DISCUSSION PAPER SERIES

No. 5314

THE INDUSTRIAL ORGANIZATION OF FINANCIAL MARKET INFORMATION PRODUCTION

Zhaohui Chen and William J Wilhelm Jr

FINANCIAL ECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: www.cepr.org/pubs/dps/DP5314.asp

ISSN 0265-8003

THE INDUSTRIAL ORGANIZATION OF FINANCIAL MARKET INFORMATION PRODUCTION

Zhaohui Chen, Temple University
William J Wilhelm Jr, University of Virginia and CEPR

Discussion Paper No. 5314
October 2005

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 5314

October 2005

ABSTRACT

The Industrial Organization of Financial Market Information Production*

In our model, information-producing agents can opt to produce from the sell-side, in which case they can only sell their information to other market participants, or produce from the buy-side, in which case they agent can trade in the financial market. If sell-side information substitutes for that produced on the buy-side, some form of subsidy is necessary to sustain sell-side production in equilibrium because sell-side agents cannot commit to narrow dissemination of their information among buy-side agents. Competition among buy-side agents leaves buy-side (private) information as the primary source of trading profits. Subsidizing sell-side research promotes welfare because such information enters financial market prices and thereby improves real investment decisions. But subsidies compromise welfare through conflicts of interest facing the sell-side analyst. We derive conditions under which the net welfare effect is positive and shed light on means of managing the tradeoff.

JEL Classification: D82, G14, G24 and L22
Keywords: conflicts of interest, financial analysts, industrial organization, investment banking and securities regulation

Zhaohui Chen
Finance Department
Fox School
Temple University
Speakman Hall, 1810 North 13th Street
Philadelphia, PA 19122-6083
USA
Email: zhchen@temple.edu

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=163411

William J Wilhelm Jr
2100 Minor Road
Charlottesville
VA 22903
USA
Tel: (1 434) 244 6363
Fax:
Email: Bill.Wilhelm@Virginia.edu

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=150056

* We thank Franklin Allen, Phillip Bond, Helena Fang, Armando Gomes, Gary Gorton, Pete Kyle, Robert Marquez, David Musto, Maureen O’Hara and Robert Verrecchia helpful discussions. We also thank Marshal Blume, Roger Edelen, Simon Gervais, Paul Grout, Andrew Metrick, Ayako Yasuda, Bilge Yilmaz, and seminar participants at the Second Oxford Finance Symposium, European Financial Association Annual Meeting 2004 (Maastricht), Houston, Kentucky, Maryland, Virginia, and the Wharton School, for helpful suggestions. We are responsible for any errors or omissions.

Submitted 27 September 2005

1 Introduction

Information is the primary output of the securities industry. Investment research is perhaps the most visible and controversial example of the industry's information production. A substantial academic literature identifies systematic biases in analyst research [See Hong and Kubik (2003)] and recent investigations led by the New York Attorney General's office and the Securities and Exchange Commission produced evidence that some biased research was linked to conflicts of interest within the organizations producing the research. Conflicts arise because of the public good nature of information: once produced and revealed to one party, it is difficult to exclude others from using the same information. As a consequence, information production most often is bundled with other financial products and services over which exclusive use rights are more readily established. In this paper we examine the traditional organizational structure for producing investment research and the potential consequences of unbundling production of research from other products and services.

Although there are specialized firms, like Sanford Bernstein and Value Line, for which investment research is the primary output, most securities firms bundle research with other products and services either on the buy-side or the sell-side of the market. Sell-side firms, such as investment banks and brokerage firms, produce research for both wholesale (institutional investor and corporate) clients and retail clients who typically acquire it bundled with other investment banking or brokerage services. Buy-side firms, like mutual funds, produce their own research in addition to that acquired from sell-side producers and bundle the research with asset management services for both retail and institutional investors.[1] The model developed in this paper enables examination of the distribution of information production across buy-side and sell-side firms and its effects on social welfare.

In the model, there are a fixed number of identical risk-neutral information-producing agents who can gather information about a traded risky asset. Each agent has the option to function on the sell-side (as an analyst) or on the buy-side (as a fund manager). In addition to gathering their own information, fund managers can buy information from analysts. Fund managers earn revenues strictly by trading in the financial market while analyst derive revenues strictly from selling information and/or other services.

[1] Cheng, Liu and Qian (2003) estimate that 71% of research is produced by buy-side firms, 24% by sell-side firms, and the remaining 5% by specialized firms.

