Buy-Side and Sell-Side: The Industrial Organization of Information Production in the Securities Industry

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Abstract

This paper studies how information production is allocated between buy-side and sell-side firms when identical information-producing agents can choose to be either sell-side analysts or buy-side fund managers. I find that for analysts to be in equilibrium, they must receive some form of subsidy. Without a subsidy, both the substitutive nature of the agents' information and the competition among fund managers to trade on analysts' information makes an analyst's profit lower than that of a fund manager. Tying investment banking to sell-side research enables such a subsidy. Even though this subsidy may cause a conflict-of-interest problem, a total separation of investment banking from sell-side research to solve the problem may not be a good idea, because analysts improve social welfare by enhancing the information efficiency of the financial markets. This paper also explains the existence of independent research and the fee structure in the credit rating industry.

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1 Introduction

A major function of the securities industry is investment research. Analysts produce information to identify securities whose prices do not accurately reflect their future values. The many organizations providing investment research fall mainly into two categories: buy-side and sell-side firms.[1] In general, buy-side firms are assets management firms, and sell-side firms are brokerage firms. Buy-side research (research generated by a buy-side firm) is used exclusively for the firm's trading. Sell-side research (research generated by a sell-side firm) is disseminated among the firm's clients. Buy-side firms profit from trading on both buy and sell-side research; sell-side firms profit from selling their research, bundled in most cases with brokerage and investment banking services.

This paper studies the allocation of information production between buy and sell side. In particluar, this paper attempts to answer the following questions. Why is information produced by both buy-side and sell-side firms? How is information production allocated between buy and sell side? What are the effects of this allocation on the securities prices and social welfare? How is buy-side and sell-side research used by the buy-side firms? Why is sell-side research linked to investment banking? What will happen if the research function is completely separated from investment banking? .

These questions also have important public policy implications. In 2003, New York Attorney General Elliot Spitzer, and later the Securities and Exchange Commission, accused investment bankers of pandering to corporate issuers by pressuring sell-side analysts to recommend the stocks of various Internet and telecommunications companies. Despite so-called Chinese wall restrictions at investment banks, at the center of these charges is a conflict of interest between a firm's research and investment banking divisions.[2] One tempting solution to this conflict-of-interest problem is to totally separate sell-side research from other businesses such as investment banking. Such a separation, not very difficult to implement, could eliminate the source of the conflict of interest. But is this a good idea? My analysis suggests that it may not be, however appealing the motivation. Even though it may eliminate the conflict of interest, separating sell-side research from investment banking could bring an end to sell-side research, which might diminish social welfare.

[1] There are also independent firms, whose main business is selling research, such as Sanford Bernstein and Value Line. According to Cheng, Liu and Qian (2003), 71% of research is produced by buy-side firms, 24% by sell-side firms, and 5% done by independent firms.

[2] Under the Security Act of 1933 and the Security Exchange Act of 1934, the SEC endorses the separation of the research departments from other departments in a brokerage firm.

In my model, there are a fixed number of identical risk-neutral information-producing agents who can gather information about a traded risky asset. Each agent can choose whether to be an analyst (i.e., on the sell-side) or a fund manager (i.e., on the buy-side). Fund managers produce their own information, and may buy information from the analysts. Using that information, fund managers then trade in the financial market. Analysts profit from selling information and also from other exogenous businesses, called "investment banking". Fund managers profit from trading on both buy and sell-side information. I assume that fund managers cannot sell any information, either their own or information they buy from analysts, and that analysts cannot trade in the financial market.

The main result is that, without profit from other businesses, an analyst's profit from selling information is so low compared to a fund manager's that no information-producing agent is willing to be an analyst in equilibrium. There are two factors that reduce the profit from selling information. One is competition among fund managers: Because fund managers compete in the financial markets to benefit from an analyst's information, they compete away the total trading profit generated by the analyst's information. The other is the substitutive nature of the agents information: As a fund manager has his own information, an analyst's information has relatively small marginal benefit to the fund manger's profit. As a result, an analyst can extract only a limited amount from a fund manager when selling his information. This is despite the assumption that the analyst has all the bargaining power. Without a subsidy from other businesses, these two factors make an analyst's profit so unfavorable compared to a fund manager's that an information-producing agent is always better off choosing to be a fund manager. Therefore, for analysts to be in equilibrium, some subsidy to the analysts is necessary. Tying investment banking to sell-side research enables such a subsidy. For the same reason, credit rating agencies need to charge bond issuers, rather than investors, for their rating services.

The result that the sell-side analysts need subsidies to exist depends on the substitutive nature of the sell-side information. In an extension of my model, I demonstrate that independent research firms, which operate only to sell information, can exist by providing basic and factual information, such as company news (as opposed to human analyses, such as analysts' recommendations, provided by sell-side firms). Such information would complement rather than substitute the fund managers information. As a result, an independent firm can extract enough surplus from the fund managers to exist without subsidies.

The competition among fund managers in trading on sell-side information implies that a sell-side analyst's information is impounded more into the security prices than a buy-side fund manager's. Therefore having more analysts may enhance social welfare, since more analysts may increase the information content of the security prices, thus enabling firms to finance its investments more efficiently. Even though an investment-banking subsidy might cause a conflict of interest problem, which tends to reduce social welfare, social welfare may be greater when there are some analysts than when there is none. As a result, totally separating investment banking from sell-side research might diminish social welfare because separation could mean the end of sell-side research.

The current literature does not consider how the information production is allocated between buy and sell side. Instead, much of the related literature studies different issues in information selling. Admati and Pfleiderer [(1986), (1988b), and (1990)] show that for a monopolistic information owner, selling information through a fund (i.e., selling information indirectly) is more profitable than selling it to investors who then trade in the financial markets (i.e., selling information directly) because of the competition among traders. Fishman and Hagerty (1995), however, demonstrate that selling information directly can arise when there are multiple competing informed traders despite the competition among traders. By selling his information to others, one informed trader can commit to trade more aggressively on his information, thus making a higher profit. In contrast, this paper shows that under certain conditions, selling information cannot exist without subsidies if information producing agents can choose to be either information buyers (fund managers) or information sellers (analysts). In their study of information selling by brokers, Brennan and Chordia (1991) show that charging investors brokerage commissions is a way for investors to share risk with risk-neutral brokers. Vishny (1985) studies a brokerage firm's incentive to sell information in order to increase the liquidity of the market. If liquidity traders trade more as the market becomes more liquid, and if the brokerage firm can make enough on trading commissions, it is optimal for the brokerage firm to sell information, even though doing so will devalue the information.

This paper is also related to Morris and Shin (2002). They study the welfare effects of public information when public information both conveys fundamentals information to the agents and coordinates the agents' actions. Similar to their paper, this paper also studies agents' uses of different kinds of information where there are strategic interactions between agents. But the key difference is that this paper focuses on the endogenous structure of information provision while theirs takes the structure as given.

In the rest of the paper, section 2 introduces the model. Section 3 characterizes the trading in the financial market, the trading in the market for information, and information-producing agents' specialization decisions. Section 4 studies the relation between sell-side research and the information efficiency of the financial market. Section 5 studies the conflict of interest in sell-side research. Section 6 extends the model to explain why independent research exists. Section 7 discusses implications of the model, with emphasis on the credit rating industry. Section 8 concludes. Proofs of propositions and other technical details are provided in the appendix.

2 The Model

In a four-dates-three-periods economy, there is one risky asset. At the end of the third period, date 3, the payoff of the asset, $\delta + V$ is realized. V is a known constant, and δ is random. The prior distribution of δ at date 0 is $N(0, \sigma_\delta^2)$. As a convention, I call $\frac{1}{\sigma_\delta^2}$ precision and denote it v_δ. Without loss of generality, I assume $v_\delta = 1$.

2.1 Agents and Information

There are three kinds of agents in the economy: information-producing agents, market makers, and liquidity traders. All of them are risk-neutral. The discount rate is normalized to be one.

There are N information-producing agents in the economy. N is exogenous for simplicity. Before date 2 but after date 1, each information-producing agent receives one signal about the asset value. The signal of agent i, $i = 1, 2, ..., N$, takes the form:

$$s_i = \delta + \varepsilon_i \tag{1}$$

where $\varepsilon_i \sim N(0, \sigma_i^2)$. For ease of notation, I denote $v_i \equiv \frac{1}{\sigma_i^2}$. δ and ε_i are independent for any i. ε_i is also independent across information producing-agents. This assumption captures the feature that each agent has a unique perspective about the asset value. I further assume that all signals have the same quality, that is, $v_i = v_j = v$ for any i and j. For simplicity I assume that each agent's cost of receiving the signal is zero.[3]

The market makers set the trading price in the financial market at date 2. I assume that the liquidity traders trade in the financial market at date 2 for liquidity reasons. Their demand for the asset is z, which is normally distributed with mean zero and variance σ_z^2.

2.2 Sequence of Events

At date 0, each information-producing agent specializes, i.e., he chooses whether to be an analyst or a fund manager.[4] An analyst cannot trade in the financial market, but can sell information to fund managers and engage in other profitable activities, which are called "investment banking".[5] Profit from investment-banking is π_I, which is exogenous in the model. On the other hand, a fund manager cannot sell any information, either his own or any bought from analysts, but he can trade in the financial market on his own information and information he chooses to buy from analysts.[6] After the information-producing agents specialize, there are m analysts and $n \equiv N - m$ fund managers (m and n are determined endogenously). I assume that the information-producing agents observe each other's specialization decisions.

At date 1, before they receive signals about the asset value, analysts try to sell their information to fund managers in the market for information. Analyst j ($j = 1, 2, ..., m$) first makes take-it-or-leave-it offers to a set of the fund managers of his choice, F_j, for his information at prices $p(F_j)$. $p(F_j)$ is a vector whose elements are p_j^i, $i \in F_j$. p_j^i is the offer price analyst j demands from fund manager i for the information.

Fund manager i ($i = 1, 2, ..., n$) receives offers from a set of analysts, S^i, with offering prices $p(S^i)$, which is a vector whose elements are p_j^i, $j \in S^i$. Fund manager i doesn't observe any analysts' offers

[3] If there is a positive cost, each agent would decide whether it is worthwile to become informed. Apart from this, the analysis would be similar.

[4] For technical completeness, I assume there is coordination between agents, i.e., there is some coordination device that tells each information-producing agent whether he should be an analyst or a fund manager. In equilibrium, each agent should find it optimal to follow the suggestion of this coordination device.

[5] Although many sell-side firms have asset management divisions, presumably there are Chinese wall restrictions that separate sell-side research and buy-side research. Unlike the relation between sell-side research and investment banking, the relation between buy-side and sell-side research doesn't seem to be significant.

[6] The assumption that fund managers cannot resell analysts' information is crucial for the existence of a market for information. Without the ability to enforce their intellectual property, analysts cannot make any profit selling information. This assumption seems to be consisitent with reality, because there are firms that are successful in selling information, such as Sanford Bernstein. However, few funds sell information, possibly because it might create opportunities for funds to profit from selling information at the cost of their investors.

to other fund managers, neither does he observe other fund managers' buying decisions.[7] But he forms beliefs about the other offers the analysts make conditional on the offers he receives to decides whether to accept any of the analysts' offers. If he decides to accept the offer from analyst j, an information sale goes through, i.e., the fund manager will pay analyst j p_j^i. In exchange, analyst j will report his signal to fund manager i once the analyst receives it. If fund manager i decides not to buy from analyst j, the information sale fails, i.e., fund manager i will pay nothing to analyst j, and analyst j will not report his signal to fund manager i. The set of analysts fund manager i chooses to buy from is A^i, which is a subset of S^i. In the basic model, there is no agency problem (such as conflict of interest) in information selling. I will study analysts' conflict of interest problem in section 5.

After date 1, each information-producing agent receives a signal about the value of the asset. The analysts then report their signals to the fund managers who have paid them. At date 2, the fund managers trade in the financial market on their information, conditional on their beliefs about other fund managers' information and strategies. As mentioned before, analysts do not participate in the financial market.

The trading mechanism is similar to that in Kyle (1985). The fund managers do not observe current prices or quantities traded by other fund managers or by liquidity traders. Market makers do not receive any private information, nor do they observe individual quantities traded by the fund managers and the liquidity traders, but they do observe the total order flow, y, from all market participants. Each trader submits a market order, x_i and the market makers clear the market by supplying liquidity at a price, P_2, conditioning on the total order flow y. I further assume that the market makers do not observe the composition of analysts in the economy, i.e., they don't know m, but they infer m correctly in equilibrium.

