Corporate Disclosures: Strategic Donation of Information

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September 21, 1999

We acknowledge helpful comments by Sugato Bhattacharyya, Anjan Thakor, and seminar participants at the Hong Kong University of Science and Technology, Hong Kong University, City University of Hong Kong, University of Minnesota, the University of Michigan Business School brown bag seminar series, 1999 Western Finance Association meeting. Please address all correspondence to Jhinyoung Shin, School of Business and Management, Ajou University, Suwon City, Gyongki-do, Korea, e-mail : jyshin@madang.ajou.ac.kr.

Abstract

In this paper we model a corporate manager's choice of a disclosure regime. In a model in which disclosure has no efficiency gains like reduced cost of capital, or no legal implications, or no signaling motivations, we show that a manager may choose to disclose payoff-relevant information as a means of making trading profits. This *truthful* disclosure is done pre-trade and is beneficial to the manager as it erodes the informational advantage of other traders with superior information. The paper also examines the effect of disclosure on insider trading regulation and shows that non-strategic shareholders can benefit from insider trading only if the managers have the ability to credibly disclose their information. We extend the model and show that there exist instances where an outsider that possesses superior information is better off giving it away for free rather than selling it. This new rationale for public disclosure needs to be empirically tested by examining the trades of managers after, not before, public disclosures.

1 Introduction

Corporate managers routinely disclose payoff-relevant information to financial markets. Most of the disclosure is mandated by securities' laws. However, these laws are often ambiguous and managers have some discretion over the disclosure's timing, its precision and its content. More importantly, managers have the discretion to disclose information over and above the levels mandated by law. In this paper, we examine the incentives of managers to disclose payoff-relevant information even when it is neither mandated by law nor it affects the value of the firm.

The question that we focus on is simple: Why would managers ever disclose payoff-relevant information if they could trade and profit from it themselves? [1] Basically, why would managers voluntarily give up part of their informational advantage against the market? We model financial markets in which there exist market participants, other than the managers, who are better informed than the average market participant. Thus, in our model, payoff-relevant information is possessed not only by the managers but also by a number of market analysts. These analysts also trade on their own account and provide competition to the manager. The paper shows that the competition between the manager and the analysts may lead to truthful pre-trade disclosure by the manager.

Competition by the analysts does not always lead to disclosure by the manager. We show that if the manager's information is exactly the same as possessed by the analysts then the manager will never choose to voluntarily disclose information to the market. Disclosure by the manager allows other market participants to share the information that initially was privy only to the manager and the analysts. In this case, disclosure of private information does not provide the manager any strategic gain against the analysts. However, it reduces the informational advantage vis-a-vis the market, of both the analysts and the manager. Disclosure simply reduces the expected profits from trading and, thus, trading on the information dominates disclosing it to the market. This strong characterization is independent of the number of analysts who possess payoff-relevant information as well as the quality of the information possessed by the agents.

The assumption that both the manager and the analysts have the exact same information is clearly unrealistic. There is always some information that is precluded from outside analysts.[2] This information could be due to informational resources exclusively available to the

[1] There exists empirical evidence that insiders earn positive trading profits. See, for example, Seyhun (1986).

[2] Although we do not model it here, it is also plausible that outside analysts have information that is not possessed by the manager. See, Boot and Thakor (1997) for a model in which market participants incur costs

managers. Examples of information that might not be possessed by the market analysts are future growth prospects of the firm, prospects of R & D projects or future strategic decisions to be made by the manager. Another possibility is that managers possess the ability to better process the signals observed by both the analysts and the manager. For example, the impact of a competitor's failure on the firm's future can be better estimated by the manager than the outside analysts. We show that, in these cases, the manager might voluntarily disclose a part of the payoff-relevant information to the market and, thus, reduce their own informational advantage.

The manager's disclosure is truthful and is not intended to manipulate the market. It is also not driven by any sort of regulatory threat or a future penalty. It is not the result of an assumed egalitarian objective like a desire to reduce the trading losses of the non-strategic shareholders. The manager's decision to surrender information is simply driven by a desire to increase trading profit. It is well known that traders can benefit from collecting more information about the fundamentals of securities. Alternatively, a manager, in our model, benefits from donating information.

The cost of disclosure to the manager is quite clear — it reduces the trading profits that can be made on the disclosed component. However, this cost is not borne by the manager alone. The manager chooses to disclose the information which is shared with the analysts. The manager's voluntary disclosure forces the analysts to relinquish their informational advantage too. The manager's disclosure decision, thus, imposes an externality on the analysts as it forces them to share in the cost of the disclosure.

To understand the advantage of disclosure one needs to examine the price formation process. Trading by informed agents allows the market participants to update their beliefs about the fundamental value of the security. Thus, the prices partially reflect the information the informed agents possess. The manager's disclosure reduces the market's uncertainty about the future payoff and causes the price to become less sensitive to order flow. The manager benefits from this lower price sensitivity by trading more aggressively on the undisclosed component of information. We show that whenever the number of analysts is high enough or the amount of information they possess is not too big a fraction of the total payoff, the benefit of disclosure outweighs its cost. In these cases, the manager truthfully discloses the shared component of information.

The analysis also highlights the importance of informational privacy. The manager has

to become better informed about the firm's prospects than the firm. Allen (1993) motivates the role of stock markets as a information feedback mechanism for the managers.

two options: (1) to not disclose and thus fully retain the information; or (2) to disclose the component of information that is shared with the analysts and retain a smaller informational advantage vis-a-vis the market, all of which is private. We show that there exist instances in which the manager is better off with the latter. By disclosing, the manager enhances the value of the private or unshared information by giving up the informational advantage on the shared component. Indeed, a small amount of private information can be more useful than having a much larger amount of partially shared information.

The ability to disclose information clearly benefits the manager and hurts the analysts who possess the superior information. The impact of disclosure on the welfare of non-strategic shareholders is less clear. On one hand, disclosure benefits the non-strategic shareholders as it reduces the adverse selection on a fraction of a securities payoff. On the other hand, the manager now makes a higher trading profit on the undisclosed information. The net effect is, however, unambiguous. We show that outlawing disclosure is always value destroying for the non-strategic shareholders.

We also examine the effect of disclosure on the incentives of non-strategic shareholders to regulate the manager's trading activity. We show that if the manager lacks the ability to credibly disclose any information to the market then disallowing the manager to trade always benefits the non-strategic shareholders. Banning the manager from the market not only allows for a higher number of analysts in equilibrium but also avoids shareholders losses on the information solely possessed by the manager. On the other hand, if the manager has the ability to disclose the information then allowing the manager to trade has two effects. First, it takes away some of the profits of the analysts whenever it is optimal for the manager to disclose. Second, it increases the losses of the non-strategic shareholders due to the adverse selection on the information solely possessed by the manager. The paper shows that the first effect can dominate the second and, thus, improving the welfare of the non-strategic shareholders.

It might seem that the free disclosure of information by the manager is largely driven by restrictions on the strategy space. The manager has been restricted either to trade on the information or to donate it. More specifically, we have not allowed the manager to sell information to the less-informed investors. We refer to a sale of information as any case in which the end user observes the information before acting on it. For example, a subscription to an investment newsletter of limited circulation. Such an information sale by managers will clearly run afoul of the current legal system. However, the sale of information is possible by outside investors. The typical question that confronts an informed trader in a financial market is why resort to selling information when one could directly trade on it. We go a step further and ask whether donation of information can be optimal in a setting where sale of information is possible. In short, yes.

There are other papers that theoretically model the disclosure of payoff relevant information by the firm.[3] Diamond and Verrecchia (1991) show that disclosure reduces informational asymmetry and thus attracts increased demand from large investors. This reduces the cost of capital for the firm. Fishman and Hagerty (1989) analyze a costly disclosure decision by firms competing with each other to attract more trade. They show that disclosure levels are higher than the social optimum. On the other hand, Diamond (1985) develops a model in which disclosure helps avoid costly information acquisition by traders. In a related model, Boot and Thakor (1998) examine the impact of mandatory disclosure on the incentives of investors to gather information and, consequently, the firms' incentives for financial innovation.

This paper is also related to the work of Bushman and Indjejikian (1995), in which the authors model a manager and market analysts who have *costly* access to information on the same random variable. They show that managers will disclose a noisy signal of their information to discourage the analysts from getting any information. Disclosure in their model reduces the potential profit for analysts and, thus, acts like an entry deterrent.[4] The intuition driving disclosure in the current paper is very different from that presented in Bushman and Indjejikian (1995). In our paper, disclosure is made after the analysts have expended resources to obtain the information. In fact the manager's sole purpose in disclosing the information is to change the price sensitivity of the market and not the information acquisition decision of the analysts. On a related note, information disclosed in our paper is done without adding any noise and as such it is verifiable. In contrast, disclosure in Bushman and Indjejikian (1995) necessarily has to have a random noise component incorporated in the disclosed signal. Later in the paper we distinguish our results from those obtained by Bushman and Indjejikian (1995) in more detail.

The paper is also related to another strand of literature on information sales. Fishman and Hagerty (1995), Sabino (1993) and Shin (1993) show that agents possessing information have incentives to sell their information to other traders who can independently trade on it. However, these models cannot be interpreted as models of disclosure as they require the person obtaining the information to, in fact, pay a price equal to the profits they can make on the information.

[3]On the other hand, Naik, Neuberger and Viswanathan (1996) study the welfare effects of trade disclosure.