The main result of our analysis establishes conditions under which the analyst's profit from selling information is too small for any agent to function as an analyst in equilibrium. There are two forces at work in this result. First, competition among fund managers in the financial markets, who trade on both their own information and that acquired from analysts, limits profitable trading on information acquired from analyst's. Fund managers earn trading profits primarily from information produced internally over which they maintain exclusive use rights. Second, if analyst research and fund manager research are substitutes for one another, the limited marginal benefit of the analyst's research to the fund manager limits the analyst's capacity for covering the costs of information production. This result holds in spite of our assumption that the analyst holds all of the bargaining power in its relationships with fund managers. Thus, in equilibrium, agents only opt to become analysts when their research is subsidized by a party incapable of trading on the information in financial markets. Examples of such subsidy arrangements might include tying research to investment-banking services for corporate securities issuers and fees paid by bond issuers to bond rating agencies.

Unsubsidized analysts only exist in equilibrium if their information is complementary to that produced by fund managers thus enabling them to extract sufficient surplus to cover information production costs. An obvious opportunity for sustaining such independent research lies in becoming the low-cost acquirer and distributor of factual information that complements human research analysis and for which their will be wide demand. Presumably, analysts will find it difficult to establish and transfer exclusive rights over factual information. Thus one would expect independent research to be a narrow-margin business dominated by a few large-scale producers characterized by timely and efficient capacity for dissemination of their information. Alternatively, one could imagine an independent analyst with unique skills that yield complementary research.

Our welfare analysis explores the consequences of unbundling sell-side research from other products and services. In our model, competition among fund managers trading on non-exclusive sell-side information causes it to be impounded in financial market prices more rapidly than information produced by fund managers for their exclusive use. Thus the presence of sell-side analysts increases the information content of prices in equilibrium and thereby improves investment decisions. This implies a tradeoff largely ignored in recent efforts to diminish conflicts of interest by separating research from investment-banking. If sell-side research has capacity for promoting competition among fund managers in the financial markets but only if it is subsidized, then eliminating the mechanisms for generating such subsidies, unless they are more costly in their own right, can undermine welfare.

The existing literature does not examine how information production in financial markets is distributed across different types of information-producing agents. Admati and Pfleiderer [(1986), (1988b), and (1990)] show that a monopolistic owner of information will find it more profitable to sell information (indirectly) through a fund rather than selling it (directly) to investors who then trade in the financial markets on their own account. Fishman and Hagerty (1995), however, demonstrate that direct sale of information can arise when there are multiple competing informed traders. By selling his information to others, an informed trader can commit to trade more aggressively on his own information, thus earning a larger profit.[2] We show that it is difficult to sustain independent, direct sale of information when information-producing agents also have the option to earn profits from trading on information they produce themselves.

Our paper is also related Morris and Shin's (2002) analysis of welfare effects of public information when public information both conveys fundamental information to agents and coordinates their behavior. Similar to their analysis, we study agents' use of different forms of information when agents interact strategically with one another. Our analysis differs in the sense that we focus on the endogenous structure of information provision whereas they take the structure as given.

In section 2 we develop the model. Section 3 characterizes trading in the financial market, trading in the market for information, and information-producing agents' decisions to produce from the sell-side or the buy-side. Section 4 studies the relation between sell-side research and the informational efficiency of financial markets. Section 5 studies the conflict of interest in subsidized sell-side research. Section 6 extends the model to explain why independent research exists. Section 7 concludes the paper. All proofs and other technical details are provided in the appendix.

2 The Model

The model's economy comprises four dates, three periods and one risky asset. The risky asset's payoff is realized at date 3 (the end of the third period) and is denoted $\delta + V$, where V is a known constant and δ

[2] Brennan and Chordia (1991) also 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 market liquidity when doing so increases potential trading commissions.

is a random variable. The prior distribution of δ at date 0 is $N(0, \sigma_\delta^2)$. By convention, we define $v_\delta = \frac{1}{\sigma_\delta^2}$ as the random variable's precision and without loss of generality assume that $v_\delta = 1$. The discount rate across periods is normalized to be one.

2.1 Agents and Information

There are three types of risk-neutral agents in the economy: information-producing agents, market makers, and liquidity traders. There are N information-producing agents and for the sake of simplicity we assume that N is exogenously determined. Between date 1 and date 2, 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 $\varepsilon_i \sim N(0, \sigma_i^2)$, δ and ε_i are independent for any i, and ε_i is independent across information producing-agents. The last assumption captures the feature that each agent has a unique perspective about the asset value. Notation is simplified by denoting $v_i \equiv \frac{1}{\sigma_i^2}$ and we further assume that all signals have the same quality so that $v_i = v_j = v$ for any i and j. Finally, without loss of generality, we assume that each agent's cost of receiving the signal is zero.