Finally, at date 3, the security value is realized and distributed. The sequence of events is summarized in Figure 1.

2.3 Definition of Equilibrium

The equilibrium concept I use here is *Perfect Bayesian Equilibrium*. Formally, an equilibrium comprises the following components:

(i) Each agent's choice of whether to be a sell-side analyst or a fund manager.

(ii) The number of analysts, m^*.

[7] This is the so called privately observable contracts setting in the multilateral contracting literature. See Hart and Tirole (1990) and McAfee and Schwartz (1994).

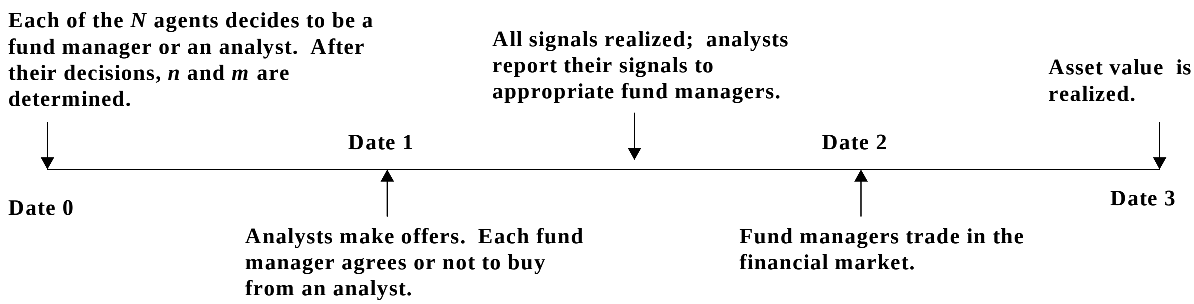

Figure 1: Sequence of Events

(iii) For analyst j, the set of fund managers to offer to, F_j, and the offer prices $p(F_j)$.

(iv) For fund manager i, the set of analysts to buy information from, A^i.

(v) The market order, x_i, submitted by fund manager i to the market makers conditional on his information.

(vi) The market makers' pricing conditional on total order flow, y.

(vii) The analysts and fund managers' beliefs about the other offers made by the analysts, and market makers' beliefs about the number of analysts and information structure of the fund managers.

In an equilibrium, conditional on other agents' equilibrium strategy, (a) each analyst (fund manager) should find it optimal to be an analyst (fund manager); (b) based on his information and beliefs about other fund managers' information, fund manager i chooses the set of analysts, A^i, to buy information from to maximize his profit (trading profit minus the cost of buying information); (c) analyst j chooses the set of fund managers, F_j, and prices $p(F_j)$ to maximize his total profit (investment-banking profit and profit from selling information); (d) based on his information and beliefs about other fund managers' information, each fund manager submits an order to maximize his expected trading profit; (e) each market maker sets the trading price conditional on the total order flow to maximize his expected payoff; and (f) all beliefs are consistent with the equilibrium strategies of all the agents in the model.

In the following analysis I mainly focus on symmetric pure strategy equilibria except in subsection 3.4 where I discuss the robustness of the results, I analyze an asymmetric equilibrium. I analyze the trading in the date 2 financial market in the normal-linear framework.

3 Equilibrium Analysis

I solve the equilibrium by backward induction. I first analyze the trading game, i.e., the fund managers' trading strategy and the market makers' pricing rule at date 2. Then I analyze the date 1 trading in the market for information. Finally, I characterize the date 0 specialization decisions of the information-producing agents and the equilibrium number of analysts.

The date 1 trading in the market for information is a multilateral contracting game with privately observable contracts.[8] It is well estabilished in this literature that if out-of-equilibrium beliefs are not restricted, there may be a plethora of PBE. To be able to make sharper predictions about equilibrium

[8] See Bolton and Dewatripont (2005) for a summary of this literature.

outcomes, several restrictions have be considered for multilateral contracing games with secret bilateral contracts (McAfee and Schwarts (1994) provide an extensive discussion of reasonable out-of-equilibrium beliefs for such contracting games). The most common restriction in this literature is *passive beliefs* introduced by McAfee and Schwarts (1994). In my model, passive beliefs means that when receiving out-of-equilibrium offers from an analysts, fund manager i believes that all other offers remain equilibrium offers. I follow the literature here and characterize the equilibrium outcomes when out-of-equilibrium beliefs are restricted to be passive.

Under passive beliefs, I can establish the following lemma about trading in the market for information.

Lemma 1 *Given passive beliefs, the equilibrium outcome is for all analysts to sell their information to all fund managers.*

The underlying intuition for this result is as follows. If an analyst only sell to a subset of fund managers in equilibrium, he may have an incentive to deviate by selling to one more fund manager. By deviating, the analyst can still get equilibrium payments from other fund managers because they don't know that the analyst has deviated. On top of that, the analyst can get a payment from the fund manager.[9] This result depends on the unobservability of the other offers made by the analysts.[10] I will relax this assumption in subection 3.4.

3.1 Trading in Financial Market

At date 2, the participants in the financial market are n fund managers, liquidity traders, and market makers. By Lemma 1, when fund manager i trades in the financial market, his information set is $F_i = \{s_i, s_{1,} ..., s_m\}$. In other words, each fund manager has his own signal, s_i, and m signals he bought from the analysts. Based on this information, fund manager i ($i = 1, 2, ..., n$) submits a market order, x_i, to the market makers to maximize the expected profit. The market makers observe only the total order

[9] I assume here that the marginal cost if selling information is zero. I believe it is a reasonable assumption because the common way of selling information is through the Internet. To sell to one more fund manager, the only thing an analyst needs to do is to provide the fund manager with access to the website, i.e., set up a user's account, and give the fund manager a user name and a password. Such activities can be carried out at negligible marginal cost.

[10] See McAfee and Schwartz (1994) for the difficulty of a supplier to make commitment to competing downstream firms under unobservability in a more general setting.

flow, $y = \sum_{i=1}^{n} x_i + z$, and with information extracted from that, they establish the market clearing prices, $P_2(y)$. Thus, fund manager i's problem is

$$\max_{x_i} E[x_i(V + \delta - P_2(\sum_{k=1}^{n} x_k + z))|F_i]. \tag{2}$$

Each fund manager takes the market makers' pricing rule $P_2(\cdot)$ and other fund managers' trading strategies as given, but exploits his information advantage by accounting for the impact of his trading decision on the price eventually set by the market makers at date 2.

I do not model the market makers' strategic behavior directly. Rather, I only assume that

$$P_2(y) = \eta y, \tag{3}$$

η is a positive number. By doing so, I wish to show that my results do not depend on the specific market-clearing mechanism, but that the market-clearing price is linear in total order flow. This formulation includes the well-known case in which the market makers are perfectly competitive:

$$P_2(y) = E[\delta|y] + V.^{11} \tag{4}$$

For the rest of the paper, I keep this case as a special example.

I propose that fund manager i's trading strategy takes the symmetric form:

$$x_i = \beta s_i + a(\sum_{j=1}^{m} s_j), \tag{5}$$

where β and a are measures of the aggressiveness with which a fund manager trades on his own information and on sell-side information, respectively (this assumption is without loss of generality, since the unique linear equilibrium is symmetric as shown in Proposition 2). I can rewrite fund manager i' strategy as

$$x_i = \beta s_i + \alpha s_p, \tag{6}$$

[11] It also includes the case where there is no market maker, but only uninformed risk-averse investors, as in Leland (1992).

where $s_p = \frac{1}{m}\sum_{j=1}^{m} s_j$ and $\alpha = am$. Note that s_p is the sufficient statistics for δ, given all sell-side signals. I show in the appendix that above strategy is indeed the unique linear equilibrium. It is characterized by Proposition 2:

Proposition 2 *(i) There exists a unique linear equilibrium for date 2 trading, in which a fund manager's trading strategy is given by (5), where*

$$a = \frac{2v}{\eta(n+1)[2(1+mv)+(n+1)v]} \tag{7}$$

$$\beta = \frac{v}{\eta[2(1+mv)+(n+1)v]}, \tag{8}$$

and the market makers' pricing rule is given by (3).

(ii)In equilibrium, the expected trading profit of a fund manager is

$$\pi = \frac{1}{4\eta}\left[\frac{4v(1+4m+2n+n^2+(1+2m+n)^2 v)}{(1+n)^2[2+(1+2m+n)v]^2}\right]. \tag{9}$$

(iii) The equilibrium asset price is

$$P_2 = V + \frac{2nv}{(n+1)[2(1+mv)+(n+1)v]}\sum_{j=1}^{m} s_j + \frac{v}{[2(1+mv)+(n+1)v]}\sum_{i=1}^{n} s_i + \eta z. \tag{10}$$

(iv) If the market makers are perfectly competitive, i.e., (4) holds, then:

$$a = \frac{2\sigma_z v}{\sqrt{nD}} \tag{11}$$

$$\beta = \frac{\sigma_z(n+1)v}{\sqrt{nD}} \tag{12}$$

$$\eta = \frac{\sqrt{nD}}{\sigma_z(n+1)[2(1+mv)+(n+1)v]}, \tag{13}$$

where $D \equiv 4mv + 4(mv)^2 + 4nv^2 + (n+1)^2(v+v^2)$.

Proposition 2 indicates that fund managers trade on buy and sell-side information differently, since a and β are different. As a result, the two kinds of information have different impacts on the market price. Corollary 3 explores the differences:

Corollary 3 *(i)* $\frac{na}{\beta} = \frac{2n}{n+1} \geq 1$, *that is, as a group, fund managers trade more aggressively on sell-side information than on their own information.*

(ii) $\frac{a}{\beta} = \frac{2}{n+1} \leq 1$, *that is, a fund manager trades less aggressively on sell-side information than on his own information.*

(iii) Ceteris paribus, the price change induced by sell-side information is greater than that induced by buy-side information.

(iv) Ceteris paribus, sell-side information generates more trading volume than buy-side information.

To understand these results, it is important to appreciate the difference between buy-side and sell-side information. Although the two kinds of information are of the same quality, sell-side information is widely known, but buy-side information is known only to the fund managers who produce it. The difference has significant impacts on the trading behavior of fund managers.

First, as a group, fund managers trade more aggressively on an analyst's signal than on a fund manager's. Because all n fund managers know an analyst's signal, but only one fund manager knows a fund manager's, there is more competition among fund managers to profit from an analyst's signal than from a fund manager's.

To see why more competition makes fund managers trade more aggressively, it is helpful to compare the response of a fund managers of a one-unit increase in an analyst's signal with that of a one-unit increase in a fund manager's own signal. All else equal, if there is a one-unit increase in an analyst's signal, a fund manager faces a trade-off: if the increase in trading will not change the price, then increasing trading by one unit will increase his trading profit. But the fund manager's trading will increase the price by η units, which will reduce the fund manager's trading profit. However, there are n fund managers trading on the analyst's signal, so increasing η units in price will reduce not one, but n, fund managers' trading profits. Because a fund manager cares only about his own benefit, when he trades off the cost and benefit of his trading, he does not consider the other $n-1$ fund managers' profit loss caused by his increased trading. In other words, increasing price is a negative externality caused by one fund manager on the others.

However, it is a different story when there is a one-unit increase in a fund manager's signal. Because the fund manager is the only one who is going to trade on the signal, he bears all the costs of the increase in price caused by his trading, so he considers all the costs and benefits of his trading in his decision.[12] Because competition in the former case causes a fund manager to put less weight on the total costs, but the same weight on the total benefits of his actions as in the latter case, the fund managers trade more aggressively on an analyst's information than on a fund manager's.

Second, a fund manager trades less aggressively on the sell-side information than on his own information. Because an analyst's signal is known to all fund managers, a fund manager takes into consideration the other fund managers' use of this signal when he makes a trading decision. For example, if there is a one-unit increase in an analyst's signal, a fund manager who is considering increasing his order knows exactly that other fund managers will do the same. Thus, the fund manager knows that the analyst's signal is going to be incorporated into the eventual trading price even in the absence of his own trading. On the other hand, when there is a one-unit increase in a fund manager's signal, he knows other fund managers have no access to it. Therefore, that signal is going to be incorporated into the price less than the analyst's signal is, if he increases his order by the same amount in both cases. Because the fund manager can hide his own information better, he can increase his order in a more aggressive response to his own signal than to the analyst's.