[4]The intuition of reducing the profits on entry is not very different from the well known entry deterence models in the industrial organization literature.

The rest of the paper is organized as follows: the next section lays out the model. Section 3 analyzes the manager's optimal disclosure decision. Section 4 examines the welfare of the non-strategic shareholders under different restrictions of the manager's strategy. Section 5 models a similar problem for a well-informed outside investor who also has an option to sell the information. The last section concludes the paper.

2 The Model

Consider a five-date world. The fundamental (full information) value of a company's stock at the end of the game ($t = 4$) is given by $\tilde{\eta}$. This value is composed of two components: the value of existing assets (i.e., asset component) and the present value of growth opportunities (i.e., growth component). We denote the innovation from the ex ante expectation of the asset component as $\tilde{\alpha}$ and that of the growth component as $\tilde{\gamma}$. Specifically,

$$\tilde{\eta} \;=\; \tilde{\alpha} + \tilde{\gamma}. \tag{1}$$

$\tilde{\alpha}$ and $\tilde{\gamma}$ are mutually independent and normally distributed with mean 0.[5] The variance of $\tilde{\alpha}$ is given by σ_α^2. The variance of $\tilde{\gamma}$ is a random variable that can take two values — it is equal to ${\sigma_\gamma^l}^2$ with probability q and ${\sigma_\gamma^h}^2$ with probability $1-q$. The exact variance of $\tilde{\gamma}$ is realized at time 1 and is assumed to be common knowledge.

There are sufficiently large number of market analyst who are able to ascertain the innovation in the asset component at time 2 if they incur the acquisition cost C at time 0. We assume that the nature of the growth component is such that these outsiders are unable to obtain superior information about its innovation. The manager is assumed to be able to observe the specific innovations of both the asset as well as the growth components costlessly.[6]

The manager has the option of disclosing information at time 2 before trading occurs. However, we assume, that if the manager wants to disclose she has to inform the market at time 1 that an information event will occur at time 2. Specifically we assume that the manager has to declare the disclosure policy of the firm at time 1 after the variance of $\tilde{\gamma}$ is publicly known but before $\tilde{\alpha}$ and $\tilde{\gamma}$ are realized.

We model the choice of disclosure policy as a garbled declaration of the manager's infor-

[5] We assume a zero mean for simplification purposes. All our results go through if the random variables, instead, have a positive mean.

[6] The results do not change even if the manager has to incur a positive cost to acquire information on the asset component as long as the cost is less than C

mation. Thus, the manager commits to declare $\tilde{s}$ a noisy transformation of her signal.[7] The manager has access to the random variables $\tilde{\mu}$ and $\tilde{\omega}$, which can be used for garbling the signal before disclosing it to the market participants. $\tilde{\mu}$ and $\tilde{\omega}$ are mutually independent and normally distributed with zero mean and variances ${\sigma_\mu}^2$ and ${\sigma_\omega}^2$ respectively. The manager choice of disclosure policy entails choosing ${\sigma_\mu}^2$ and ${\sigma_\omega}^2$ and declaring the following signals:

$$\tilde{s}_\gamma = \tilde{\gamma} + \tilde{\mu}, \tag{2}$$

$$\tilde{s}_\alpha = \tilde{\alpha} + \tilde{\omega}. \tag{3}$$

Note that this structure is without loss of any generality. The manager can choose to fully disclose the information by allowing the variance of $\tilde{\mu}$ and/or $\tilde{\omega}$ to be zero. Similarly, the manager can choose no disclosure by allowing the above variances to be infinite.

In addition to the analysts and the manager, there also exist liquidity traders who trade for reasons exogenous to the model, and competitive market makers[8] who set prices that give them zero expected profits conditional on their information. The liquidity trader's demand, which gets aggregated with the demand by the informed traders, is $\tilde{u}$. The random variables $\tilde{u}$ is independent of all other random variables and is normally distributed with mean 0 and variance ${\sigma_u}^2$. The properties of the random variables and the number of analysts incurring information acquisition cost and getting informed are common knowledge and everyone in the model is risk-neutral.

The sequence of events is as follows (see figure 1): At $t = 0$, N market analysts spend information acquisition cost C. At time $t = 1$, ${\sigma_\gamma}^2$ is publicly known and everyone in the model gets to know the manager's choice of disclosure regime. At $t = 2$, the manager and the analysts who had incurred the information acquisition cost at $t = 0$ observe their respective signals. At this time, the manager discloses information according to the pre-announced policy and the price functionals set by the market makers become common knowledge. At $t = 3$, the manager and the analysts place market orders, and the orders of these informed traders get aggregated with the realized liquidity demand. The market makers observe the total demand, set prices that give them zero expected profits, and internalize the order imbalance. At the end of the game at time $t = 4$, the true payoff is realized, and the price is equal to the

[7] This method of disclosing information is similar to the one generally modeled in the literature. See, for example, Admati and Pfleiderer (1986) and Bushman and Indjejikian (1995). The specific methodology used to commit to a disclosure regime is left unmodeled. What we have in mind are the long-term choices made by managers to obtain a reputation for informative disclosures. In such a setting, no disclosures might have a serious enough price impact that, in fact, disclosure becomes optimal. The major difference with the earlier literature is that here the manager will optimally choose either full disclosure or no disclosure, a policy which is ex post verifiable.

[8] Although we do not explicitly model the game among market makers that guarantees zero profits for them, it can be thought of as a Bertrand competition of commitment to a price schedule before the start of the game.

0 N analysts incur acquisition cost C.

1 σ_γ^2 (variance of growth component) is realized.
Manager declares the disclosure policy.

2 Manager and analysts learn the realization of α and γ.
Manager discloses as per the declared policy.
Market makers declare the price functionals.

3 Trading occurs.

4 Realization of α and γ become common knowledge.

Figure 1: Timeline

realization of $\tilde{\eta}$ given by equation (1).

To complete the description of the model we need to specify an objective function for the manager. Various papers have identified the costs and advantages of disclosure to firms. Presumably, the manager's choice of disclosure policy will affect the cost of capital, the clientele of shareholders, the number of informed traders, the trading profit, etc. In this paper, the focus is on a rather simple objective function for the manager. The manager's objective function is assumed to maximize the ex ante profits that she can make before the information is made public.

The Bayesian Nash equilibrium consists of (1) a disclosure policy and a trading strategy for the manager that maximize expected profits when the price functional is taken as given; (2) information acquisition decision, and trading strategies for the analysts that maximize their expected profits when the price functional and trading strategies of other traders are taken as given; and (3) a price functional for the market makers such that they obtain a zero expected profit for every realization. The equilibrium trading strategies and the pricing functional of this game follows from the analysis in Kyle (1985) and Admati and Pfleiderer (1988a). Specifically, in equilibrium,[9] the market makers set the price at $t = 2$ equal to the expected value conditional on the aggregate net trading order $\tilde{y}$, and $\tilde{s}_\alpha$ and $\tilde{s}_\gamma$. Using the

[9]We follow the literature in this area and solve for the unique linear equilibrium. This does not preclude the existence of other non linear equilibria.

linearity of the conditional expectation of normal variables, we define the price at $t = 2$ as:

$$P = E[\tilde{\eta}|\tilde{s}_\alpha, \tilde{s}_\gamma, \tilde{y}]$$

3 Optimal Choice of Disclosure

In this section, we analyze the manager's incentive to disclose information to the market given the number of analysts who spend the information acquisition cost, and the realization of ${\sigma_\gamma}^2$. It is the cost of acquiring information which limits the number of analysts getting informed. We analyze the game backwards. The next proposition presents the equilibrium profits from trading at $t = 3$ for a given disclosure policy and a given number of informed analysts.

Proposition 1 *If the manager discloses information by announcing signals ($\tilde{s}_\alpha$, $\tilde{s}_\gamma$) given by equations (2) and (3) then*

1. *The equilibrium price schedule is $P = \hat{s} + \hat{\lambda}\tilde{y}$, where*

$$\hat{s} = (1-\rho_\alpha)\,\tilde{s}_\alpha + (1-\rho_\gamma)\,\tilde{s}_\gamma, \qquad \hat{\lambda} = \frac{1}{\sigma_u}\sqrt{\frac{\rho_\gamma\sigma_\gamma^2}{4} + \frac{(N+1)}{(N+2)^2}\rho_\alpha\sigma_\alpha^2};$$

$$\rho_\alpha = \frac{{\sigma_\omega}^2}{{\sigma_\omega}^2 + {\sigma_\alpha}^2} = \frac{Var(\tilde{\alpha}|\tilde{\alpha}+\tilde{\omega})}{\sigma_\alpha^2}, \qquad \rho_\gamma = \frac{{\sigma_\mu}^2}{{\sigma_\mu}^2 + {\sigma_\gamma}^2} = \frac{Var(\tilde{\gamma}|\tilde{\gamma}+\tilde{\mu}))}{\sigma_\gamma^2}.$$

2. *Each analyst's expected trading profit is,*

$$\Pi_a({\sigma_\alpha}^2, {\sigma_\gamma}^2, {\sigma_\omega}^2, {\sigma_\mu}^2) = \frac{1}{\hat{\lambda}}\frac{\rho_\alpha\sigma_\alpha^2}{(N+2)^2};$$

3. *The manager's expected trading profit is,*

$$\Pi_c({\sigma_\alpha}^2, {\sigma_\gamma}^2, {\sigma_\omega}^2, {\sigma_\mu}^2) = \frac{1}{\hat{\lambda}}\left[\frac{\rho_\gamma\sigma_\gamma^2}{4} + \frac{\rho_\alpha\sigma_\alpha^2}{(N+2)^2}\right] = \frac{\rho_\gamma\sigma_\gamma^2}{4\hat{\lambda}} + \Pi_a({\sigma_\alpha}^2, {\sigma_\gamma}^2, {\sigma_\omega}^2, {\sigma_\mu}^2);$$

In Proposition 1, we show that the impact of disclosure on the manager's expected profits can be proxied by the equivalent reduction in the variance of the disclosed component. It, thus, greatly simplifies our analysis. For example, $\rho = 0$ makes the variance of a specific component vanish and is equivalent to full disclosure in our model. Similarly, $\rho = 1$ leaves the variance unchanged and is equivalent to no disclosure. A commitment to disclose effectively reduces the conditional variance of the innovations in the asset and the growth component and, thus, the asymmetry between the informed traders and the market. The next corollary formalizes the above intuition. Thus, the original problem of disclosing information can be transformed to the one in which the manager chooses a fraction of the asset component's variance and the growth component's variance.