Market makers set the trading price in the financial market at date 2. Liquidity traders enter the financial market at date 2 with risky asset demand z that is normally distributed with mean zero and variance σ_z^2.

2.2 Sequence of Events

At date 0, each information-producing agent decides whether to be an analyst or a fund manager.[3] After the information-producing agents specialize, there are m analysts and $n \equiv N - m$ fund managers (m and n are determined endogenously) each of whom observes all other agents' decisions. Analysts cannot trade in the financial market, but can sell information to fund managers and engage in other profitable activities, identified as "investment banking." Profit from investment-banking is π_I and is exogenously

[3]For technical completeness, we assume the presence of a coordination device that tells each information-producing agent whether he should be an analyst or a fund manager. In equilibrium, each agent finds it optimal to be guided by the coordination device.

determined. Fund managers cannot sell information directly, either their own or any bought from analysts, but he can trade on behalf of clients in the financial market exploiting both information they produce and any information purchased from analysts. The assumption that fund managers cannot directly resell information produced by analysts effectively provides for the existence of a market for analyst research.[4]

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 for his information to a set of the fund managers of his choice, F_j 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, at a vector of offering prices $p(S^i)$, whose elements are p_j^i, $j \in S^i$. Fund manager i does not observe any offers made by analysts to other fund managers, nor does he observe the buying decisions of other fund managers.[5] However, fund manager i does form beliefs about other offers conditional on the offers he receives and conditions whether to accept an analyst's offer on these beliefs. If he accepts the offer from analyst j, the fund manager pays analyst j the amount p_j^i. In exchange for this payment, analyst j reports his signal to fund manager i. If fund manager i declines analyst $j's$ offer, there is no payment and analyst j does 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 are no agency problems arising from conflicts of interest in the sale of information. We study conflicts of interest facing analysts in section 5.

After date 1, each information-producing agent receives a signal about the value of the asset and analysts report their signals to the fund managers who have paid for them. At date 2, fund managers, but not analysts, trade in the financial market on their information, conditional on their beliefs about other fund managers' information and strategies. The trading mechanism is similar to that in Kyle (1985). 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

[4]In practice, direct resale of analyst research is uncommon. We also abstract from the fact that modern sell-side firms commonly have asset management divisions. Sell-side and buy-side research efforts are separated by Chinese walls similar to those that stand between sell-side research and investment-banking divisions.

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

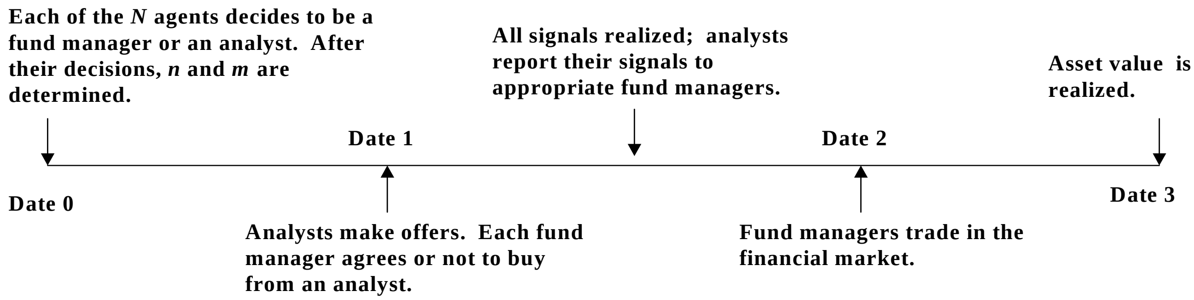

Figure 1: Sequence of Events

supplying liquidity at a price, P_2, conditioning on the total order flow y. We further assume that market makers do not observe the composition of analysts in the economy. In other words, they do not 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 used here is *Perfect Bayesian Equilibrium* (PBE). 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^*.

(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 analyst's and fund managers' beliefs about offers made by other analysts and market makers' beliefs about the number of analysts and the 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 we mainly focus on symmetric pure strategy equilibria except when we discuss the robustness of our results by analyzing an asymmetric equilibrium. Trading in the date 2 financial market is analyzed in the normal-linear framework.

3 Equilibrium Analysis

The equilibrium is solved by backward induction beginning with the trading game comprising the fund managers' trading strategy and the market makers' pricing rule at date 2. Then we analyze date 1 trading in the market for information. Finally, we characterize the date 0 specialization decisions of the information-producing agents and the equilibrium number of analysts.