It is worth noticing that $\frac{a}{\beta}$ is decreasing in n, and $\frac{na}{\beta}$ is increasing in n. Because competition among fund managers causes them to trade on buy-side and on sell-side information differently, such differences are more pronounced if there are more fund managers in the economy. Because the market makers' pricing rule is linear in total order flow, a greater change in order flow implies a greater change in price. Therefore, sell-side research is more influential in the sense that it can affect the price more. It is often said of sell-side research that it generates trade for the brokerage business. My model seems to support this argument, because according to Corollary 3, sell-side information generates more trading volume than does buy-side information.

[12] To be more precise, even in this case there is an externality: suppose a fund manager increases his order in response to his own positive signal, the resulting increase in price will also hurt other fund managers' trading profits on average. The reason is that when the fund manager increases his trading, the resulting increased price reveals other people's signals too, because on average, the other signals are also positive. But the extent of the externality here is less. Because it is caused by the correlation among signals, unlike the externality in the competition to trade on an analyst's signal, which is caused by the fact that the fund managers know the analyst's signal perfectly.

3.2 Market for Information

In studying the date 1 market for financial information, I look at the analysts' choices of fund managers to offer to, the offer prices, and the fund managers' choice of analysts to buy from.

3.2.1 Fund Managers' Demand for Sell-Side Information

From the set, S^i, of the analysts who make offers to him, how should fund manager i choose a subset, A_i, of analysts from whom to buy information?

After fund manager i chooses A^i, his trading strategy is given by solving the problem:

$$\max_{x_i} E[x_i(V + \delta - (V + \eta y))|F_i], \tag{14}$$

where $F_i = \{s_i, s_j, \forall j \in A^i\}$. The information that fund manager i has now includes his own information, s_i, and the analysts' information he bought, s_j, $j \in A^i$. Fund manager i solves problem (14) with the belief that everybody else will play the equilibrium strategy, that is, every other fund managers will buy from all the analysts and trade according to strategy as specified in Proposition 2. Proposition 4 characterizes analyst i's optimal trading profit:

Proposition 4 *(i) Conditional on other fund managers' equilibrium strategies, fund manager i's optimal trading profit, $\pi_i(A^i)$, only depends on, $l \equiv l(A^i)$, the number of analysts in A^i.*

(ii) $\pi_i(l)$ is strictly increasing and concave in l.

Because the equilibrium is symmetric, fund manager i's strategy and expected trading profit are functions of only the number of analysts from whom he buy, not his choice of particular analysts.

Fund manager i's profit is increasing in l, since more analysts' information reduces his information disadvantage relative to other fund managers who have all the analysts' information. But the marginal benefit of analysts' information is decreasing, since as fund manager i gets more analysts' information, he can make more precise assessments about the asset's value and other fund managers' order flows. The more precise is the fund manager i's assessment, the less it is going to be changed by one more analyst's information. Therefore, the marginal value of one more analyst's information is less.

Because of the concavity of $\pi_i(l)$, the classical marginal analysis yields fund manager i's optimal set of analysts to buy. The following proposition summarizes it.

Proposition 5 *Given the prices of the analysts' information, $p(S^i)$, fund manager i chooses to buy from the l^* cheapest analysts, and l^* is determined by*

$$\begin{aligned} \pi_i(l^*) - \pi_i(l^* - 1) &\geq p^i_{l^*} \text{ if } l^* > 0, \text{ and} \\ \pi_i(l^* + 1) - \pi_i(l^*) &\leq p^i_{l^*+1} \text{ if } l^* < l(S^i), \end{aligned} \tag{15}$$

where $p^i_{l^*}$ ($p^i_{l^*+1}$) denotes the l^*th ($l^* + 1th$) lowest price in $p(S^i)$.

Because a fund manager's profit is only affected by the number of analysts he buys from, if he wants to buy from l^* of them, he chooses the cheapest ones. The optimal l^* is determined by (15), which says that it is profitable to buy the last analyst's information, but buying one more analyst's information will result in a loss for the fund manager.

3.2.2 Price of Analysts' Information

Since an analyst makes take-it-or-leave-it offers to the fund managers, he can extract all the marginal surplus of his information from all the fund managers. In equilibrium, the marginal benefit of an analyst's information to a fund manager is $\pi(m) - \pi(m-1)$ (I can drop the subscript i because of symmetry). Therefore, I conjecture that an analyst's offering price is:

$$p^i_j = p = \pi(m) - \pi(m-1), \ \forall i, \ j. \tag{16}$$

If all the analysts use such a strategy, each fund manager will buy information from all analysts by Proposition 5, so an analyst's profit from selling information is $\pi_r \equiv np$ in equilibrium.

Why can no analyst benefit from deviating from such a strategy? First, an analyst cannot benefit from offering a lower price to any fund manager, since by Proposition 5 the fund manager would accept the offer, leading to a less profit for the analyst. Second, neither can an analyst benefit from offering a higher price to any fund manager, since by Proposition 5 the fund manager would reject the offer, again leading to a less profit for the analyst.

Proposition 6 characterizes the equilibrium in the market for information:

Proposition 6 *In the market for analysts' information,*

(i) an analyst makes offers to all fund managers to sell information, and the offer price is

$$p = \frac{1}{4\eta}[\frac{16v(1+v+mv)}{(1+n)^2(1+mv)[2+(1+m+n)v]^2}]; \tag{17}$$

(ii) all the fund managers accept the offers;

(iii) a fund manager's and an analyst's expected equilibrium profits are

$$\pi_b = \frac{1}{4\eta}\{\frac{4v[(n+1)^2+[4m^2+(1+n)^2+m(1+n(6+n))]v+m(1+2m+n)^2v^2]}{(1+n)^2(1+mv)[2+(1+m+n)v]^2}\} \tag{18}$$

and

$$\pi_s = \frac{1}{4\eta}[\frac{16nv(1+v+mv)}{(1+n)^2(1+mv)[2+(1+m+n)v]^2}] + \pi_I(m,n), \tag{19}$$

respectively.

Proposition 6 characterizes the equilibrium payoffs of a fund manager and an analyst as functions of m and n. Because $n = N - m$, π_b and π_s are functions of m only.

3.3 Specialization Decision

The next step is to determine the equilibrium composition of analysts and fund managers, that is, the number of information-producing agents who choose to be analysts in equilibrium, m^*.

By equilibrium definition, m^* is an equilibrium composition if and only if

$$\pi_b(m^*) \geq \pi_s(m^*+1) \text{ if } m^* \leq N-1, \text{ and} \tag{20}$$

$$\pi_s(m^*) \geq \pi_b(m^*-1) \text{ if } m^* > 0. \tag{21}$$

(20) is the fund manager's incentive compatibility condition. It says that if a fund manager deviates by becoming an analyst unilaterally, his profit is less than what he can get as a fund manager. Similarly, (21) is the analyst's incentive compatibility condition. It says that if an analyst deviates by becoming a fund manager unilaterally, his profit is less than what he can get as an analyst.

What will happen to the equilibrium composition of analysts if there is no investment banking subsidy? Proposition 7 describes the result.

Proposition 7 *If there is no investment-banking subsidy, then an analyst always has an incentive to deviate to be a fund manager. The equilibrium outcome is that all information production agents choose to be fund managers.*

Proposition 7 says analysts cannot exist in equilibrium without investment-banking profit, because the profit an analyst makes by selling information is less than what he could get if he became a fund manager. There are two factors that reduce the profit from selling information. The first factor is competition among fund managers. Because fund managers compete to benefit from an analyst's information in the financial market, they compete away the total expected trading profit generated by the analyst's information. To see this, notice that Corollary 3 shows that as a group, fund managers trade more aggressively on an analyst's signal (with intensity na) than on a fund manager's (with intensity β). As a result, the analyst's signal is impounded too much into the price, which makes the total profit generated by the signal less than what it could be if fund managers traded on it less aggressively (with intensity β).[13]

The second factor is the substitutive nature of the agents' information. As a fund manager has his own information and analysts' information, the last analyst's information has a relatively small marginal benefit to the fund manger's profit. Because this marginal benefit is all that an analyst can capture, an analyst can extract a limited amount from a fund manager even though the analyst has all the bargaining power.

Figure 2 is helpful to understand this factor. In equilibrium an analyst can extract only the last analyst's marginal benefit, p, from a fund manager, a fund manager's total payment to all the analysts, np, is only a fraction of the total surplus created by the analysts' information. The rest of the surplus is captured by the fund manager. Furthermore, this factor implies that the total surplus created by all the analysts' information is only a small fraction of a fund manager's total trading profit. This is because a fund manager's information is a substitute for the analysts' information. To see this, it is helpful to look at the extreme case where all the signals are perfect, i.e., $s_i = \delta$. Because all the signals are the same, they

[13] It can be shown that if all the fund managers can lower a so that na equals the equilibrium β, i.e., if fund managers can commit to trade on an analyst's signal with the same intensity as they do on a fund manager's, they will earn higher trading profits, *ceteris paribus*.

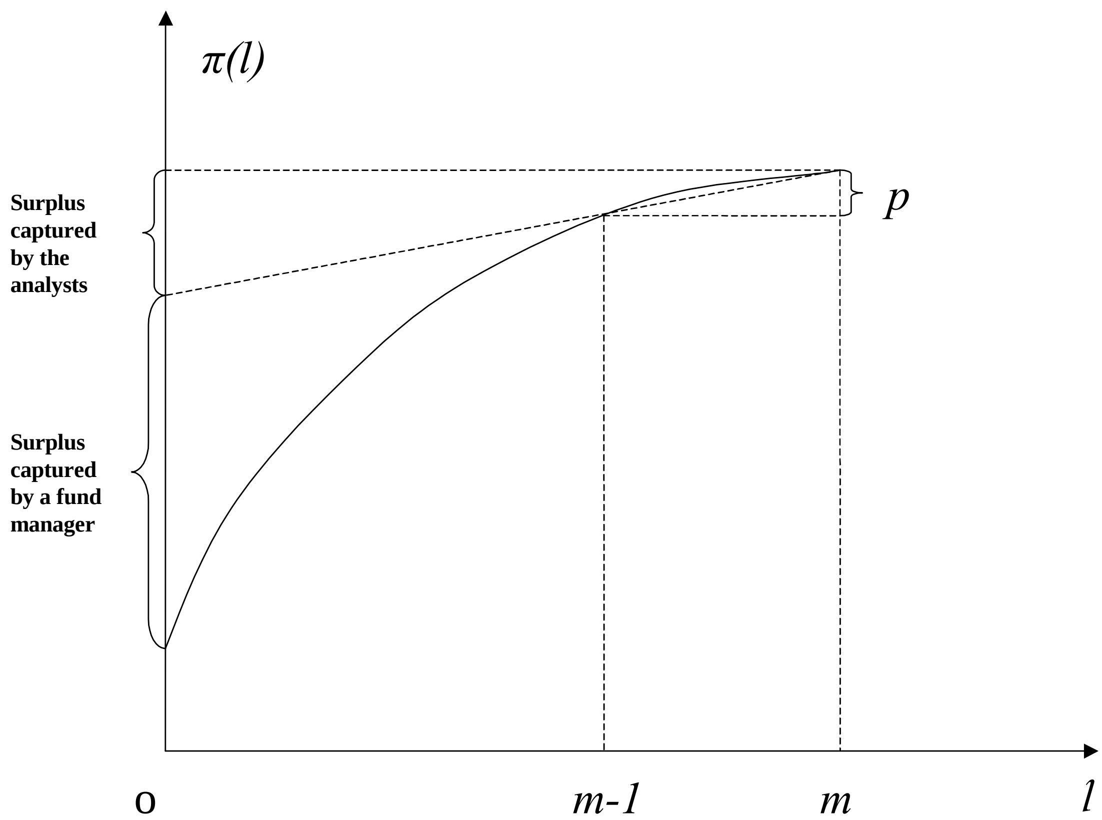

Figure 2: Price of Analysts' Information

are perfect substitute for each other. Therefore, the total surplus created by the analysts' information is zero and the fund managers would not pay any positive price for the analysts' information.

On the other hand, when an analyst chooses to be a fund manager, there is more competition among fund managers which tends to reduce a fund manager's profit. This effect makes choosing to be a fund manager less attractive. But the above two factors are so strong that they dominate the agents' specialization decisions.