Corollary 1 *A setting in which the equilibrium entails the manager disclosing information on component $i \in \{\alpha, \gamma\}$ is strategically equivalent to a setting in which there is no disclosure and the manager instead chooses ex ante the variance of component i to be $\rho_i \sigma_i^2$ where $\rho_i \in [0,1]$.*

Intuitively, the manager's profit is due to the superiority of the manager's information relative to that of the market. By (partially) disclosing information, the manager effectively reduces this informational superiority. Specifically, a setting in which the manager discloses a noisy signal on the growth component such that the conditional variance of the growth component (conditioned on the disclosure) goes down from ${\sigma_\gamma}^2$ to (say) $\hat{\sigma}^2$, is isomorphic to a setting in which the variance of the growth component is $\hat{\sigma}^2$ and the manager chooses not to disclose.

It is interesting to note that the expected profits of the manager are simply the sum of the expected profits of the analyst and the expected profits made on trading on the growth component. This is due to the assumed additive structure of the random variables. The manager shares the asset component information with the analysts and also has to compete with them to make profits on that component. Even though the manager is a monopolistic owner of information on the growth component, the trading profits on that component are also affected by the presence of analysts. This is due to the linkage inherent in the price functional. A higher number of analysts reduces the slope of the price function λ and, thus, increases the expected profit of the manager from the growth component. This potential increase in profit can motivate the manager to disclose information on the asset component.

Given the trading profits that the manager can make at $t = 3$, the next proposition analyzes the managers disclosure decision at $t = 2$.

Proposition 2 *1. The manager will never choose disclose the growth component ($\tilde{\gamma}$), that is, the optimal choice of ρ_γ is always 1.*

2. The manager chooses to fully disclose the asset component (i.e. $\rho_\alpha = 0$) if,

$$\frac{{\sigma_\alpha}^2}{{\sigma_\gamma}^2} < \frac{(N+2)^2(N-1)}{4}. \tag{4}$$

otherwise, no information on asset information is disclosed at all (i.e. $\rho_\alpha = 1$).

The manager has monopolistic access to the growth component and will lose the informational advantage by disclosing it to the market. In fact, it not only improves the information of the market maker but also the informativeness of the competing analysts. The net effect of the growth component's disclosure is a reduction in the manager's profit on two accounts. First, it reduces the profits of the informed traders as a group. Second, it reduces the fraction of that profit obtained by the manager. Clearly, both factors make disclosure of the growth component by the manager sub-optimal.

The same intuition does not apply to the case of the asset component. The potential gain by disclosure comes from reducing the amount of adverse selection for the market maker. The manager's trading profit is made up of two components: the expected profit from the growth component information and the expected profit from the asset component information. Disclosure of the asset component information effectively reduces the conditional variance of the asset component, which reduces the expected profits obtained from this component. However, this decrease is accompanied by a decrease in the slope of the price function, which increases the expected profit from the growth component. The manager shares the profit reduction from the asset component with the analysts and obtains *all* the increased profits in the growth component. The relative weight of these two components of the manager's trading profit determines the optimal disclosure policy.

The relative weight of the manager's profit from the two components is a function of the variances of the two components and the number of analysts. Given the variance of growth component, as the variance of the asset component increases, the manager's profit from the asset component goes up and that from the growth component goes down. Consequently, the manager's total expected profits are initially decreasing and then increasing in variance of the asset component. If condition given in equation (4) is satisfied with equality given the variance of growth component and the number of analysts, then the expected profit is same as that with full disclosure. This defines the threshold ${\sigma_\alpha}^2$. Thus, for all ${\sigma_\alpha}^2$ less the threshold, the manager is better off by effectively making ${\sigma_\alpha}^2 = 0$. This is accomplished by disclosing the realization of α to the market. On the other hand, if ${\sigma_\alpha}^2$ is greater than the threshold, the manager's profit actually decreases by disclosing and the optimal ρ_α=1.

A special case that is easy to see is one where ${\sigma_\gamma}^2$ is zero. In this case both the analysts and the manager have exactly the same information. In this case, disclosure is never optimal (equation (4)). Thus, disclosure would seem more likely for firms in which the informational differential between the analysts and the manager is potentially high. We believe small firms and start-ups are more likely to have such informational differentials than well established firms.

Voluntary disclosure in our model is not driven by any of the following reasons:[10] (1) legal threats; (2) improved investment efficiencies; (3) reduction in wasteful information gathering; (4) improved risk sharing; (5) a desire to manipulate the market; (6) assumed egalitarian motives; (7) a desire to preempt information gathering by other investors; etc. It is instead driven by the desire of a profit-seeking manager to reduce competition. We refer to this as donation of information in spite of the motives of the manager because no direct payment is obtained from disclosing this information.[11] It is an interesting contrast with the standard intuition where agents are willing to expend resources to get superior information. Here the manager benefits from full disclosure and, thus, might even expend resources to disseminate information.

This result highlights the importance of informational privacy. The manager had two options. First, to fully retain the informational advantage by not disclosing. Second, to disclose the component of information that is shared with the analysts and retain a smaller informational advantage vis-a-vis the market, all of which is private. If condition given in equation (4) is satisfied then the manager benefits from choosing the later option. By disclosing, the manager enhances the value of the private or unshared information by giving up the informational advantage on the shared component. Indeed, a small amount of private information can, in fact, be more useful than having a much larger amount of partially shared information.

Proposition 2 has identified the sufficient condition for information disclosure by the manager. The next numerical example illustrates the likelihood of disclosure. The right-hand side of the inequality (4) is plotted in the following graph for a given level of N. As N increases, disclosure is optimal even when the variance of growth component is an extremely small fraction of the asset component. For example, for a relatively small N, say 5, disclosure is optimal as long as the variance of the asset component is *less than 49 times* the variance of the growth component. Thus, even for a relatively small amount of private information, the manager finds it optimal to publicly disclose the shared information and, thus, undermine the information possessed by the analysts.

(Insert Figure 2 about here)

[10] Some of these reasons have been discussed in the literature

[11] This is in contrast to papers on information sales, in which the manager obtains the profit earned by the person receiving information. We will return to this issue in section 5.

Given the trading strategy in Proposition 1 and the manager's choice of a disclosure regime in Proposition 2, we are now in a position to derive the number of analysts who will spend the acquisition cost at $t = 0$. Note that the manager's choice of disclosure regime is a function of both the realization of ${\sigma_\gamma}^2$ and the number of analysts having information on the asset component. Thus, the number of analysts will in turn depend on the likelihood of the ${\sigma_\gamma^h}^2$.

We denote the ex ante expected trading profit earned by each of the N analysts acquiring costly information at $t = 0$ by $\hat{\Pi}_a(N)$. For analyzing the information acquisition decision of the analysts we define N^* and N^{**} as the number of analysts that satisfy the following two equations.

$$\begin{aligned} \frac{{\sigma_\alpha}^2}{{\sigma_\gamma^h}^2} &= \frac{(N^*+2)^2(N^*-1)}{4} \\ \frac{{\sigma_\alpha}^2}{{\sigma_\gamma^l}^2} &= \frac{(N^{**}+2)^2(N^{**}-1)}{4} \end{aligned} \tag{5}$$

For $N = N^*$ the manager is indifferent between the disclosure and the no-disclosure regimes if the variance of the growth component is σ_γ^h, and the manager is strictly better-off not disclosing if σ_γ^l is realized. For simplicity we assume that the manager will not disclose in case he is indifferent. Thus, it is optimal for the manager not to disclose any information irrespective of the realization of ${\sigma_\gamma}^2$ for $N \leq N^*$. The expected trading profits for the analysts in this case are given by,

$$\hat{\Pi}_a(N) = \Pi_a^{nd}(N) \equiv q \frac{\frac{{\sigma_\alpha}^2}{(N+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^l}}^2}{4} + \frac{(N+1){\sigma_\alpha}^2}{(N+2)^2}}} + (1-q) \frac{\frac{{\sigma_\alpha}^2}{(N+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^h}}^2}{4} + \frac{(N+1){\sigma_\alpha}^2}{(N+2)^2}}} \qquad \text{for } N \leq N^* \tag{6}$$

Similarly, for $N = N^{**}$ the manager is indifferent between disclosure and no-disclosure if σ_γ^l is realized, and is strictly better-off by disclosing the information on asset component if σ_γ^h is realized. Thus, for $N > N^{**}$ the optimal strategy of the manager is to disclose irrespective of the realization of ${\sigma_\alpha}^2$ and the will earn zero trading profit even if they acquire costly information. The upper bound on the number of analysts in equilibrium is therefore N^{**}.