Date 1 trading in the market for information is a multilateral contracting game with privately observable contracts.[6]

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

[6] Bolton and Dewatripont (2005) provide a summary of the literature. It is well established that if out-of-equilibrium beliefs are not restricted, there may be a plethora of PBE. McAfee and Schwarts (1994) provide an extensive discussion of reasonable out-of-equilibrium beliefs for sharpening predictions about equilibrium outcomes, the most common of which is their *passive beliefs* restriction. We adopt this convention and note that it implies that upon receiving an out-of-equilibrium offer from an analyst, fund manager i believes that all other offers remain equilibrium offers.

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

The intuition for this result rests with an analyst's incentive to deviate from any equilibrium in which he sells to a subset of fund managers. This incentive arises because the analyst can sell to one more fund manager at the equilibrium payment without other fund managers observing his deviation and therefore withholding their payment.[7] The result depends on the unobservability of the other offers made by the analysts but we relax this assumption later.[8]

3.1 Trading in the Financial Market

At date 2, liquidity traders, market makers, and n fund managers participate in the financial market. 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 purchased from analysts. Based on this information, fund manager i $(i = 1, 2, ..., n)$ submits to the market makers the market order x_i that maximizes his expected profit. Market makers observe only the total order flow, $y = \sum_{i=1}^{n} x_i + z$, and with information extracted from that observation, 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.

We do not model the market makers' strategic behavior directly. Rather, we assume that

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

[7] We assume a zero marginal cost in selling information. Given recent advances in information technology, this is not a particularly strong assumption.

[8] See McAfee and Schwartz (1994) for analysis of supplier commitments to competing downstream firms under unobservability in a more general setting.

η is a positive number. By doing so, we wish to show that our 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:

$$P_2(y) = E[\delta|y] + V.^9 \tag{4}$$

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

We 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 measure how aggressively 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). We can rewrite fund manager i' strategy as

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

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. We show in the appendix that this strategy is indeed the unique linear equilibrium and 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).

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

(ii)In equilibrium, the fund manager's expected trading profit is

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

(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 market makers are perfectly competitive so that (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 $D \equiv 4mv + 4(mv)^2 + 4nv^2 + (n+1)^2(v+v^2)$.

Since a and β are different, Proposition 2 indicates that fund managers trade differently with respect to buy-side and sell-side information. Consequently, buy-side and sell-side information have different effects on the market price. Corollary 3 outlines the differences:

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

(ii) $\frac{a}{\beta} = \frac{2}{n+1} \leq 1$ *so that individual fund managers trade less aggressively on sell-side information than on their 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.

Although buy-side and sell-side information are of the same quality, sell-side information is known by all n fund manager. Thus competition among fund managers seeking to profit from sell-side information exceeds competition around a fund manager's private signal. In spite of greater scope for competition, fund managers *collectively trade more aggressively on analyst signals* because they do not fully internalize their individual impact on the market price. Given a one-unit increase in an analyst's signal, a one-unit increase in trading by a fund manager increases the price by η units and thus reduce his expected trading profit. However, the manager does not internalize the lost trading profits faced by the other $n-1$ fund managers. By contrast, individual fund managers bear the entire cost of price impact from trading on their own information.[10]

Fund managers *individually* trade less aggressively on sell-side information because they recognize and fully internalize the consequence of common knowledge of the analyst's signal among fund managers. Any fund manager considering trading more aggressively on a one-unit increase in an analyst's signal recognizes that other managers are considering the same strategy. By contrast, the marginal price impact from trading more aggressively on a one-unit increase in one's own private signal is smaller, since others are not expected to follow suit. Thus individual fund managers respond more aggressively to their own signals than to those purchased from analysts.

It is worth noting that $\frac{a}{\beta}$ is decreasing in n while $\frac{na}{\beta}$ is increasing in n. Because competition among fund managers causes them to trade differently with respect to buy-side and sell-side information, such differences are more pronounced when 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 generates more price impact. It is often said of sell-side research that it generates trade for a firm's brokerage business. Corollary 3 lends support to this idea.

3.2 The Market for Information

In the date 1 market for information, we examine to whom among fund managers analysts offer to sell their signals, the offer prices for these signals, and from which analysts fund managers choose to buy signals.

[10]Even in this case there can be an externality. When a fund manager increases his order in response to his own positive signal, the resulting price impact damages other fund managers' trading profits on average. The magnitude of the externality depends on the correlation among fund managers' private signals. Because the analyst's signal is known by all fund managers in equilibrium, trading in this dimension essentially takes place with respect to a perfectly correlated signal.