Proposition 8 gives the properties of the investment-banking profit π_I that can support a positive number of analysts in equilibrium:

Proposition 8 *m^* is the equilibrium number of analysts if and only if the investment-banking profit satisfies*

$$\pi_I(m^*+1) \leq \pi_b(m^*) - \pi_r(m^*+1) \text{ if } m^* \leq N-1, \text{ and} \quad (22)$$

$$\pi_I(m^*) \geq \pi_b(m^*-1) - \pi_r(m^*) \text{ if } m^* \geq 1. \quad (23)$$

Proposition 8 states that in equilibrium, analysts must do other business, such as investment banking, in addition to selling information. Thus the proposition explains why sell-side research is usually bundled with investment banking. Totally separating investment banking and sell-side research to eliminate the conflicts of interest might not be a good idea if regulators want to maintain a positive number of sell-side analysts. The division of business could make it impossible for sell-side analysts to survive.

The overall equilibrium is summarized as follows. In equilibrium, m^* information-producing agents specialize as analysts and the rest as fund managers at date 0, as described by Proposition 8. In the information market, each analyst sells his information successfully to all the fund managers at price p, as specified by Proposition 6. Each fund manager buys from all the analysts and then trades in the financial market as described by Proposition 2.

In an equilibrium with a positive number of analysts, is an analyst's profit from selling information higher or lower than a fund manager's profit? More precisely, is $\pi_b(m^*) \geq \pi_r(m^*)$? By the intuition in Proposition 7, this should be so. Proposition 9 shows it is actually the case:

Proposition 9 *In an equilibrium with $m^* \geq 1$ and $n^* \geq 1$,*

$$\pi_b(m^*) > \pi_r(m^*). \quad (24)$$

That is, an analyst's profit from selling information is always less than a fund manager's profit.

The empirical prediction of Proposition 9 is that, controlling for research capacity, a sell-side firm's profit from selling information should be less than a fund manager's profit.

3.4 Robustness

In this subsection, I explore the robustness of the main result, analysts need subsidy to exist. In the above analysis, I assume that the contracts between the analysts and the fund managers are only privately observable, which leads to the equilibrium outcome that analysts cannot commit to sell to only a subset of the fund managers. This lack of commitment may hurt analysts' profits from selling information.[14]

To see whether the main result is robust against this assumption, I study the case where analysts can commit to sell to only a subset of fund managers. Because specifying all the possible analysts and fund managers relations is complicated for the general N agents case, I limit the analysis to the special case where $N = 3$. The game is the same as before except that now the analysts can commit to sell to only a subset of fund managers. The following proposition summarizes the result.

Proposition 10 *If $N = 3$ and analysts can commit to sell to any subset of the fund managers, the only equilibrium outcome is that all information producing agents choose to be fund managers.*

In the case where there is one analyst and two fund managers, even when the analyst sells to only one fund manager, thus there is no competition among fund managers, the analyst still cannot survive without investment banking subsidy.[15] The key factor here is the substitutive nature of the agents' information. As shown in the appendix, the analyst's profit from selling information is only $\frac{1}{2(1+v)}$ of the fund manager's total profit. The higher the precision of agents' signals, v, the more substitutive the fund manger's information is for the analyst's information, the less the analyst can extract profit from the fund manager.

Given the importance of the substitutive nature of the agents' information to the main result, the natural question to ask is whether it still holds if the signals are complimentary rather than substitutive. One simple way to model the complementarity is to assume that an analyst's signal precision increases a fund manager's signal precision. For example, a fund manager needs factual information (such as acounting information) gathered by an analyt in order to produce its own information more efficiently. It turns out that if the complimentarity is high enough, the analyst may be able to extract so much surplus from the

[14] Both Hart and Tirole (1990) and McAffee and Schwartz (1994) show that a supplier' inability to commit against his own opportunism reduces his profit in general.

[15] This result can be generalized more. It can be shown that in a general n fund managers and $N - n$ analysts setting, with the restriction that analysts sell to no more than one fund manager, the analyst always do better by trading on his own information.

fund managers that an agent chooses to be an analyst in equilibrium without investment banking subsidy. Section 6 provides detailed analysis of this case..

Now I explore the robustness from another angle. I assume that the information producing agents can coordinate ex ante to determine the composition of analysts to maximize their joint profit (that is, the agents can make arrangement to share the total profits equally). For anti-trust reasons, there has to be at least n fund managers.[16] Now the game is modifies as follows. The information producing agents can determine who should work for the fund managers and who should work as analysts to maximize their joint trading profit. Notice that now I allow multiple agents work for one fund manager (on the buy-side). Once an agent works for a fund manager, he cannot sell his information to any one else. Analysts can sell their information to any fund managers as before. For the same reason as in the previous analysis (Lemma 1), the analysts sell to all fund managers in equilibrium. In this setting, I want to study the optimal allocation of research between sell-side and buy-side. The the optimal symmetric allocation turns out to be that every agent works for one fund manager, that is, on the buy-side and there is no sell-side analysts.[17] The reason is that the competition among fund managers to trade on analysts' information reduces the fund managers trading profits.

3.4.1 Numerical Illustration

I assume that an analyst's profit from investment banking is proportional to his profit from selling information, that is

$$\pi_I = \frac{1-\rho}{\rho} np, \; 0 < \rho \leq 1, \tag{25}$$

where ρ is a constant.[18] The higher the ρ, the lower the investment-banking profit proportional to an analyst's total profit. In the extreme case in which $\rho = 1$, $\pi_I = 0$. I further assume that $\rho = 0.015$, $N = 100$, and $v = 0.8$. I can then calculate π_b and π_s as a function of m, as shown in Figure 3.

In Figure 3, π_b and π_s cross at E. That is, a fund manager and an analyst have the same profit at E. At this point, an analyst has no incentive to become a fund manager, because if he does, a fund manager's profit will decline, in which case the profit will be less than the profit gained as an analyst. Nor does a

[16] Without this constraint, the optimal composition is that there is only one fund manager and all others are analysts. It is not surprising that if one fund manager has monopoly of all the information he can maximize the trading profit from the information.

[17] The proof is available from the author.

[18] The results are qualitatively the same if I assume that π_I is a constant.

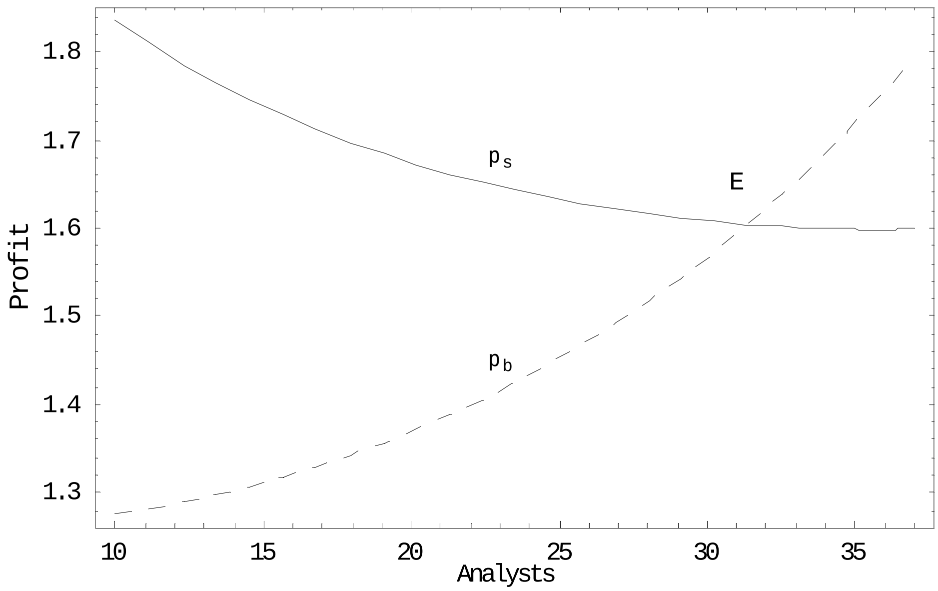

Figure 3: The Profits of Analyst and Fund Manager

fund manager have an incentive to switch, if he does, an analyst's profit will decline too, in which case the profit will be less than the profit gained as a fund manager. At E, $m^E = 31.37$, but the equilibrium number of analysts, m^*, must be an integer. Therefore, I need to verify whether $m = 31$, or $m = 32$, or both satisfy the equilibrium conditions (20) and (21). It turns out that $m^* = 32$ is an equilibrium number of analysts.

Notice that ρ is 0.015, which means that in equilibrium the profit from selling information accounts for only 1.5% of an analyst's total profit. It can be shown that if $\rho \geq 0.031$, the equilibrium number of analysts is zero ((21) is never satisfied if $\rho \geq 0.031$). Therefore, to have a positive number of analysts in equilibrium, the investment-banking profit must be a significant portion of an analyst's total profit, at least 96.9%. Further, $\frac{\pi_r(32)}{\pi_b(32)} = 1.48\%$. That is, an analyst's profit from selling information is only 1.48% of a fund manager's profit in equilibrium.

4 Social Welfare and Sell-Side Research

In this section I study the welfare effects of the allocation of information production between buy and sell-side. In particular, will welfare be decreased if analysts cease to exist as a result of totally separating investment banking from research?

The general effects of an increased sell-side research are equivocal. Under certain conditions, however, increased number of analysts can enhance welfare for two reasons. First, because asset prices affect corporate investment, more informative asset prices improve economic efficiency, thus enhancing social welfare.[19] Second, because analysts' information is incorporated more into asset prices than fund managers' information, increasing the number of analysts could enhance the information content of asset prices.

4.1 Information Efficiency and Social Welfare

To study the relation between the information efficiency of asset prices and corporate investment efficiency, I introduce into my model a firm that sells its stocks in the financial markets.[20] I assume that at date 0, the firm has one project. The firm must invest in the project to increase its production capacity. At date 3, the value per unit of the firm's production capacity is $V + \delta$, which can be thought of as the future price of the firm's product. The investment cost of setting up q units of production capacity to the firm is $f(q)$, $f'(q) > 0$ and $f''(q) > 0$. The firm needs to invest $f(q)$ at date 2 after it raises capital from the financial market. The firm's owner sells the firm's stock at date 2 in the primary market, and uses part of the proceeds to finance the project, retaining the rest for his own consumption.

For simplicity, I assume the total shares of the firm's stock amount to q, which implies that the date 3 price of its stock is $V + \delta$. To model the firm's equity issuance in a parsimonious way, I assume that the number of shares issued by the firm, thus its production capacity, is q, which can depend on the date 2 market price of its shares. That is, the firm sells its stock through limit orders. I assume that the firm's selling order is public information. I further assume that (4) holds, i.e., the market makers provide liquidity at the expected value of the stock, conditional on the total order flow. Finally, the firm pays each analyst investment banking fee π_I, which is determined exogenously.

According to these assumptions, the firm's problem is

$$\max_{q} qP_2 - f(q) - n\pi_I.^{21} \tag{26}$$

[19] There are numerous studies on the positive relation between asset prices and corporate investment. See Baker, Stein, and Wurgler (2003) for a review of this literature.

[20] I follow Leland (1992) closely in modeling social welfare here.

[21] If $P_2 < 0$, the problem does not have a well defined economic meaning. But the probability of $P_2 < 0$ can be made arbitrarily close to zero by assuming that V, the mean of P_2, is very large relative to the standard deviation of P_2.

Thus, the optimal q is uniquely determined by:

$$q^* = f'^{-1}(P_2). \tag{27}$$

Because $f(q)$ is convex, (27) implies that q^* is increasing in P_2. Thus, the model captures the positive relation among stock prices, corporate investment, and equity issuance as documented by Baker, Stein, and Wurgler (2003). Because the firm's investment decision depends only on the stock price, the firm's selling share has no information content. Therefore, whether the firm has private information about δ or not makes no difference in the model.[22]

Because the firm's selling order is public information and has no information content, the market makers consider only the total market orders when they set the price. The date 3 stock value is $V + \delta$ as before. Therefore, a fund manager solves the same problem, (2), as before. As a result, all results in section 3 carry over here.

I define social welfare, W, as the sum of all agents' ex ante expected payoff.[23] It is straightforward to show that

$$W = E[q^* P_2 - f(q^*)]. \tag{28}$$

That is, the social welfare equals the firm's production profit. Because all agents are risk-neutral, trading cannot enhance social welfare. One dollar in trading profit to one person is one dollar in trading loss to somebody else, so trading is welfare-neutral. Therefore, social welfare must be created within the firm, as stated by (28).