The case when N is such that $N^* < N \leq N^{**}$ is the most interesting. The manager finds it optimal to fully disclose information on the asset component if ${\sigma_\gamma^h}^2$ is realized. On the other hand the manager chooses the no-disclosure regime if ${\sigma_\gamma^l}^2$ is realized. Therefore, the ex ante expected trading profits of the analysts who acquire information are given by,

$$\hat{\Pi}_a(N) = \Pi_a^{d}(N) \equiv q \frac{\frac{{\sigma_\alpha}^2}{(N+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^l}}^2}{4} + \frac{(N+1){\sigma_\alpha}^2}{(N+2)^2}}} \qquad \text{for } N^* < N \leq N^{**} \tag{7}$$

The number of analysts who incur information acquisition cost of C at $t = 0$ is denoted by $\hat{N}$. Clearly, for $C > \Pi_a^{nd}(1)$, the analysts cannot recover their information acquisition cost and $\hat{N} = 0$. However, for $C \leq \Pi_a^{nd}(1)$, $\hat{N}$ is determined by the following:

$$\hat{N} = sup\{N : \hat{\Pi}_a(N) \geq C \quad \text{AND} \quad N \geq 1\} \tag{8}$$

The next proposition characterizes the number of analysts as a function of the information acquisition costs and is presented without proof.[12]

Proposition 3 *The equilibrium is as follows:*

1. *The number of analysts, N^*, satisfy:*

$$\begin{cases} C > \Pi_a^{nd}(1) & \hat{N} = 0 \\ \Pi_a^{nd}(1) \geq C > \Pi_a^{nd}(N^*) & \hat{N}* \textit{ satisfies } \Pi_a^{nd}(\hat{N}) = C \\ \Pi_a^{nd}(N^*) \geq C \geq \Pi_a^{d}(N^*) & \hat{N} = N^* \\ \Pi_a^{d}(N^*) > C > \Pi_a^{d}(N^{**}) & \hat{N} \textit{ satisfies } \Pi_a^{d}(\hat{N}) = C \\ \Pi_a^{d}(N^{**}) \geq C & \hat{N} = N^{**} \end{cases} \tag{9}$$

2. *For $C < \Pi_a^d(N^*)$ the manager fully discloses the asset component only if ${\sigma_\gamma^h}^2$ is realized. For $C \geq \Pi_a^d(N^*)$ the manager never discloses her information.*

3. *The market makers set price as per Proposition 1.*

Figure 3 illustrate the determination of equilibrium number analysts and the probability of disclosure. For $C > \Pi_a^{nd}(1)$, none of the market analysts find it optimal to acquire information on asset component and therefore, corporate manager does not disclose any information. Even for a lower level of information acquisition cost such that $\Pi_a^{nd}(1) \geq C \geq \Pi_a^d(N^*)$, the corporate manager does not find it optimal to disclose any information irrespective of the realization of ${\sigma_\gamma}^2$. Notice that the number of analysts is decreasing in the information acquisition cost in this region. However, a further decrease in the information acquisition cost is not accompanied by an increase in the number of informed analysts. For $\Pi_a^{nd}(N^*) \geq C \geq \Pi_a^d(N^*)$, the threat of disclosure by the manager will limit the number of analysts at N^*. In this region the informed analysts are expected to earn positive gain net of information acquisition cost. Thus, for $C \geq \Pi_a^d(N^*)$, the probability of disclosure is 0. On the other hand, if the information acquisition cost is less than $\Pi_a^d(N^*)$, the probability of disclosure is $1-q$. This is because now the manager finds it optimal to disclose information if ${\sigma_\gamma^h}^2$ is realized. Again the number of analysts are

[12]For the simplicity of analysis, we essentially ignore the integer problem.

decreasing in the information acquisition cost in this region. Since corporate manager finds it optimal to fully disclose the information on asset component for any realization of ${\sigma_\gamma}^2$ for $N > N^{**}$, the equilibrium number of analysts who acquire costly information on asset component still remains at N^{**} even if C goes down below $\Pi_a^d(N^{**})$.

(Insert Figure 3 about here)

In a related paper, Bushman and Indjejikian (1995)(BI hereafter) also derive conditions for the manager to disclose information to the market. In BI the manager discloses information *before* the analysts make a choice on information acquisition. Thus, the manager's disclosure decision reduces the potential profits that can be made by the analysts and acts as an entry deterrent. In the current paper, the manager discloses *after* the analysts have incurred the information acquisition cost. Entry for the analysts is costless after the disclosure and, thus, disclosure is not a means of entry deterence. Disclosure in this paper increases the privacy of the manager's information and allows her to make more net profit.

The impact of the information acquisition cost on the disclosure decision clarifies the difference of the disclosure result in this paper from that obtained in BI. In their paper, as the information acquisition cost gets sufficiently low, the effect of the manager's disclosure on the entry decision is substantially weakened. For example, for a zero information acquisition cost there will be no disclosure by the manager. On the other hand, in the current paper a reduction in the acquisition cost increases the potential number of analysts and, thus, increases the advantage of disclosure to the manager. In the case of a zero information cost, the probability of disclosure in fact does not fall (see Proposition 3).[13]

Another difference of this paper with Bushman and Indjejikian (1995) lies in the impact of the manager's informational superiority on the disclosure decision. In BI the condition for corporate manager to publicly disclose part of her information is that she does not have a large information advantage against analysts. In this paper, the manager finds it optimal to fully disclose the information on asset component if $\frac{\sigma_\alpha^2}{\sigma_\gamma^2}$ is sufficiently low. A low $\frac{\sigma_\alpha^2}{\sigma_\gamma^2}$ implies that corporate manager commands a greater information advantage against analysts, which drives the corporate manager to the full disclosure of the information on asset component.

In this section we have shown that the manager might find it optimal to disclose private information to the market instead of trading on it. The impact of this disclosure on the shareholders of the firm is not clear. We turn to this question next.

[13]For tractability, we have assumed that σ_γ^2 can only take two values and σ_α^2 is fixed. Similar results can be obtained even if we allow multiple values for σ_γ^2 and/or make σ_α^2 stochastic.

4 Welfare Effects of Disclosure Policy

Previous sections in the paper have assumed the shareholders of the firm as passive. However, if they have a choice, they might benefit from regulating the manager's participation in the market. In this section, we examine the welfare effects of regulating the manager's trading given her ability/inability to disclose. We compare the welfare of shareholders in two cases: (i) when the manager lacks the ability to donate her information; and (ii) when the manager is able to credibly disclose her information.

Voluntary disclosure by the manager clearly benefits the manager and reduces the profits for the analysts. To analyze the net effect on the non-strategic traders examine the following equation derived from Proposition 1.[14]

$$\frac{1}{\lambda}\left[\frac{\sigma_\gamma^2}{4} + \frac{(N+1)}{(N+2)^2}\rho_\alpha\sigma_\alpha^2\right] = \lambda\sigma_u^2. \tag{10}$$

The left-hand side of equation (10) is equal to the combined expected profits earned by the manager and the N analysts. Given that the market maker earns zero expected profits, it is also equal to the expected losses incurred by the non-strategic traders. Thus, for a given ${\sigma_u}^2$, the equilibrium λ is a measure of the expected losses incurred by the non-strategic shareholders. An increase in the number of analysts intensifies the competition amongst them and thereby reduces λ benefiting the non-strategic shareholders. Full disclosure of the asset component by setting $\rho_\alpha = 0$ similarly benefits the non-strategic shareholders as it is equivalent to having an infinite number of analysts. Thus, disclosure not only benefits the manager as it deprives the analysts from trading on their information, and enables the manager to earn higher profits on the growth component, it also reduces the welfare loss incurred by non-strategic shareholders.

Even though the ability of the manager to credibly disclose information benefits the non-strategic shareholders, the impact of the manager's trading activity on the non-strategic shareholders wealth is less clear. That is the issue we turn to next.

Suppose the shareholders have the ability of regulating the manager's trade.[15] We assume that if the manager is not allowed to trade on his own account then she would have no incentive to collect information and disclose it to the market.[16] The next proposition shows that the

[14] We have used the fact from Proposition 2, that the manager does not disclose any information on the growth component, *i.e.*, $\rho_\gamma = 1$.

[15] The implementation of such a policy is not modeled in the current paper. Shin (1996) shows that even if the manager's insider trading cannot be monitored perfectly, as far as the penalty imposed on the manager caught for insider trading is sufficiently large, insider trading can be effectively banned.

[16] This assumption can be easily justified if the manager has a positive cost to acquire information. The

manager's trading activity can be beneficial to the shareholders only if she has the ability to credibly disclose her information.

Proposition 4 *Allowing the manager to trade on her account:*

1. *is welfare reducing for the non-strategic shareholders if the manager does not have the ability to credibly disclose information.*
2. *can be welfare improving for the shareholders if the managers has the ability to credibly disclose information.*

To gain intuition for the above proposition, first consider the case where the manager is unable to disclose information. Restricting the manager from trading benefits the non-strategic shareholders in following two ways. First, as the manager is removed from the trading process, analysts faces less competition in their trading on asset component, and more analysts acquire costly information on asset component. Thus, adverse selection in the asset component is reduced. Second, removal of the manager completely eliminates the adverse selection on the growth component, which also benefits the non-strategic shareholders.

