[1 + \frac{k_1}{1+\rho_N}\right] \tag{3.56}$$

$$\beta_1 = \frac{k_1}{1+\rho_N} \tag{3.57}$$

$$\beta_2 = \frac{k_1}{1+k_1}\frac{\rho_N}{[1+\rho_N]} \tag{3.58}$$

We use the above values of β_0, β_1, β_2 to obtain the equilibrium informed trader's order and the equilibrium market price set by the market maker. We have shown above that the informed trader's order does not depend on the manager's action. The equilibrium market price set by the market maker is:

$$\alpha_0 = \theta_0 + k_0 + k_1\theta_0 \tag{3.59}$$

$$\alpha_1 = \frac{\sqrt{N}}{N+1}(1+k_1)\frac{\sigma_\theta^2}{\sigma_y(\sigma_t^2+\sigma_\theta^2)^{1/2}} \tag{3.60}$$

Expected Profits of the Informed Trader in Equilibrium

We find the profits of the informed trader i ($\pi_i(s_t)$) by substituting the equilibrium β_1 to be:

$$\pi_i(s_t) = (1+\beta_1)\,\frac{\sigma_y}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}}\frac{1}{N+1}\frac{\sigma_\theta^2(s_t-\theta_0)^2}{(\sigma_t^2+\sigma_\theta^2)} \tag{3.61}$$

The expected profits of the informed trader i before receiving private information s_t are:

$$E[\pi_i(s_t)] = \left(1 + \frac{k_1}{1+\rho_N}\right)\frac{\sigma_y\sigma_\theta^2}{N^{1/2}(\sigma_\theta^2+\sigma_t^2)^{1/2}}\frac{1}{N+1} \tag{3.62}$$

The total profit of all informed traders $E[\pi(s_t)] = \sum E[\pi_i(s_t)]$is:

$$E[\pi(s_t)] = \left(1 + \frac{k_1}{1+\rho_N}\right) \frac{\sigma_y \sigma_\theta^2}{N^{1/2}(\sigma_\theta^2 + \sigma_t^2)^{1/2}} \frac{N}{N+1} \tag{3.63}$$

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