Because the firm's profit depends on its stock price, how informative the stock price is can have important welfare implications. Here, I define information efficiency as the ex post reduction in uncertainty about stock value by the market price. From the market makers' point of view, δ can be written as

$$\delta = E[\delta|y] + e. \tag{29}$$

[22] This result is because I assume that the firm's owner sells all his shares in the primary market. If the own keeps holding some shares of the firm, then he could signal his information through his equity holding, as in Leland and Pyle (1977).

[23] A *caveat* of this definition is that because I have not specified the liquidity traders' utility functions or their motives for trading, the social welfare defined here may not reflect all agents' welfare. However, as will become clear soon, the welfare defined here measures the information efficiency of the security prices. As long as the information efficiency is an important social welfare variable, the analysis here remains valid.

The uncertain value of the stock can thus be decomposed into two parts, the revealed part $E[\delta|y]$, and the concealed part e. The revealed part is the market price minus V, thus is public information. The concealed part remains unknown to the uninformed agents.

From Proposition 2, $E[\delta|y] = \eta y$. Further, it is easy to verify that e and y are independent. Therefore,

$$1 = Var[\delta] = Var[\eta y] + Var[e]. \tag{30}$$

I denote $\Sigma_r \equiv Var[\eta y]$. The greater the Σ_r, the less uncertain about δ conditional on the market price, and the more informationally efficient the stock price is. Because Σ_r equals $Var[P_2]$, the reduction in uncertainty equals the volatility of the stock price. The more volatile the price, the more information it reveals.

Proposition 11 states the relation between the information efficiency and social welfare:

Proposition 11 *Social welfare increases with the information efficiency.*[24]

The intuition is straightforward. Because the firm makes its investment decision based on its stock price, a more informative price improves the efficiency of the firm's investment decision.

4.2 Sell-Side Research and Information Efficiency

Because analysts' information is incorporated more into stock prices than fund managers' information is, under some conditions, increasing the number of analysts might enhance the information efficiency of stock price, and thus social welfare.

Increasing m has two offsetting effects on Σ_r. First, as Corollary 3 shows, having more analysts improves information efficiency because analysts' information is impounded more into the stock prices than fund managers' information is. I call this the sell-side effect. Second, having more analysts diminishes information efficiency by reducing the competition among fund managers. Because the number of total information-producing agents is fixed in the economy, more analysts means fewer fund managers. In turn, fewer fund managers reduces the competition among all fund managers, which leads to less informative prices because the fund managers bid less aggressively (as a group). I call this the competition effect.

[24] This result may not be true in general because more information may destroy risk-averse agents' incentive to share risk optimally. This is the well-known Hirshleifer Effect (see Hirshleifer (1971)). Hirshleifer effect does not apply here because of risk neutrality.

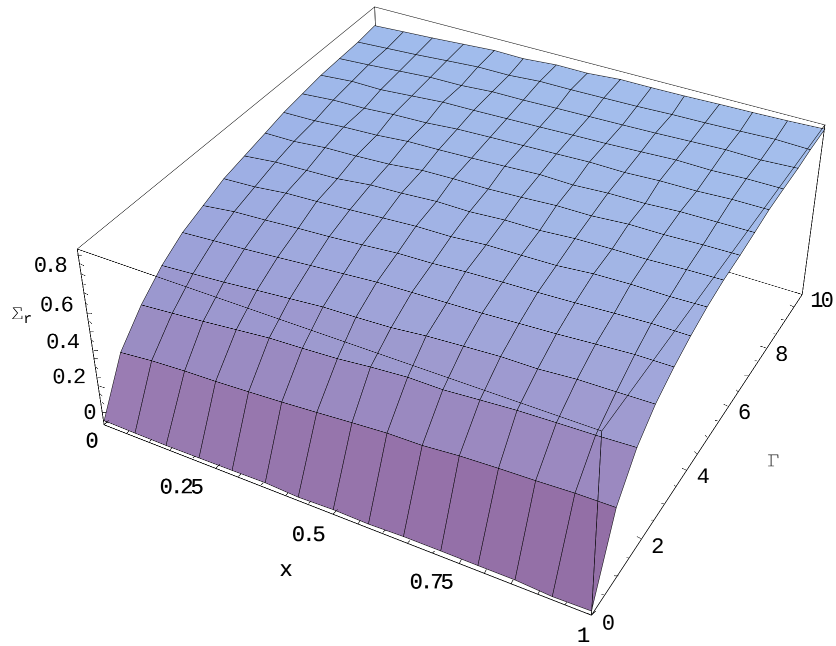

Figure 4: Information Efficiency and Sell-Side Research: The Limit Case

Depending on which effect dominates, increasing the number of analysts can improve or diminish the information efficiency of the price.[25]

However, when N is large, the ambiguity of increasing m disappears. It can be shown that when N goes to infinity while the total information in the economy $\Gamma = Nv$ is fixed, increasing the number of analysts improves the information efficiency of the economy, as illustrated in Figure 4.

Therefore, under some conditions, increasing the number of analysts improves social welfare. As a result, totally separating the investment banking and research functions in a firm may not be the good idea it seems to be, since the information efficiency of the financial market could decrease, which might diminish social welfare.

5 Analysts' Conflict of Interest

In the above analysis, I make the assumption that when analysts sell information to fund managers, there is no agency problem, that is, analysts report their signals truthfully to fund managers. This assumption

[25] In an earlier version of the paper, I provided a sufficient condition under which increasing the number analysts improves information efficiency.

is not realistic, since it is difficult for the fund managers to verify the quality of the analysts' information. This difficulty gives the analysts discretion over what to report. In this section, I relax this assumption by assuming that analyst j can choose to report r_j, a real number, to the fund managers after receiving his signal s_j. I define the bias $b_j \equiv r_j - s_j$. Under the new assumption, allowing the investment-banking subsidy to research may cause the conflict-of-interest problem.

By envelope theorem, the firm's production profit, $q^* P_2 - f(q^*)$, is increasing in its stock price. As a result, the firm has an incentive to increase its stock price. One way the firm can influence its stock price is through the influence it has over the analysts. More specifically, the firm can link its investment-banking payment to an analyst to the analyst's report to the fund managers. The more positive the analyst's report, the more the investment-banking payment to him. The analyst responds to this investment banking fee scheme by optimally biasing his report. However, the fund managers rationally expect an analyst's bias and so discount the analyst's report in equilibrium. Therefore, in equilibrium, the firm fails to influence its stock price because the fund managers filter the biases out, but the firm does it anyway. The effect of this conflict of interest in equilibrium is that if the fund managers have difficulty to back out the analyst's signal, the quality of the analyst's report can decrease. This is a welfare cost, since some information is lost in information selling.

To fix the idea, I assume that the investment banking fee for analyst j is

$$\pi_j r_j + I_j. \tag{31}$$

That is, the investment banking fee is linear and increasing in the analyst report, r_j. I_j is an exogenous constant, presumably determined by the relative bargaining power of analyst j and the firm. For simplicity, I assume that $I_j = I$ for all j. π_j is chosen by the firm and is not observable to other analysts and fund managers.

After receiving s_j, analyst j reports r_j to the fund managers. He chooses his bias optimally to maximize his objective function

$$\max_{b_j} \pi_j r_j + I_j - \frac{b_j^2}{2t_j}. \tag{32}$$

$\frac{b_j^2}{2t_j}$ represents analyst j's cost of bias. This cost function reflects the analyst's litigation risks, reputation costs, or psychological cost of a biased report. t_j is different across analysts. This assumption captures the idea that analysts have different costs of lying. I assume that t_j is normally distributed with mean T and precision v_t.[26] I further assume that t_j is i.i.d. across analysts and independent from any other random variables in the model. t_j is realized after date 1, but before analysts report to fund managers. Only analyst j observes it. All other agents only know its distribution.

The firm chooses π_j for each analyst at date 1, and its production capacity $q(P_2)$ at date 2 to maximize its objective function

$$\max_{\pi_j, q(P_2)} E[P_2 q(P_2) - f(q(P_2))] - \sum_j^m [\pi_j E[r_j] + I]. \tag{33}$$

For tractability, I assume that $f(q) = \frac{Fq^2}{2}$. When the firm chooses π_j, it does not know t_j because t_j has not realized yet.

After receiving reports from analysts, fund managers filter out the analysts' biases from these reports. Although the fund managers do not observe π_j, in equilibrium they correctly infer π_j^*. But because the fund managers do not know the exact t_j, they do not know the exact b_i. As a result, they cannot perfectly back out s_j. The uncertainty about t_j adds noise to an analyst's information.

Proposition 12 summarizes the equilibrium.

Proposition 12 *If $T + \frac{1}{Tv_t} \leq 2F$, there exists one equilibrium in which*

(i) the firm sets $\pi_j^* = \pi^*$, which is a positive root to equation (79) in the appendix, and $q^*(P_2) = \frac{P_2}{2F}$;

(ii) conditional on analyst j's report, r_j, fund manager i trades $x_i = \beta s_i + a(\sum_{j=1}^m \widehat{s}_j)$, where $\widehat{s}_j \equiv r_j - \pi^* T$, and

$$a = \frac{2\widehat{v}}{\eta[2(1+m)\widehat{v} + (1+n)v](1+n)}, \tag{34}$$

$$\beta = \frac{v}{\eta[2(1+m\widehat{v}) + (n+1)v]}, \tag{35}$$

where $\widehat{v}$ is the precision of $\widehat{s}_j$ as given by

$$\widehat{v} = \frac{vv_t}{\pi^{*2}v + v_t}; \tag{36}$$

(iii) analyst chooses $b_j^* = t_j \pi^*$ for all s_j.[27]

[26] t_i can be negative here, in this case the cost function is not well defined. But the parameters of the distribution can be choosen such that the probability of $t_i \leq 0$ is arbitrarily close to zero. This is achieved by assuming that the mean of t_i, T, exceeds the standard deviation, $\sqrt{\frac{1}{v_t}}$, by a large amount.

[27] The condition $T + \frac{1}{Tv_t} \leq 2F$ ensures that the second-order condition of the firm's problem is satisfied. To understand it, notice that T measures analysts' average cost of lying (the smaller T, the greater the cost) and F measures the firm's

Notice that after the fund managers filter out the bias, the precision of an analyst's report is only $\widehat{v}$, which is smaller than v, the precision of an analyst's own signal. Some information is lost during information selling because of the conflict of interest. Equation (36) shows that the quality of an analyst's report decreases with π^*, the extent of conflict of interest. Moreover, if $\pi^* = 0$, an analyst's report has the same quality as his own signal, since there is no conflict of interest.

Adding up all agents' ex ante expected payoff yields the social welfare

$$W = E[P_2 q^*(P_2) - f(q^*(P_2))] - mE[\frac{b_j^{*2}}{2t_j}]. \tag{37}$$

Here, unlike the earlier case in which there is no conflict of interest, now the social welfare includes an extra term, the analysts' cost of biased reports, $mE[\frac{b_j^{*2}}{2t_j}]$. Thus, the sell-side research has two additional costs to the social welfare that are due to the conflict of interest. One is the cost of biases. The other is the loss of information during information selling, which reduces the firm's production profit because it lowers the information efficiency of the stock price. The benefit of sell-side research is that it can increase the firm's production profit by increasing the information efficiency of the firm's stock price. The opposing forces makes the general welfare effects of increasing sell-side research ambiguous. However, under some conditions, social welfare is greater when there are some analysts than when there are not. Figure 5 illustrates this case.

Thus I onclude that although separating sell-side research from investment banking eliminates the cost of conflict of interest, it may destroy welfare by reducing the information efficiency of the financial markets. When solving the conflict-of-interest problem, regulators have to trade-off between the costs and benefits of the sell-side research.

The analysis suggests that the key to the conflict of interest is the linkage between the analysts' pay to investment banking payment, i.e., a positive π^*. If we can limit π^* so that it is close to zero, but still keep the positive constant investment banking subsidy to the analysts, then we get the best of the two worlds. On the one hand, we can still maintain a positive level of sell-side research; on the other, we minimize the conflict of interest problem. One way to achieve this goal is for the regulators to i) allow subsidy

production cost (the greater F, the greater the cost). The condition says that the cost of lying cannot be too small relative to the gain from lying (the lower the production cost, the higher the gain from higher stock price). If the condition is violated, then there may be no equilibrium because the firm is willing to induce $b_j = \infty$.