In the case where the manager has the ability to credibly disclose, allowing her to trade might eliminate the adverse selection in asset component. However, allowing the manager to trade allows for adverse selection in the growth component. Proposition 4 shows that if ${\sigma_\gamma^h}^2$ is small enough then the first effect dominates the second. In this case allowing the manager to trade is welfare enhancing for the shareholders.

This section has analyzed the welfare effect of regulating the manager's trading on the non-strategic shareholders. It has been shown that the ability of the manager to disclose is critical for the non-strategic shareholders to benefit from the manager's participation in the market. The conclusion is simple: if the manager lacks the ability to credibly disclose then she should be barred from trading on her own account.

5 To Sell or Donate Information

The previous sections have concentrated on the case where the manager is endowed with superior information. The manager's choice set is limited to trading on all the information

results in previous section do not change if the information acquisition cost for the manager is sufficiently low that it is always optimal for him to acquire information regardless of the number of analysts.

or disclosing some information and trading on the rest. There is nothing in the analysis that restricts the individual with the superior information to be the firm's manager. In fact, if there exist outsiders with superior information their incentives are similar to the manager. An outsider also has a strategy that is not available to the manager. The outsider can sell the information instead of donating it. We refer to a sale of information as any case in which the end user gets to observe the information before acting on it, for example, an investment newsletter. The question is simple: can the donation of information ever be optimal in a setting in which a sale of information is possible? We analyze this question holding the number of analysts in the acquiring information fixed.[17] We focus on the case in which σ_α^l is realized and, thus, donation of information would have taken place.

The issue of the selling information in the context of financial markets has been analyzed by Admati and Pfleiderer (1986, 1988b). Admati and Pfleiderer (1986) show that in a competitive rational expectations set-up, the optimal way to sell information is to make it coarser by means of adding personalized noise to the information. This prevents full revelation of information by the market price in the rational expectations equilibrium and, thus, preserves the value of private information. Admati and Pfleiderer (1988b) show that it may be optimal for a monopolistic risk averse information possessor to sell the information in order to achieve better risk sharing. In related work Fishman and Hagerty (1995), Sabino (1993), and Shin (1993) have also provided essentially similar models in which sale of information is an equilibrium outcome. In these models, the sale of information by an informed trader, who already faces competition, results in even more competition in the financial market. This reduces the profits of the informed traders as a group. However, the seller of information is able to capture a larger fraction of the profits.[18] As a result, although the reduction in overall profits might be substantial, the individual seller of information does not bear the full cost of the reduction in overall profits.

We specifically assume that there exists a sophisticated outsider who has perfect information on both the asset and the growth components. There also exist analysts who possess information on the asset component. The sophisticated outsider has an option to trade on the information, sell it or donate it. If information is sold, we assume that it is done without adding any noise. Thus, the veracity of the information can be verified ex post. A seller of information obtains a price of $\beta\pi_b$, where π_b is the expected trading profit earned by each client and β is the result of an unmodeled bargaining game. Other aspects of the model

[17]Endogenously solving for the number of analysts given the sale of information strategy adds considerably to the complexity without providing any major insight.

[18]These papers assume that all the expected profits obtained by the buyers of information are extracted by the seller up-front.

remain the same.

As the sophisticated outsider is a monopolistic owner of information on the growth component, it is easy to show that there is no benefit from donating or selling that component. Thus, we focus on the sale or donation of the information on the *asset* component.

Proposition 5 *Suppose there is a single sophisticated outsider who can sell his information.*

1. *The total profit when the information on the asset component is sold to K clients is:*

$$\Pi_s = \frac{\frac{\sigma_\gamma^2}{4}}{\lambda_s} + \frac{\frac{\sigma_\alpha{}^2}{(N+K+2)^2}}{\lambda_s} + \frac{\beta K \frac{\sigma_\alpha{}^2}{(N+K+2)^2}}{\lambda_s} \quad \textit{where} \quad \lambda_s = \frac{1}{\sigma_u}\sqrt{\frac{\sigma_\gamma^2}{4} + \frac{(N+K+1)\sigma_\alpha{}^2}{(N+K+2)^2}}. \tag{11}$$

2. *The donation of information obtains higher expected profits for the sophisticated outsider than sale of information if $\beta < \frac{1}{2}$ and $\frac{\sigma_\gamma{}^2}{\sigma_\alpha{}^2}$ is high enough. However, if $\beta \geq \frac{1}{2}$ and $N \geq 2$, then sale of information is always superior to the donation of information.*

The first two terms of equation (11) are the sophisticated outsider's *trading profit* from the growth and the asset component, respectively. The expected trading profit earned by each client is $\pi_b = \frac{\sigma_\alpha{}^2}{\lambda_s(N+K+2)^2}$, and the last term of equation (11) is the outsider's profit from selling the information on the asset component. The outsider's problem is to determine the optimal K^*. We can also see from equation (11) that $K = \infty$ is equivalent to the full disclosure of the asset component. In that case, $\pi_b = 0$ and the seller does not earn any benefit from selling.

An informed outsider may choose to disclose or donate information to the market even though there is the option of selling it at a strictly positive price. The intuition for the result is more obvious close to the limit. For example, suppose the price that can be charged by the newsletter is bounded by a small quantity (i.e. β is small). In this case, most of the expected profit from sales is retained by the buyers of information. An increase in the number of buyers reduces the profits from the asset component, but due to a previously explained intuition, it increases the profit in the growth component. For a small β, the increase in profits of the growth component outweighs the decrease in the asset component and, thus, full disclosure ($K^* = \infty$) is optimal.

The result in Proposition 5 can be compared to the results derived Fishman and Hagerty (1995), Sabino (1993), and Shin (1993). In these models, as there is only one component of information, it is never optimal to donate information irrespective of the size of β. Their models can, thus, be regarded as special cases of the model presented here, with $\sigma_\gamma^2 = 0$ and

$\beta = 1$. Although, these papers do not discuss the issue, a reduction in β will make information sales sub optimal in their models. Thus, for a low β, the informed trader's strategy is reduced to just trading on the information. In our model, the trader still has a choice between trading on the information and donating the information, even for a low β.

6 Conclusion

In this paper, we have shown that the firm's disclosure decision is affected by the managerial opportunity to trade and the information structure. Thus, in a model in which there is no exogenous gains to the firm from disclosure or penalties from non disclosure, we have shown that truthful pre-trade disclosure can be an equilibrium outcome. Specifically, managers that have information over and above that possessed by the analysts, might choose to disclose truthful information to the market. This disclosure is purely due to the manager's desire to increase trading profits by reducing the total amount of adverse selection in the market.

The donation of information has been shown to be an equilibrium outcome even when sale of information is allowed. Individuals may choose to give away information instead of selling it for a positive price. This choice crucially depends on the amount of surplus that can be extracted from the buyers of information. For a low price, it is more advantageous to have a higher degree of information dissemination than earning a small amount of money from the sale of the information. Consequently, the donation of information is value maximizing.

The paper predicts that firms will disclose the variables on which an outsider is likely to have information, but not disclose those innovations that are specific to the firm. The model predicts that, ceteris paribus, the probability of disclosure is higher for firms that have a higher number of outside investors following the firm. Basically, if there are a large number of investors who possess information about the company's prospects, the more likely it is that the manager will disclose that information to the market. We believe that this new rationale for public disclosure needs to be empirically tested by examining the trades of managers *after, not before,* public disclosures.

Although the paper does not explicitly model hedging, it is easy to see that there is a parallel between disclosure and hedging. The benefit obtained by disclosing a stochastic variable can also be obtained by constructing an ex ante hedge on the same stochastic variable. For example, if the manager and the analysts both have information on firm's degree of dependence on oil prices then the manager, as modeled in this paper, has the option of disclosing this degree of dependence to the market and, thus, making the analysts information moot. However, the manager also has another credible method of obtaining the same goal. She can hedge the oil price risk and also make the analysts' information irrelevant. It is an open question, whether some of the observed attempts at risk management by firms can be attributed to reasons identified here. The model does predict that the risk that a firm will hedge is the innovation that the analysts can be expected to have superior information on and not the one that only the manager has superior information. Thus, for example, a firm might hedge the macro-economic factors and not the production uncertainties on which the management has better information. Testing these predictions is left for future work.

This paper also provides some guidance for regulating the trading of managers. It shows that even though the ability to disclose benefits the manager at the cost of outside analysts, banning these activities clearly hurts the non-strategic shareholders. The paper advocates a selective regulatory policy. The welfare of non-strategic shareholders can be improved by allowing insider trading for firms whose managers have an ability and incentives to disclose information. In absence of the incentive to disclose insider trading reduces the welfare of non-strategic shareholders.

Appendix

Proof of Proposition 1: Suppose the following linear price schedule is announced by the market maker given the manager's public disclosure of $\tilde{s}_\gamma = \tilde{\gamma} + \tilde{\mu}$ and $\tilde{s}_\alpha = \tilde{\alpha} + \tilde{\omega}$:

$$E[\tilde{\alpha} + \tilde{\gamma} | \tilde{s}_\alpha, \tilde{s}_\gamma] + \lambda \tilde{y} = \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha + \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma + \lambda \tilde{y}.$$

We are going to prove that this price schedule and the trading orders specified in Proposition 1 form a Nash equilibrium.