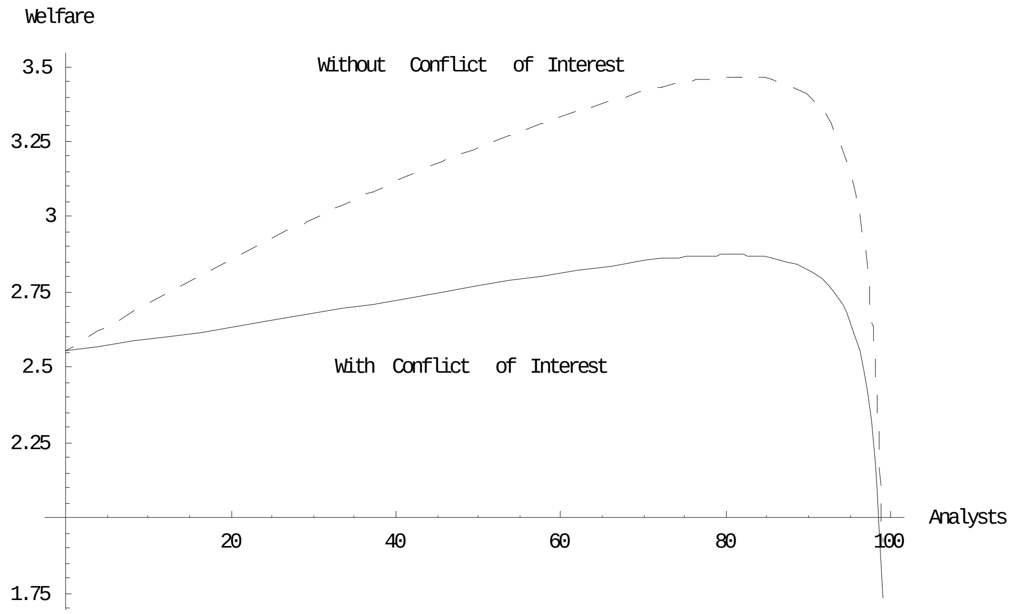

Figure 5: Social Welfare and Number of Analysts

from investment banking to research, but ii) require that the analysts' pays be separate from investment banking payments. It seems that the recent regulations (e.g., the global settlement reached by the SEC and New York Attorney General Elliot Spitzer with ten of the most prestigious sell-side firms in 2003) are trying to do that.

6 Extension: Independent Research

In the real world, there are independent research firms whose main business is selling research. Examples are Standard & Poor's, First Call, and Bloomberg. Why can independent research firms exist without the benefit of investment-banking profit while sell-side research firms cannot? The answer lies in the differences of information that sell-side research and independent research provide. Sell-side research firms focus more on providing human analyses and opinions, such as analysts' recommendations. Independent research firms focus more on providing basic and factual information, such as company news and historical information. I call the former direct information and the latter indirect information.

Information-producing agents need indirect information that independent research firms provide to generate their own information. For example, a fund manager needs a company's financial statements and industry information to generate his own view about the company. That is, fund managers' information and independent research firms' information are complementary. By providing complementary information rather than substitutive information, independent research firms can exist without investment-banking profit because fund managers are willing to pay a high price for that information.

To incorporate this idea formally into the model, I assume that without indirect information, which is signal s_I, an information-producing agent's own signal has precision γv, $\gamma \leq 1$, but with signal s_I, his own signal has precision v. The smaller the γ, the poorer the quality of the information-producing agents' signals without s_I, the more important s_I is to other agents' information production. Thus, γ measures the complementarity between s_I and other agents' signals. Because s_I is the basic, factual information such as company news, I assume that if two or more information-producing agents produce s_I, they obtain the same signal. I further assume that s_I cannot be traded on directly. To generate tradable information, such as an estimate of a company's value, information-producing agents must analyze and interpret the indirect information.

The model is the modified as follows. At date 0, an information-producing agent can choose to be a fund manager, or an independent analyst.[28] At date 1, independent analysts sell their information to fund managers. Here, the quality of information is contractible so there is no conflcit of interest. The events at dates 2 and 3 remain the same.

Proposition 13 shows that if s_I is important enough to the information production of other agents, then even without investment-banking profit, there remains an equilibrium in which there is one independent analyst:

Proposition 13 *There exists a* $\underline{\gamma} > 0$*, such that for* $\gamma \in (0, \underline{\gamma})$*, there exists an equilibrium in which:*

(i) There is one independent analyst and $N-1$ *fund managers.*

(iii) The independent analyst sells s_I *to all the fund managers, and the fund managers trade in the financial market as characterized by Proposition 2.*

[28] I also analyze the case where agents can choose to be analysts also. The results are qualitatively the same.

A fund manager without s_I is at a disadvantage in trading in the financial market, because he has poor-quality information while other fund managers have high-quality information. Therefore, the fund manager is willing to pay a high price for the independent analyst's information.

Comparing this result with Proposition 7, which shows that sell-side research cannot exist without subsidy, we can see the important role the substitutive nature of agents' information plays in Proposition 7. Unlike the case there, the independent analyst here can exist because he can capture a significant portion of the fund managers' trading profits (when γ is close to zero, the independent analyst captures almost all the fund managers' trading profits).

7 Implications

This study has a variety of implications for firms operating in the capital markets, their clients, and their regulators.

7.1 Equities Research

The equities research departments at major securities firms ("analysts" in my model) have long been bundled with investment banking, as my theory predicts. Unfortunately, this structure has given rise to the conflict-of -interest problem in sell-side research. However, from a regulator's point of view, it may actually be desirable to maintain a certain level of sell-side research regardless the conflict-of-interest problem, because sell-side research might improve information efficiency in the economy.

The global settlement reached by the SEC and New York Attorney General Elliot Spitzer with ten of the most prestigious sell-side firms in 2003 seems to be consistent with my theory. That is, first of all, the settlement does not require the investment banks to spin off their research departments; and second, in an effort to promote independent research, the settlement requires the ten firms to subsidize the independent research firms.[29] The intention of the settlement is to let the investment banks subsidize research without undesired influence on analysts by the investment bankers.

[29] The $1.5 billion settlement requires the sell-side firms to pay $460 million for independent research over five years, and to distribute independent research reports together with their own reports. See "Pain of Wall Street Settlement To Be Eased by U.S. Taxpayers," Wall Street Journal, Feb. 13, 2003, for details of the settlement.

7.2 Credit Rating

In the credit rating industry, the bulk of the credit rating agency revenue comes from bond issuer fees rather than selling research to institutional investors.[30] Just as the sell-side research departments need the investment-banking subsidy, so do the credit rating agencies need payment from bond issuers to sustain their research function. Credit rating agencies and sell-side research departments are similar in that both generate and distribute information about issuers, and both are compensated mainly by the issuers in the form of direct payment in the former case and investment-banking profit in the latter case. Because of this similarity, the credit rating agencies are subject to the same conflict-of-interest problem as the sell-side equities research departments, as evidenced by the Nov. 15, 2002, SEC public hearing on credit rating agencies.

As in case of sell-side equity research, eliminating the conflict-of-interest problem by prohibiting credit rating agencies from receiving payment from issuers may not be a good idea. Because the credit rating agencies can make more profit by setting up bond funds, regulation that prohibits issuer fees could cause rating agencies to cease to exist as information providers.[31]

Originally, credit rating agencies provided rating services free to issuers, and financed their operations solely through the sale of publications and related materials. It was not until the late 1960s and the early 1970s that rating agencies started to charge issuers for ratings. Cantor and Packer (1995) and White (2001) argue that the change was caused by the wide-spread use of copy machine, which made it hard for the rating agencies to maintain their profit margins. I think this explanation is inadequate because there are firms doing well despite facing the same problem. Information providers such as Dun & Bradstreet Credit Rating have been successful in selling information despite the fact that they are under the same pressure from cheap copying technology.[32] In fact, when Moody's started to charge the issuers, Dun & Bradstreet Credit Rating, the parent company of Moody's at that time, continued to maintain itself on subscriber fees.

My analysis suggests a more plausible explanation. Before the change in fee structure, today's wide-spread professionalization of portfolio management was not well developed. An individual trading on his

[30] According to Moody's annual report, in 1999 close to 90% of its revenue was from rating services, paid by the issuers.

[31] To be more precise, here I mean direct information providers. Indirect information providers may still exist, for the same reason that independent research firms do.

[32] Dun & Bradstreet provides credit information on firms around the world, which is not intended for tading. Thus, the result that research needs subsidy may not apply here.

own wealth would not find trading particularly profitable, simply because of limited capital.[33] Therefore, selling information to more investors would be a better alternative for the rating agencies. As professional portfolio management became more advanced at the end of the 1960s and the early 1970s, establishing a fund became increasingly attractive for a rating agency. Facing increasing opportunity costs, to maintain their business credit rating agencies had to charge issuers. As Leo O'Neill, president of Standard & Poor's, put it during the SEC hearing: "The practice (charging issuers for rating services, added by the author) was implemented because of increasing costs related to credit ratings surveillance and growing need for more rating coverage. Prior to that, Standard & Poor's provided its credit rating services on the basis of subscription fees, which were not adequate to offset the increased costs of maintaining a high level of quality in this business."

8 Conclusion

My analysis examines the allocation of information production between the buy-side and the sell-side firms when identical information-producing agents can choose to be either sell-side analysts or buy-side fund managers. Analysts profit by selling information to fund managers and doing investment banking; fund managers profit by trading on both their own information and the information they buy from the analysts.

I show that for analysts to be in equilibrium, an investment-banking subsidy to analysts is necessary. Without a subsidy, an information-producing agent earns less as an analyst than he would as a fund manager, because both the substitutive nature of the agents' information and the competition among fund managers to trade on analysts' information limit an analyst's profits from selling information. Tying investment banking to sell-side research enables such a subsidy. Even though this subsidy may cause a conflict-of-interest problem, a total separation of investment banking from sell-side research may not be a good idea, because analysts improve social welfare by enhancing the information efficiency of the financial markets. Instead, regulators may have to tolerate some degree of conflict of interest in the economy.

My analysis also explains the existence of independent research and the fee structure in the credit rating industry.

[33] In the model, the assumption that the fund managers can take arbitrary large positions is more appropriate for mutual funds or hedge funds. However, for small individal investors, this assumption is unrealistic.

Appendix: Proofs of Propositions

Proof of Lemma 1: Suppose the opposite is true, that is, there exist an equilibrium in which analyst j don't sell to fund manager i. Because analyst j's information can never reduce fund manager i' s profit, it implies that fund manager i values analyst j's information at zero. Otherwise analyst j would be better off by making an offer to i at a positive price and i would accept it. A contradiction to equilibrium definition. Under passive belief, if i values j's information at zero, it must be that i's trading strategy x_i is the same with s_j as without s_j by the uniqueness of the fund manager's problem $\max_{x_i} E[x_i(V + \delta - (V + \eta y))|F_i]$. F_i is i's equilibrium information set defined in the main text. By the first order conditions for x_i, this implies

$$
\begin{aligned}
x_i(F_i) &= \frac{E[\delta|F_i] - \eta \sum_{k \neq i} E[x_k|F_i]}{2\eta} \\
&= \frac{E[\delta|F_i, s_j] - \eta \sum_{k \neq i} E[x_k|F_i, s_j]}{2\eta} \\
&= x_i(F_i, s_j)
\end{aligned}
$$

Because $E[\delta|F_i]$, $E[\delta|F_i, s_j]$, $E[x_k|F_i]$, and $E[x_k|F_i, s_j]$ are linear in signals in i's information set in linear equilibrium, matching coefficient gives us a set of linear equations on model parameter values. For model parameter values outside the set defined by these equations, $x_i(F_i) \neq x_i(F_i, s_j)$, which is a contradiction. The set of parameter values as defined by the set of equations is of measure zero in the Euclidean space. Therefore, one can conclude that Lemma **1** holds generically.

Proof of Proposition 2: I substitute equations (6) and into fund manager i's objective function (2), simplify, and get

$$
\max_{x_i} \quad x_i\{E[\delta|F_i] - \alpha\eta(n-1)s_p - \beta\eta(n-1)E[\delta|F_i] - \eta x_i\}, \tag{38}
$$

where $E[\delta|F_i] = \frac{mvs_p + vs_i}{1+mv+v}$ by Bayes rules. The first-order condition for this problem is

$$
\begin{aligned}
x_i^* &= \frac{[1 - \beta\eta(n-1)]E[\delta|F_i] - \alpha\eta(n-1)s_p}{2\eta} \\
&= \frac{1}{2\eta}\{[[1 - \beta\eta(n-1)]\frac{mv}{1+mv+v} - \alpha\eta(n-1)]s_p + [1 - \beta\eta(n-1)]\frac{v}{1+mv+v}s_i\}.
\end{aligned} \tag{39}
$$

Because $x_i = \alpha s_p + \beta s_i$ in symmetric equilibrium:

$$\alpha = \frac{1}{2\eta}[(1-\beta\eta(n-1))\frac{mv}{1+mv+v} - \alpha\eta(n-1)], \quad (40)$$
$$\beta = \frac{1}{2\eta}(1-\beta\eta(n-1))\frac{v}{1+mv+v}. \quad (41)$$

Solving equations (40) and (41), I get α and β. For part (ii), fund manager i's expected trading profit is

$$E[\frac{[(1-\beta\eta(n-1))E[\delta|F_i] - \alpha\eta(n-1)s_p]^2}{4\eta}]. \quad (42)$$

Simplifying it by using the fact that $E[(E[\delta|F_i])^2] = \frac{v+mv}{1+mv+v}$, $E[(E[\delta|F_i])s_p] = 1$, and $E[s_p^2] = 1 + \frac{1}{mv}$, I get

$$\frac{1}{4\eta}\{[1-\eta\beta(n-1)]^2\frac{v+vm}{1+v+vm} + [\alpha\eta(n-1)]^2\frac{1+vm}{vm} - 2[1-\eta\beta(n-1)][\alpha\eta(n-1)]\}. \quad (43)$$

Substituting in α and β, I get (9). For part (iii), substituting α and β into (3) yields the result.

For part (iv), the market maker sets the price according to (4). But,

$$E[\delta|y] = \frac{\frac{1}{n(\alpha+\beta)}y}{1 + (\frac{\alpha}{\alpha+\beta})^2\frac{1}{mv} + \frac{n\beta^2}{(n(\alpha+\beta))^2 v} + \frac{\sigma_z^2}{(n(\alpha+\beta))^2}}, \quad (44)$$

which implies

$$\eta = \frac{\frac{1}{n(\alpha+\beta)}}{1 + (\frac{\alpha}{\alpha+\beta})^2\frac{1}{mv} + \frac{n\beta^2}{(n(\alpha+\beta))^2 v} + \frac{\sigma_z^2}{(n(\alpha+\beta))^2}}. \quad (45)$$

Together with equations (40) and (41), solving for α, β, and η gives the desired results.

For uniqueness, the general linear trading strategy is defined as $x_i = \beta_i s_i + \sum_{j\in A^i} a_i^j s_j$. Equations (40) and (41) become

$$2\eta\beta_i = \frac{v}{1+mv+v}(1-\eta\sum_{j\neq i}\beta_j), \quad (46)$$
$$2\eta a_i^l = \frac{v}{1+mv+v}(1-\eta\sum_{j\neq i}\beta_j) - \eta\sum_{j\neq i}a_j^l, \ \forall l \text{ such that } s_l \in A^i. \quad (47)$$

Substracting $\frac{v}{1+mv+v}\eta\beta_i$ from both sides of the equation (46) and rearranging terms gives us

$$\beta_i = \frac{1}{(2-\frac{v}{1+mv+v})\eta}\frac{v}{1+mv+v}(1-\eta\sum_j \beta_j).$$

Therefore, $\beta_i = \beta_j = \beta$, for any i and j. Similarly, substracting ηa_i^l from both sides of equation (47) and rearranging terms gives us $a_i^l = \frac{1}{\eta}[\frac{v}{1+mv+v}(1-\eta(n-1)\beta) - \eta\sum_j a_j^l]$. That is, $a_i^l = a_j^l = a_l$ for any i and j. Substituting the a_l and β into equation (47), we have $a_l = \frac{1}{(n+1)\eta}\frac{v}{1+mv+v}(1-\eta(n-1)\beta)$. Therefore, $a_l = a_q = a$ for any l and q. That is, symmetry assumption is without loss of generality. Since the above α, β are uniquely determined, the uniquness follows.

Proof of Corollary 3: Proofs of Part (i), (ii), and (iii) are already given in the main text. For part (iv), the volume generated by sell-side analyst j and by fund manager i are $naE[|s_j|]$ and $\beta E[|s_i|]$, respectively. Because $\beta > na$, as shown in part (i), and s_i and s_j are identically distributed, I conclude that $naE[|s_j|] > \beta E[|s_i|]$.

Proof of Proposition 4: Conditional on all other fund managers buying from all analysts and trading as specified in Proposition 2, fund manager i's objective is

$$\max_{x_i} \quad x_i(E[\delta|F_i] - \alpha\eta(n-1)E[s_p|F_i] - \beta\eta(n-1)E[\delta|F_i] - \eta x_i) \tag{48}$$

where α and β are as in Proposition 2. I have

$$E[s_p|F_i] = \frac{1}{m}(\sum_{j\in A^i} s_j + \sum_{k\notin A^i} E[s_k|F_i]) \tag{49}$$

$$= \frac{l}{m}s_l + \frac{m-l}{m}E[\delta|F_i]. \tag{50}$$

Substituting (50) into the objective function and taking the first-order condition, I get fund manager i's optimal trading strategy

$$x_i^*(A^i) = \frac{(1-\beta\eta(n-1) - \alpha\eta(n-1)\frac{m-l}{m})E[\delta|F_i] - \alpha\eta(n-1)\frac{l}{m}s_l}{2\eta}. \tag{51}$$

The expected profit under the optimal trading strategy is

$$\pi_i(A^i) = \frac{1}{4\eta}E[[1-\beta\eta(n-1)-\alpha\eta(n-1)\frac{m-l}{m}]E[\delta|F_i]-\alpha\eta(n-1)\frac{l}{m}s_l)^2] \tag{52}$$

Substituting $E[\delta|F_i] = \frac{lvs_l+vs_i}{1+v+lv}$ into equations (51) and (52), and simplifying by using $E[(E[\delta|F_i])^2] = \frac{v+lv}{1+lv+v}$, $E[(E[\delta|F_i])s_l] = 1$, and $E[s_l^2] = 1+\frac{1}{lv}$, I get

$$\begin{aligned}\pi_i(A^i) &= \pi_i(l) = \frac{1}{4\eta}\{(1-\eta\beta(n-1)-\eta\alpha(n-1)\frac{m-l}{m})^2\frac{v+v_l}{1+v+v_l}+[\alpha\eta(n-1)\frac{l}{m}]^2\frac{1+v_l}{v_l} \\ &\quad -2(1-\eta\beta(n-1)-\eta\alpha(n-1)\frac{m-l}{m})\alpha\eta(n-1)\frac{l}{m}\},\end{aligned} \tag{53}$$

which is part (i).

Part (ii) follows from:

$$\begin{aligned}\frac{d\pi_i(l)}{dl} &= \frac{16(1+v+mv)^2}{(1+n)^2(2+(1+2m+n)v)^2(1+v+lv)^2} > 0, \\ \frac{d^2\pi_i(l)}{dl^2} &= -\frac{32v(1+v+mv)^2}{(1+n)^2(2+(1+2m+n)v)^2(1+v+lv)^3} < 0.\end{aligned}$$

Proof of Proposition 5: Formally, fund manager i's problem is

$$\pi_b(S^i) \equiv \max_{A_i\subseteq S_i} \pi_i(l(A^i)) - \sum_{j\in A_i} p_j^i. \tag{54}$$

Recall that p_j^i is analyst j's offer price to fund manager i. I use two steps to solve (54). The first is to determine the optimal A^i for fixed l. Because fund manager i's profit depends on only the number of analysts he buys from, not the particular choice of analysts, if fund manager i decides to buy from l analysts, he chooses to buy from the l cheapest analysts. The second step is to determine the optimal l. On the one hand, the marginal benefit of analysts' information is decreasing, as shown by Proposition 4. On the other hand, the marginal cost of the information is increasing because as l increases, more expensive analysts will be included in A^i. Thus, (15) is necessary and sufficient for the unique optimum for problem (54).

Proof of Proposition 6: Simplifying (16) using 53, I get part (i). Part (ii) is proved in the main text. Part (iii) follows by simplifying $\pi_b = \pi(m) - mp$ and $\pi_s = np + \pi_I(m,n)$.

Proof of Proposition 7: The equations in this proof are derived using Mathematica. The progam is avaliable from the author upon request. After simplification, I have

$$\pi_s(m) - \pi_b(m-1) =$$
$$-\frac{4v}{(1+N-m)^4}[\frac{4(m-1)^2}{1+(m-1)v} + \frac{(N-m-1)(1+N-m)(5+2N+N^2-2(3+N)m+m^2)}{(2+(N+m-1)v)^2}$$
$$+\frac{(N+m-1)(5+2N+N^2-2(3+N)m+m^2)}{2+(N+m-1)v} - \frac{4(N-m-1)(1+N-m)(N-m)}{(2+(N+m-1)v)^2}$$
$$+\frac{4(N-m)m}{1+mv} - \frac{4(1+N+m)(N-m)}{2+(N+m-1)v}].$$

Thus, $\pi_s(m) - \pi_b(m-1)$ has the opposite sign of the term in the square brackets. I then combine the terms in the square brackets into a big fraction. Because the denominator is positive, I need to show only that the numerator is positive. The numerator is $(1+N-m)^2$ times:

$$\begin{aligned}B(N,m) \equiv\ & 4(1+N-m)^2 + 4[5+N^3+N^2(m-1) - K(m+1)(5m-3) + m(m(7+3m)-7)]v \\ & + [13+24N-6N^2+N^4+8(3+N+N^2+N^3)m - 2(45+N(3N-8))m^2 - 8(2N-5)m^3 \\ & + 13m^4]v^2 + [-8(N-1)^2N + 2(21+N(4+N(-6+N(N+4))))m + 4(1+N(-7+N(7+N)))m^2 \\ & - 8(10+(-4+N)N)m^3 - 4(-7+N)m^4 + 6m^5]v^3 + [-(-1+N)^4 \\ & + (-1+N)(N+1)(3+(-12+N)N)m + (23+N(-8+N(-12+N(12+N))))m^2 \\ & + 2(-3+N(-14+11N))m^3 - (23+2(-10+N)N)m^4 + 9m^5 + m^6]v^4 \\ & + (-1+m)m(-1+N+m)^2(1+N+m)^2v^5. \end{aligned} \tag{55}$$

I show that $B > 0$ in three steps: B is convex in N, B is increasing in N, and B is positive. First

$$\begin{aligned}\frac{\partial^2 B}{\partial N^2} =\ & 4\{2 + 2(-1+3N+m)v + [-3+3N^2+12Nm+(4-3m)m]v^2 \\ & +2[4+3N^2m+m(-3+(7-2m)m)+3N(-2+m(2+m))]v^3 \\ & +[-3+m-m^2(6+(-11+m)m)+6N(1+3(-1+m)m)+3N^2(-1+m+m^2)]v^4 \\ & +(-1+m)m(-1+3(N+m)^2)v^5\}. \end{aligned} \tag{56}$$

The coefficients of v, v^2, v^3, and v^5 are non-negative for $m \geq 1$ and $N \geq m+1$. The coefficient of v^4 is increasing in N. So, for a given m, the smallest possible value of the coefficient can be achieved by the smallest N, which is $m+1$. Substituting $N = m+1$ into the coefficient, the coefficient of v^4 becomes

$$2m[-7 + m^2(19+m)], \tag{57}$$

which is positive for $m \geq 1$. Thus, I conclude that the coefficient of v^4 is positive. Hence, I have shown $\frac{\partial^2 B}{\partial N^2} > 0$.

Because $\frac{\partial B}{\partial N}$ is increasing in N for a given m, the smallest $\frac{\partial B}{\partial N}$ can be achieved by the smallest N. Again, the smallest possible N is $m+1$. At $N = m+1$, $\frac{\partial B}{\partial N}$ is

$$\frac{\partial B}{\partial N}|_{N=m+1} = 16v(1+v)(1+v+mv)(1+m(1+(-1+m)v)(1+v+2mv). \tag{58}$$

$\frac{\partial B}{\partial N}|_{N=m+1} > 0$. Thus, I can conclude that $\frac{\partial B}{\partial N} > 0$.

Finally, because $\frac{\partial B}{\partial N} > 0$, the smallest B can be achieved by the smallest N. Substituting $N = m+1$ into B, I get

$$B|_{N=m+1} = 16v(1+mv)^2(1+v+mv)[2+(-1+m)m(1+v+mv)], \tag{59}$$

which is positive. Thus, I have shown that for a given $m \geq 1$, B is positive. Hence, $\pi_s(m) - \pi_b(m-1)$ is negative for $1 \leq m \leq N-1$.