Suppose the manager and analysts respectively have the following linear trading strategies:

$$\kappa(\tilde{\gamma} - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma) + \phi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha)$$
$$\psi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha).$$

Taking the price schedule and analysts' trading strategies as given, the manager's optimal trading strategy is derived from following maximization problem given the information of $\tilde{\alpha}$ and $\tilde{\gamma}$:

$$\max_x E[x(\tilde{\alpha} + \tilde{\gamma} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma - \lambda(x + N\psi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) + \tilde{u})) | \tilde{\alpha}, \tilde{\gamma}, \tilde{s}_\gamma, \tilde{s}_\alpha].$$

The first order condition is given by:

$$(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) + (\tilde{\gamma} - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma) - 2\lambda x - N\lambda\psi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) = 0. \tag{A.1}$$

Similarly, given information on $\tilde{\alpha}$, each analyst solves the following maximization problem taking price schedule, $\tilde{s}_\gamma$, $\tilde{s}_\alpha$ and other traders' trading strategies as given:

$$\begin{aligned} & \max_z E[z(\tilde{\alpha} + \tilde{\gamma} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma \\ - & \lambda(z + \kappa(\tilde{\gamma} - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma) + \phi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) + (N-1)\psi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) + \tilde{u})) | \tilde{\alpha}, \tilde{s}_\gamma, \tilde{s}_\alpha]. \end{aligned}$$

From $E[\tilde{\gamma} | \tilde{s}_\gamma] = \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma$ the first order condition is given by:

$$(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) - 2\lambda z - \lambda\phi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) - (N-1)\lambda\psi(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) = 0. \tag{A.2}$$

From equations (A.1) and (A.2), we can obtain $\kappa = \frac{1}{2\lambda}$ and $\phi = \psi = \frac{1}{\lambda(N+2)}$, which are derived by solving following simultaneous equations:

$$\begin{aligned} 2\lambda\phi + N\lambda\psi &= 1 \\ \lambda\phi + (N+1)\lambda\psi &= 1. \end{aligned}$$

Given price schedule, the net aggregate trading order submitted to the market maker is given in the following equation:

$$\tilde{y} = \frac{1}{2\lambda}(\tilde{\gamma} - \frac{{\sigma_\gamma}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2} \tilde{s}_\gamma) + \frac{(N+1)}{\lambda(N+2)}(\tilde{\alpha} - \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \tilde{s}_\alpha) + \tilde{u}. \tag{A.3}$$

The market maker sets the price schedule that obtains a zero expected profit for each realization of $\tilde{s}_\gamma$, $\tilde{s}_\alpha$ and $\tilde{y}$, and the price schedule satisfies the following conditional expectation:

$$\hat{s} + \lambda\tilde{y} = E[\tilde{\alpha} + \tilde{\gamma} | \tilde{s}_\gamma, \tilde{s}_\alpha, \tilde{y}]$$

where $\hat{s} = \hat{a}\tilde{s}_\gamma + \hat{b}\tilde{s}_\alpha$.

From DeGroot (1971), we can see that $\hat{a}$, $\hat{b}$ and λ can be obtained by solving simultaneous equations derived from following matrix and the solutions of κ, ϕ and ψ:

$$\begin{aligned}
\begin{pmatrix} \hat{a} \\ \hat{b} \\ \lambda \end{pmatrix} &= \begin{bmatrix} Var(\tilde{s}_\gamma) & Cov(\tilde{s}_\gamma, \tilde{s}_\alpha) & Cov(\tilde{s}_\gamma, \tilde{y}) \\ Cov(\tilde{s}_\gamma, \tilde{s}_\alpha) & Var(\tilde{s}_\alpha) & Cov(\tilde{s}_\alpha, \tilde{y}) \\ Cov(\tilde{s}_\gamma, \tilde{s}_\alpha) & Cov(\tilde{s}_\alpha, \tilde{y}) & Var(\tilde{y}) \end{bmatrix}^{-1} \begin{pmatrix} Cov(\tilde{\alpha}+\tilde{\gamma}, \tilde{s}_\gamma) \\ Cov(\tilde{\alpha}+\tilde{\gamma}, \tilde{s}_\alpha) \\ Cov(\tilde{\alpha}+\tilde{\gamma}, \tilde{y}) \end{pmatrix} \\
&= \begin{bmatrix} {\sigma_\gamma}^2 + {\sigma_\mu}^2 & 0 & 0 \\ 0 & {\sigma_\alpha}^2 + {\sigma_\omega}^2 & 0 \\ 0 & 0 & \frac{1}{4\lambda^2}\frac{{\sigma_\gamma}^2{\sigma_\mu}^2}{{\sigma_\gamma}^2+{\sigma_\mu}^2} + \frac{(N+1)^2}{(N+2)^2\lambda^2}\frac{{\sigma_\alpha}^2{\sigma_\omega}^2}{{\sigma_\alpha}^2+{\sigma_\omega}^2} + \sigma_u^2 \end{bmatrix}^{-1} X \\
&\quad \begin{pmatrix} {\sigma_\gamma}^2 \\ {\sigma_\alpha}^2 \\ \frac{1}{2\lambda}\frac{{\sigma_\gamma}^2{\sigma_\mu}^2}{{\sigma_\gamma}^2+{\sigma_\mu}^2} + \frac{(N+1)}{\lambda(N+2)}\frac{{\sigma_\alpha}^2{\sigma_\omega}^2}{{\sigma_\alpha}^2+{\sigma_\omega}^2} \end{pmatrix}.
\end{aligned}$$

By solving the simultaneous equations derived from the above equation, we have

$$\hat{s} = (1-\rho_\alpha)\tilde{s}_\alpha + (1-\rho_\gamma)\tilde{s}_\gamma \tag{A.4}$$

$$\lambda = \frac{1}{\sigma_u}\sqrt{\frac{1}{4}\rho_\gamma{\sigma_\gamma}^2 + \frac{(N+1)}{(N+2)^2}\rho_\alpha{\sigma_\alpha}^2} \tag{A.5}$$

where

$$\rho_\alpha = \frac{{\sigma_\omega}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2} \qquad \rho_\gamma = \frac{{\sigma_\mu}^2}{{\sigma_\gamma}^2 + {\sigma_\mu}^2}.$$

From $\kappa = \frac{1}{2\lambda}$, $\phi = \psi = \frac{1}{(N+2)\lambda}$, the equilibrium λ derived in equation (A.4) and the net trading order given in equation (A.3), the expected trading profit earned by each analyst denoted Π_a is given by:

$$\begin{aligned}
& E[\frac{1}{(N+2)\lambda}(\tilde{\alpha} - (1-\rho_\alpha)\tilde{s}_\alpha)(\tilde{\alpha} + \tilde{\gamma} - (1-\rho_\alpha)\tilde{s}_\alpha - (1-\rho_\gamma)\tilde{s}_\gamma - \lambda\tilde{y})] \\
= \; & \frac{1}{\lambda(N+2)^2}\rho_\alpha{\sigma_\alpha}^2 \\
= \; & \sigma_u[\frac{1}{(N+2)^2}\frac{{\sigma_\alpha}^2{\sigma_\omega}^2}{{\sigma_\alpha}^2 + {\sigma_\omega}^2}]/\sqrt{\frac{1}{4}\rho_\gamma{\sigma_\gamma}^2 + \frac{(N+1)}{(N+2)^2}\rho_\alpha{\sigma_\alpha}^2}. \qquad (A.6)
\end{aligned}$$

Similarly, the manager's expected profit denoted Π_c is given in the following equation:

$$\begin{aligned}
& E[(\frac{1}{(N+2)\lambda}(\tilde{\alpha} - (1-\rho_\alpha)\tilde{s}_\alpha) + \frac{1}{2\lambda}(\tilde{\gamma} - (1-\rho_\gamma)\tilde{s}_\gamma))(\tilde{\alpha} + \tilde{\gamma} - (1-\rho_\alpha)\tilde{s}_\alpha - (1-\rho_\gamma)\tilde{s}_\gamma - \lambda\tilde{y})] \\
= \; & \frac{1}{4\lambda}\rho_\gamma{\sigma_\gamma}^2 + \frac{1}{\lambda(N+2)^2}\rho_\alpha{\sigma_\alpha}^2 \\
= \; & \sigma_u[\frac{1}{4}\rho_\gamma{\sigma_\gamma}^2 + \frac{1}{(N+2)^2}\rho_\alpha{\sigma_\alpha}^2]/\sqrt{\frac{1}{4}\rho_\gamma{\sigma_\gamma}^2 + \frac{(N+1)}{(N+2)^2}\rho_\alpha{\sigma_\alpha}^2}. \qquad (A.7)
\end{aligned}$$

Proof of Proposition 2: Since we have

$$Var(\tilde{\alpha}|\tilde{\alpha}+\tilde{\omega}) = \frac{{\sigma_\omega}^2}{{\sigma_\alpha}^2+{\sigma_\omega}^2}{\sigma_\alpha}^2 = \rho_\alpha {\sigma_\alpha}^2 \qquad Var(\tilde{\gamma}|\tilde{\gamma}+\tilde{\mu}) == \frac{{\sigma_\mu}^2}{{\sigma_\gamma}^2+{\sigma_\mu}^2}{\sigma_\gamma}^2 = \rho_\gamma {\sigma_\gamma}^2,$$

choice of optimal disclosure policy is equivalent to the determination of optimal ρ_α and ρ_γ to maximize the corporate manager's expected trading profit.