Part (ii) follows directly by checking that $m^* = 0$ satisfies both (20) and (21).

Proof of Proposition 9: $\pi_b(m^*) > \pi_r(m^*)$ if and only if

$$\frac{1}{4\eta}\left(\frac{4v[(n^*+1)^2 + [4m^{*2} + (1+n^*)^2 + m^*(1+n^*(6+n^*))]v + m^*(1+2m^*+n^*)^2v^2]}{(1+n^*)^2(1+m^*v)(2+(1+m^*+n^*)v)^2}\right.$$
$$\left. > \frac{1}{4\eta}\left(\frac{16n^*v(1+v+m^*v)}{(1+n^*)^2(1+m^*v)(2+(1+m^*+n^*)v)^2}\right).\right.$$

After some simplification, this condition is equivalent to

$$4v[(n^*+1)^2+[4m^{*2}+(1+n^*)^2+m^*(1+n^*(6+n^*))]v+m^*(1+2m^*+n^*)^2v^2-16n^*v(1+v+m^*v)] > 0. \tag{60}$$

Simplifying the right-hand side, I get

$$4v[(-1+n^*)^2 + [4m^{*2} + (-1+n^*)^2 + m^*(1+n^*)^2]v + m^*(1+2m^*+n^*)^2v^2], \tag{61}$$

which is positive for $m^* \geq 1$ and $n^* \geq 1$.

Proof of Proposition 10: There are two cases need to be analyzed, namely $m = 1$ and $m = 2$. Since $m = 2$ case is the same as the non-commitment case studied before, I focus on $m = 1$ case. The analyst can choose whether to sell to one or two fund managers. Selling to two fund managers cannot be equilibrium since the analyst's profit is less than what he can make if he chooses to be a fund manager by Proposition 7. Now lets study the case where the analyst choose to sell to only one fund managers. It turns out that the analyst still has incentive to deviate. Denote the fund manager buys analyst's signal agent 1, the one who doesn't, agent 2, and analyst agent 3. When trading in the financial market, the fund managers solve

$$\max_{x_i} E[x_i(V + \delta - (V + \eta y))|F_i], \tag{62}$$

The optimal solution is $x_i = \frac{E[\delta|F_i] - \eta E[x_j]}{2\eta}$. I assume that $x_1 = a_1 s_3 + \beta_1 s_1$ and $x_2 = \beta_2 s_2$. Solving for a_1, β_1, and β_2, we have

$$\begin{aligned} a_1 &= \beta_1 = \frac{v(2+v)}{2\eta[2+3v(2+v)]}; \\ \beta_2 &= \frac{v(1+v)}{\eta[2+3v(2+v)]}. \end{aligned}$$

The profit of fund manager 1 is

$$\pi_1(1) = \frac{E(E[\delta|s_1, s_3])^2(1-\eta\beta_2)^2}{4\eta}.$$

If fund manager 1 does not buy analyst's information, the profit is $\pi_1(0) = \frac{E(E[\delta|s_1])^2(1-\eta\beta_2)^2}{4\eta}$. Thus the analyst's profit is

$$\begin{aligned}\pi_3 &= \pi_1(1) - \pi_1(0) = \frac{(1-\eta\beta_2)^2}{4\eta}[E(E[\delta|s_1, s_3])^2 - E(E[\delta|s_1])^2] \\ &= \frac{(1-\eta\beta_2)^2}{4\eta}[\frac{2v}{1+2v} - \frac{v}{1+v}] \\ &= \frac{(1-\eta\beta_2)^2}{4\eta}\frac{v}{(1+2v)(1+v)} \qquad (63)\end{aligned}$$

Consider the case where agent 3 chooses to be a fund manager. Solving for the symmetric equilibrium, $x_i = \beta'_i s_i$, we have

$$\beta'_1 = \beta'_2 = \beta'_3 = \frac{v}{2\eta(1+2v)}$$

Agent 3's profit is

$$\begin{aligned}\pi'_3 &= \frac{E(E[\delta|s_3])^2(1-\eta\beta'_2-\eta\beta'_1)^2}{4\eta} \\ &= \frac{1}{4\eta}\frac{v}{1+v}(1-\frac{v}{2+3v})^2(1-\eta\beta'_2)^2\end{aligned}$$

The last equation follows because $\eta\beta'_1 = \frac{1-\eta\beta'_2}{2+3v}$. After some algebra, I get $\beta_2 - \beta'_2 > 0$. The proposition holds if $\pi'_3 > \pi_3$. In order to show that $\pi'_3 > \pi_3$, I only need to show that $\frac{v}{1+v}(1-\frac{v}{2+3v})^2 > \frac{v}{(1+2v)(1+v)}$. It is straight forward to check it is indeed the case.

The proof of Proposition 11: It is enough to show that in two economies, denoted by 1 and 2, if $\Sigma_{r0} > \Sigma_{r1}$, then $W_0 > W_1$.

Because $\Sigma_{r0} > \Sigma_{r1}$, P_2^0 and $P_2^1 + \phi$ have the same distribution, where $\phi \backsim N(0, \Sigma_{r0} - \Sigma_{r1})$ and ϕ and P_2^1 are independent. Thus I have

$$W_0 = E[P_2^0 q^*(P_2^0) - f(q(P_2^0))] = E[(P_2^1+\phi)q^*(P_2^1+\phi) - f(q^*(P_2^1+\phi))]. \qquad (64)$$

But

$$(P_2^1+\phi)q^*(P_2^1+\phi) - f(q^*(P_2^1+\phi)) \geq (P_2^1+\phi)q^*(P_2^1) - f(q^*(P_2^1)), \qquad (65)$$

since $q^*(P_2^1+\phi)$ uniquely maximizes $(P_2^1+\phi)q - f(q)$. Furthermore, the inequality in (65) is strict for $\phi \neq 0$. Taking expectation of both sides, I get

$$\begin{aligned} E[(P_2^1+\phi)q^*(P_2^1+\phi) - f(q^*(P_2^1+\phi))] &> E[(P_2^1+\phi)q^*(P_2^1) - f(q^*(P_2^1))] \\ &= E[E[(P_2^1+\phi)q^*(P_2^1) - f(q^*(P_2^1))|P_2^1]] \\ &= E[P_2^1 q^*(P_2^1) - f(q^*(P_2^1))]. \end{aligned} \quad (66)$$

The last equality follows because $E[\phi|P_2^1] = 0$. Combining (64) and (66) yields $W_0 > W_1$.

Proof of Proposition 12: The FOC of analyst j's problem yields

$$b_j = \pi_j t_j. \quad (67)$$

Thus, $r_j = s_j + \pi_j t_j$. Fund managers do not observe π_j and t_j, but in equilibrium they infer π_j^* correctly. That is, they would use $\widehat{s}_j = r_j - \pi_j^* T$, which equals $s_j + \pi_j^*(t_j - T)$ in equilibrium, in their trading. Thus, $\widehat{s}_j$ has precision

$$\widehat{v}_j = \frac{v v_t}{\pi_j^{*2} v + v_t} \quad (68)$$

in equilibrium. In a symmetric equilibrium, $\widehat{v}_j = \widehat{v}$ and $\pi_j^* = \pi^*$, for given j.

As in section 3, all fund managers buy from all analysts (to save space, I omit the details in market for information). By the same analysis as in the proof of Proposition 2, we get the fund managers trading strategy, which is given by

$$a = \frac{2\widehat{v}}{\eta[2(1+m\widehat{v}) + (1+n)v](1+n)}, \quad (69)$$

$$\beta = \frac{v}{\eta[2(1+m\widehat{v}) + (n+1)v]}. \quad (70)$$

The stock price is given by

$$P_2 = V + na\eta \sum_{j=1}^{m} \widehat{s}_j + \beta\eta \sum_{i=1}^{n} s_i + \eta z. \quad (71)$$

The FOC of the firm's problem with respect to q yields

$$q(p) = \frac{P_2}{2F}. \quad (72)$$

Substituting (72), (67) and $E[s_j] = 0$ into the firm's problem yields

$$\max_{\pi_j} E[\frac{P_2^2}{2F} - \sum_j^m \pi_j^2 t_j]. \tag{73}$$

Taking the first-order condition, I get

$$E[\frac{P_2}{F}\frac{\partial P_2}{\partial \pi_j} - 2\pi_j t_j] = 0 \tag{74}$$

But $\frac{\partial P_2}{\partial \pi_j} = na\eta t_j$, substituting it into equation (74) yields

$$\frac{na\eta}{F} E[P_2 t_j] - 2\pi_j T = 0. \tag{75}$$

In equilibrium, I have

$$\begin{aligned} E[P_2 t_j] &= E[(V + na\eta \sum_{k=1}^m (s_k + \pi_k^*(t_k - T)) + \beta\eta \sum_{i=1}^n s_i + \eta z) t_j] \\ &= E[V t_j + na\eta \pi_j^* (t_j - T) t_j] \\ &= VT + na\eta \pi_j^* \frac{1}{v_t}. \end{aligned} \tag{76}$$

Substituting equation (76) and equilibrium condition, $\pi_j = \pi_j^*$, into (75), yields

$$\frac{na\eta}{F} VT + \frac{(na\eta)^2}{F} \pi_j^* \frac{1}{v_t} - 2\pi_j^* T = 0 \tag{77}$$

Taking the second-order condition of the firm's problem

$$\frac{(na\eta)^2}{F}(T^2 + \frac{1}{v_t}) - 2T < 0. \tag{78}$$

Because $na\eta \leq 1$, (78) is satisfied if $T + \frac{1}{Tv_t} \leq 2F$. Notice that because the objective function is quadratic, SOC also guarantees that FOC yields the unique global maximum of the firm's problem.

Solving (77) and (68) yields $\pi_j^* \equiv \pi^*$, which is a positive solution to the following fifth-order polynomial equation

$$2\{-n(1+n)TvVv_t[\pi^{*2}v(2+v+nv)+[2+(1+2m+n)v]v_t]+$$
$$F\pi^*\{(1+n)^2\pi^{*4}Tv^2(2+v+nv)^2+2v[-n^2v+(1+n)^2\pi^{*2}T(2+v+nv)(2+(1+2m+n)v)]v_t$$
$$+(1+n)^2T[2+(1+2m+n)v]^2v_t^2\}\}=0. \tag{79}$$

There is always at least one positive solution to this equation because when $\pi^* = 0$, the LHS is negative but the coefficient of π^{*5} is positive. So for a large enough π^* , the LHS is positive. By continuity, there must be a positive π^* such that (79) is satisfied.

Proof of Proposition 13: At date 2, the equilibrium path is characterized by Proposition 2, with $m = 1$ and $n = N - 1$. At date 1, by the same analysis as in section 3.2, the equilibrium price for an independent analyst's information is

$$p = \frac{4(1-\gamma)v(1+v)}{(2+v+nv)^2(1+\gamma v)}. \tag{80}$$

Therefore, the independent analyst's equilibrium profit is

$$\pi_i = \frac{4n(1-\gamma)v(1+v)}{(2+v+nv)^2(1+\gamma v)}, \tag{81}$$

and a fund manager's profit is

$$\pi_b = \frac{4\gamma v(1+v)^2}{(1+\gamma v)(2+v+nv)^2}. \tag{82}$$

I first check the independent analyst's IC condition. If the independent analyst decides to be a fund manager, then there will be $n + 1$ fund managers and each fund manager's signal has precision γv. Thus, the deviating independent analyst will get

$$\pi_b(n+1) = \frac{4\gamma v(1+\gamma v)}{(2+\gamma v+(n+1)\gamma v)^2} \tag{83}$$

and the independent analyst's IC condition is satisfied iff $\pi_i - \pi_b(n+1) \geq 0$. But

$$\lim_{\gamma \to 0} \left[\pi_i - \pi_b(n+1)\right] = \frac{4nv(1+v)}{(2+v+nv)^2} > 0. \tag{84}$$

Therefore, there exists an $\underline{\gamma} > 0$, such that if $\gamma \in (0, \underline{\gamma})$, the independent analyst's IC is satisfied.

Now I check a fund manager's IC. If a fund manager deviates to become an independent analyst, he will produce the same s_I as the other independent analyst. But in the market for information, the two independent analysts will engage in Bertrand competition, which implies that the deviating fund manager's profit is zero. Thus, a fund manager is not willing to deviate to become an independent analyst.

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