1. From (A.7), we can see that for any σ_α^2, ρ_α and N, $\hat{\Pi}_c(\rho_\alpha,\rho_\gamma)$ always increases in ρ_γ and we obtain the result.
2. Since optimal ρ_γ is 1, we are going to show that optimal ρ_α is either 0 or 1 at $\rho_\gamma = 1$. From (A.7), we have

$$\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} = \frac{\sigma_u\sigma_\alpha^2[\frac{\sigma_\gamma^2}{4}(1-N)+\frac{N+1}{(N+2)^2}\rho_\alpha\sigma_\alpha^2]}{2(N+2)^2(\frac{\sigma_\gamma^2}{4}+\frac{(N+1)}{(N+2)^2}\rho_\alpha\sigma_\alpha^2)^{\frac{3}{2}}}. \tag{A.8}$$

From (A.8), we can see that for $N=1$, $\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} \geq 0$ and optimal ρ_α is 1. For $N \geq 2$, as ρ_α increases from zero to 1, we have three possibilities:

   (a) $\hat{\Pi}_c(\rho_\alpha,1)$ monotonically increases in ρ_α *i.e.* $\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} \geq 0$ for all $0 \leq \rho_\alpha \leq 1$.

   (b) $\hat{\Pi}_c(\rho_\alpha,1)$ monotonically decreases in ρ_α *i.e.* $\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} \leq 0$ for all $0 \leq \rho_\alpha \leq 1$.

   (c) There exists $\bar{\rho}_\alpha$ such that for $\rho_\alpha \leq \bar{\rho}_\alpha$, $\hat{\Pi}_c(\rho_\sigma,1)$ decreases in ρ_α but for $\rho_\alpha > \bar{\rho}_\alpha$, $\hat{\Pi}_c(\rho_\sigma,1)$ increases in ρ_α *i.e.* for $\rho_\alpha \leq \bar{\rho}_\alpha$, $\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} \leq 0$, but $\rho_\alpha \geq \bar{\rho}_\alpha$ $\frac{\partial\hat{\Pi}_c(\rho_\alpha,1)}{\partial\rho_\alpha} \geq 0$.

   In each of three cases, we can see that the optimal ρ_α is either zero or 1.

   From the result obtained above, we can see that full disclosure is optimal if $\hat{\Pi}_c(0,\rho_\gamma) \geq \hat{\Pi}_c(1,\rho_\gamma)$ which is equivalent to

$$\frac{\sigma_\gamma^2}{4} \geq \frac{\sigma_\alpha^2}{(N+2)^2(N-1)}. \tag{A.9}$$

   and the result follows. ∎

Proof of Proposition 4:

1. Suppose there is no restriction on the manager's trading and she cannot credibly disclose any of her private information. From Proposition 3, we can see that equilibrium number of analysts acquiring costly information, denoted N^{nd} satisfies following equation.

$$\Pi_a(N^{nd}) = q\frac{\frac{{\sigma_\alpha}^2}{(N^{nd}+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^l}}^2}{4}+\frac{(N^{nd}+1){\sigma_\alpha}^2}{(N^{nd}+2)^2}}} + (1-q)\frac{\frac{{\sigma_\alpha}^2}{(N^{nd}+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^h}}^2}{4}+\frac{(N^{nd}+1){\sigma_\alpha}^2}{(N^{nd}+2)^2}}} = C \tag{A.10}$$

   In this case, non-strategic shareholders' expected trading loss is

$$(q\hat{\lambda}^l+(1-q)\hat{\lambda}^h)\sigma_u^2 = \left(q\sqrt{\frac{{\sigma_{\gamma^l}}^2}{4}+\frac{(N^{nd}+1){\sigma_\alpha}^2}{(N^{nd}+2)^2}} + (1-q)\sqrt{\frac{{\sigma_{\gamma^h}}^2}{4}+\frac{(N^{nd}+1){\sigma_\alpha}^2}{(N^{nd}+2)^2}}\right)\sigma_u \tag{A.11}$$

Suppose the manager is removed from trading. Then, the equilibrium number of analysts acquiring information, denoted N^b satisfies following equation.

$$\Pi_a^b(N^b) = \frac{\sigma_\alpha}{\sqrt{N^b}(N^b+1)}\sigma_u = C \tag{A.12}$$

and the non-strategic shareholders' expected loss is

$$\lambda_b \sigma_u^2 = \frac{\sqrt{N^b}\sigma_\alpha}{(N^b+1)}\sigma_u \tag{A.13}$$

From equations (A.10) and (A.12), we have $\hat{\Pi}_a(N^{nd}) = \Pi_a^b(N^b) = C$, and thereby $N^{nd}+1 < N^b$ is derived. Equations (A.11) and (A.13) show that $(q\lambda_b^h + (1-q)\lambda_b^l)\sigma_u^2 < \lambda_b\sigma_u^2$ for $N^{nd}+1 < N^b$, and the result follows.

2. Suppose there is no restriction on the manager's trading and in equilibrium she fully discloses the asset component information when ${\sigma_\gamma^l}^2$ is realized. From Proposition 3, we can see that equilibrium number of analysts acquiring costly information, denoted N^d satisfies following equation.

$$\Pi_a^d(N^d) = q\frac{\frac{{\sigma_\alpha}^2}{(N^d+2)^2}\sigma_u}{\sqrt{\frac{{\sigma_{\gamma^l}}^2}{4} + \frac{(N^d+1){\sigma_\alpha}^2}{(N^d+2)^2}}} \geq C \tag{A.14}$$

From Proposition 2, N^d and ${\sigma_\gamma^h}^2$ satisfies following inequality.

$$\frac{{\sigma_\gamma^h}^2}{4} \geq \frac{{\sigma_\alpha}^2}{(N^d+2)^2(N^d-1)} \tag{A.15}$$

In this case, non-strategic shareholders' expected trading loss is

$$(q\hat{\lambda}^l + (1-q)\hat{\lambda}^h)\sigma_u^2 = ((1-q)\frac{\sigma_\gamma^h}{2} + q\sqrt{\frac{{\sigma_\gamma^l}^2}{4} + \frac{(N^d+1){\sigma_\alpha}^2}{(N^d+2)^2}})\sigma_u \tag{A.16}$$

From equations (A.12) and (A.14), we have $\Pi_a^d(N^d) \geq \Pi_a^b(N^b)$, and $N^d+1 < N^b$ is derived. That means, as the manager is removed from trading, more analysts acquire costly information than when the manager is allowed to trade, and non-strategic traders do not incur any trading loss due the manager's trading on her information on growth component. Although the number of analysts acquiring costly information decreases as the manager is allowed to trade, there is a possibility that the manager fully discloses the information on asset component and thereby non-strategic traders do not suffer any trading loss on asset component.

We present a numerical example illustrating the benefit of allowing the manager to trade. Let $\sigma_\alpha = 50$, $\sigma_{\gamma^h} = 15$, $\sigma_{\gamma^l} = 15$ $\sigma_u = 1$, $q = 0.3$ and $C = 0.8$. In this case, when the manager is allowed to trade, equilibrium number of analysts acquiring information is 5, and the manager finds it optimal to donate information when σ_γ^h is realized but she does not disclose any information when σ_γ^l is observed. Thus, the expected loss for the non-strategic shareholders is 10.44. However, if the manager is not allowed to trade then the equilibrium number of analysts is 15 and the expected loss to the shareholders in this case is 12.07. Thus, allowing the manager to trade is beneficial than removing her from trading. ∎

Proof of Proposition 5:

1. Suppose the outsider sells the information on the asset component to K clients. Then we have one outsider with information on both asset and growth components, and $K+N$ traders with private information on the asset component only. Following the proof of Proposition 2, we can obtain the equilibrium, λ_s, and expected trading profit earned by each client given in the following equation:

$$\pi_b = \frac{\frac{{\sigma_\alpha}^2}{(N+K+2)^2}}{\lambda_s}.$$

Since the price charged to the individual client is $\beta\pi_b$, the result follows.

2. By taking the derivative of Π_s with respect to K, we have

$$\frac{\partial \Pi_s}{\partial K} = \frac{{\sigma_\alpha}^2}{\sigma_u (N+K+2)^3}\left(\frac{\sigma_\gamma^2}{4} + \frac{(N+K+1){\sigma_\alpha}^2}{(N+K+2)^2}\right)^{-\frac{3}{2}}[A+B] \tag{A.17}$$

where

$$\begin{aligned} A &= \frac{\sigma_\gamma^2}{8}(K(1-2\beta) + N(2\beta+1) + 4(\beta-1)) \\ B &= \frac{{\sigma_\alpha}^2}{2(N+K+2)^2}(-\beta K^2 + K(\beta N + 2\beta - 3) + (N+1)(2\beta N + 4(\beta-1)) + N) \end{aligned} \tag{A.18}$$

and

$$\begin{aligned} \frac{\partial A}{\partial K} &= \frac{\sigma_\gamma^2}{8}(1-2\beta) \\ \frac{\partial B}{\partial K} &= \frac{{\sigma_\alpha}^2}{2(N+K+2)^2}(1-\beta(N+2))(3K+3N+2). \end{aligned} \tag{A.19}$$

For $\beta \geq \frac{1}{2}$ and $N \geq 2$, $\frac{\partial A}{\partial K} + \frac{\partial B}{\partial K} < 0$ holds for all K and from equation (A.18) we can see that $A+B > 0$ at $K=0$ and $K=1$, but as K increases, $A+B$ decreases to $-\infty$. Therefore, there exists a unique $K^* > 1$ such that $\frac{\partial \Pi_s}{\partial K}|_{K=K^*} = 0$ and $\frac{\partial^2 \Pi_s}{\partial K^2}|_{K=K^*} < 0$, and Π_s is maximized at K^*.

If Π_s increases in $K \geq 0$, i.e., $\frac{\partial \Pi_s}{\partial K} \geq 0$, then optimal K^* is $+\infty$ and donation of information is the optimal strategy that maximizes Π_s. For $\beta < \frac{1}{2}$, we can consider two possibilities.

- $\beta < \frac{1}{2}$ and $1 - \beta(N+2) > 0$

  In this case, from equation (A.19) we have $\frac{\partial A}{\partial K} > 0$ and $\frac{\partial B}{\partial K} > 0$. Thus, if $A+B > 0$ holds at $K=0$, *i.e.*,

$$\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)) + \frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N + 4(\beta-1)) + N) > 0$$

  then $\frac{\partial \Pi_s}{\partial K} \geq 0$ for all K and $K^* = +\infty$ is obtained.

- $\beta < \frac{1}{2}$ and $1 - \beta(N+2) \leq 0$

  In this case, $\frac{\partial A}{\partial K} > 0$ is still true, and the minimum of A obtained at $K=0$ is

$$\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)).$$

But $\frac{\partial B}{\partial K} \leq 0$ holds for all K, and the minimum of B is now obtained at $K = +\infty$, which is $-{\sigma_\alpha}^2\beta$. Therefore, $A + B > 0$ is satisfied for all K if following condition is satisfied.

$$\min A + \min B = \frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)) - {\sigma_\alpha}^2\beta > 0$$

By combining two cases, we now have sufficient condition for the donation of information.

(a) $\beta < \frac{1}{2}$ and

(b)

$$\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)) + \frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N + 4(\beta-1)) + N) > 0$$

and

$$\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)) - {\sigma_\alpha}^2\beta > 0.$$

Notice that $\frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N + 4(\beta-1)) + N)$ increases in N, and we have following implication.

Consider the first case of $1 - \beta(N+2) > 0$. In this case, as stated above, the sufficient condition for donation of information is $\frac{\sigma_\gamma^2}{8}(N(2\beta+1)+4(\beta-1)) + \frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N+4(\beta-1))+N) > 0$. But due to $1 - \beta(N+2) > 0$, we have $\frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N + 4(\beta-1)) + N) < 0$, and thus $\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta-1)) > 0$ must hold. Since $\frac{{\sigma_\alpha}^2}{2(N+2)^2}((N+1)(2\beta N + 4(\beta-1)) + N)$ increases in N, we can see that as N and σ_γ^2 increase but ${\sigma_\alpha}^2$ decreases it is more likely that this sufficient condition holds.

The second case is quite obvious. We can see that for $1 - \beta(N+2) < 0$, $\frac{\sigma_\gamma^2}{8}(N(2\beta+1) + 4(\beta - 1)) - {\sigma_\alpha}^2\beta > 0$ is more likely to hold for bigger N and σ_γ^2 but smaller σ_γ^2. ∎

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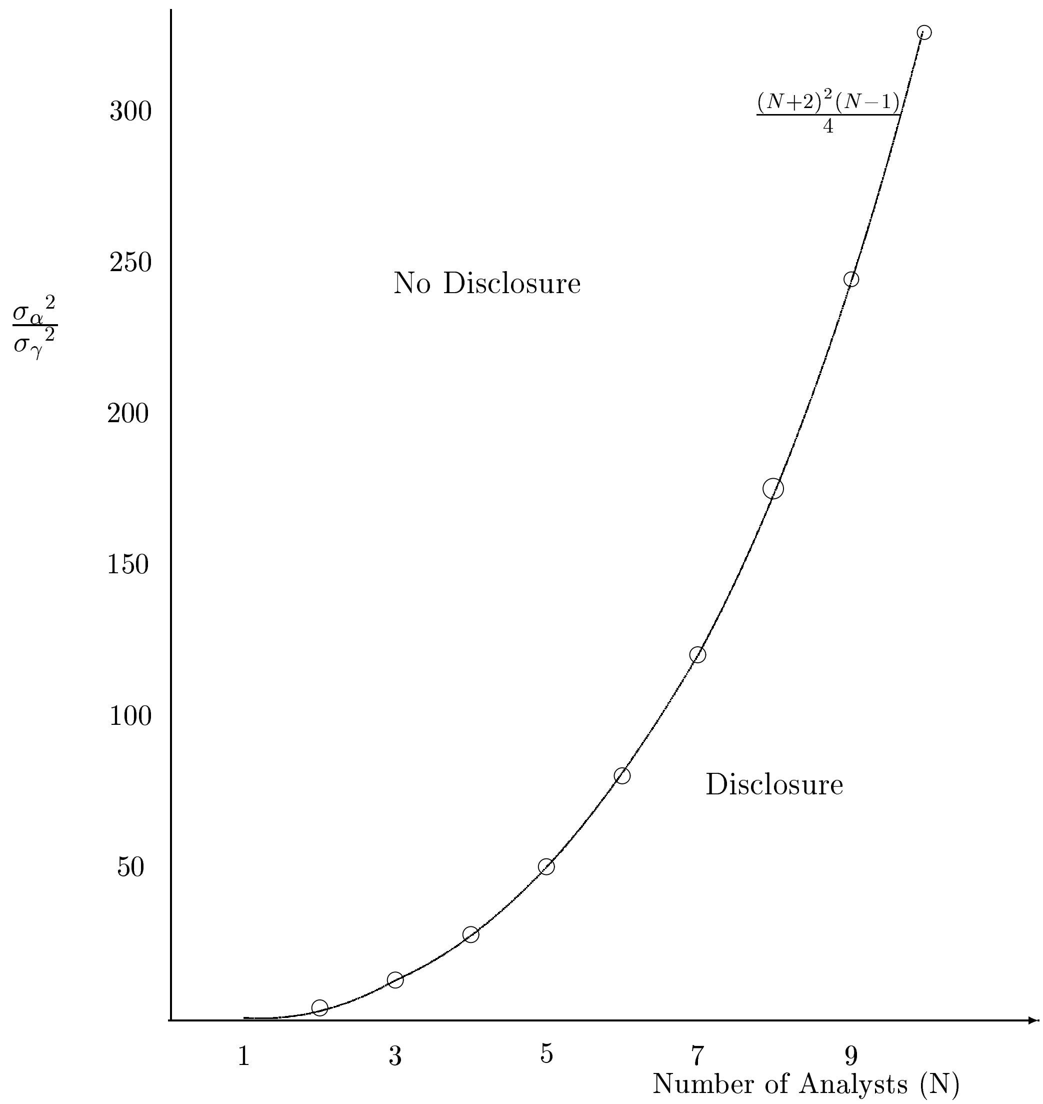
Figure 2: Condition for Disclosure to be Optimal

$\left[\text{Disclosure is optimal if } \frac{{\sigma_\alpha}^2}{{\sigma_\gamma}^2} \text{ is less than the plotted value.}\right]$



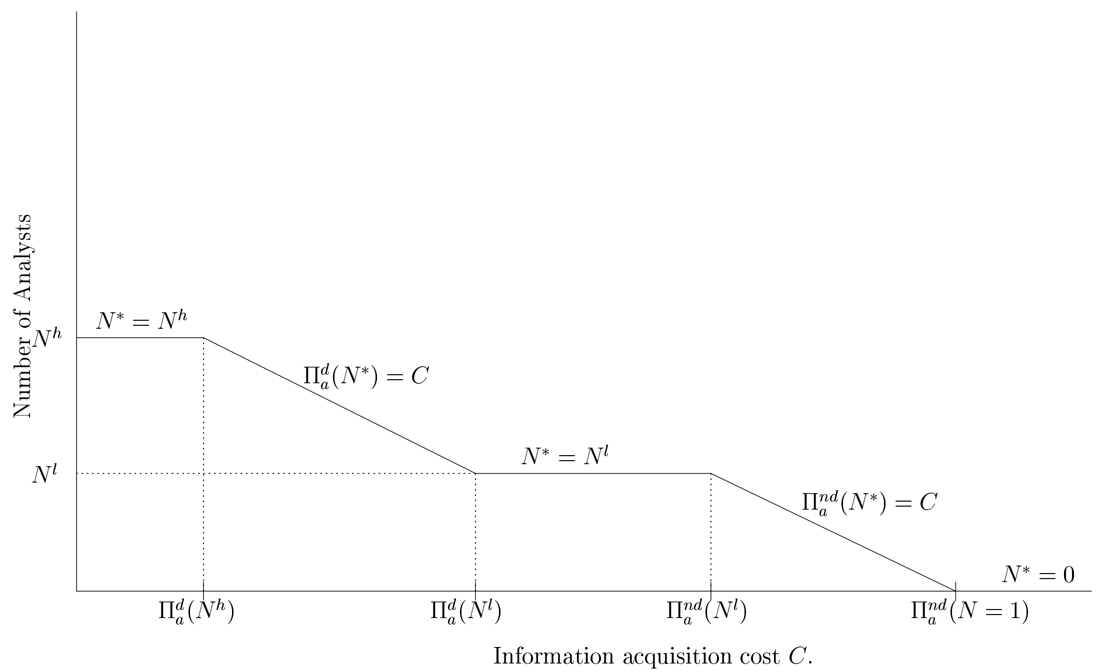


Figure 3: Equilibrium Number of Analysts