3.2.1 Fund Managers' Demand for Sell-Side Information

Given the set, S^i, of analysts who offer signals for sale, how should fund manager i determine the subset, A_i, of analysts from whom to buy signals?

Upon choosing A^i, fund manager $i's$ trading strategy is the solution to:

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

where $F_i = \{s_i, s_j, \forall j \in A^i\}$. Fund manager $i's$ information now includes both his own, s_i, and that which he acquired from analysts, s_j, $j \in A^i$. Fund manager i solves problem (14) with the belief that everybody else will play the equilibrium strategy: every other fund managers buys signals from all analysts and trade according to the strategy specified in Proposition 2. Proposition 4 characterizes fund manager 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 only of the number of analysts from whom he buys, not their identify.

Fund manager i's profit is increasing in l, since acquiring more information from analysts reduces his information disadvantage relative to other fund managers who acquire all analyst information. But the marginal benefit of an analyst's signal is decreasing, since the precision of fund manager i assessments of asset value and other fund managers' order flows increases with the number of analyst signals acquired. The more precise is the fund manager i's assessment, the less it will be influenced by an additional analyst's information.

The concavity of $\pi_i(l)$ implies that the classical marginal analysis yields fund manager i's optimal set of analysts from whom to acquire signals as summarized in the following proposition:

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 from whom he buys information, if he wants to buy information from l^* analysts, he simply chooses those selling their signals at the lowest prices. 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 The Price of Analysts' Information

Since an analyst makes take-it-or-leave-it offers to the fund managers, he extracts the entire marginal surplus of his information from the fund managers. In equilibrium, the marginal benefit of an analyst's information to a fund manager is $\pi(m) - \pi(m-1)$ (symmetry enables dropping the subscript i). Therefore, we 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 follow this strategy, each fund manager buys information from every analysts by Proposition 5. Thus an analyst's equilibrium profit from selling information is $\pi_r \equiv np$.

Analysts will not deviate from this strategy because offering a lower price to any fund manager would lead to its acceptance (by Proposition 5) and thus diminish the analyst's profit. Moreover, offering his information at a higher price to any fund manager only leads to the offer being rejected (by Proposition 5) and thus once again diminishes the analyst's profit.

Proposition 6 characterizes the equilibrium in the market for information:

Proposition 6 *In the market for analysts' information,* *(i) an analyst makes offers to sell his information to all fund managers, 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 fund managers accept the offer;

(iii) equilibrium profits for a fund manager and an analyst 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 The Specialization Decision

The next stage of analysis determines the equilibrium composition of analysts and fund managers implied by the equilibrium number, m^*, of information-producing agents who opt to become analysts.

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

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

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

The fund manager's incentive-compatibility condition, (20), implies that a fund manager's profit is smaller if he unilaterally deviates by becoming an analyst. Similarly, the analyst's incentive-compatibility condition, (21), implies that it is suboptimal for an analyst to unilaterally deviate by becoming a fund manager.

Proposition 7 describes the equilibrium composition of analysts when there is no investment banking subsidy.

Proposition 7 *If there is no investment-banking subsidy, then an analyst always has incentive to deviate become a fund manager. Thus, in equilibrium all information is produced by fund managers and is therefore not available for sale.*

Proposition 7 establishes that analysts cannot exist in equilibrium without a subsidy – profits from direct sale of a signal are less than those from trading on the same signal when others can only learn the nature of the signal through one's private impact on financial market prices. This result is driven by two effects. First, competition among fund managers trading on the analyst's signal in the financial market limits expected trading profits associated with 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 their own signals (with intensity β). As a result, the analyst's signal is more fully impounded in the price than it would be if fund managers could coordinate to trade less aggressively.[11]

Moreover, because the analyst's information is assumed to be a substitute for the fund manager's signal (albeit an imperfect one), the marginal analyst's information has a relatively small marginal benefit to the fund manager. Thus analysts are limited in what they can extract from fund managers in spite of the fact that they have all of the bargaining power. In equilibrium, fund managers pay analysts only the marginal benefit associated with the last analyst's signal. This payment is decreasing in both the number of analysts and in the degree of correlation among information signals produced in the economy. In the extreme case where $s_i = \delta$, so that signals are perfect substitutes for one another, fund managers will not pay a positive price for information produced by analysts.

Proposition 8 establishes boundaries on the investment-banking subsidy, π_I, necessary to support a positive number of analysts in equilibrium:

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

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

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

[11] It can be shown that if all the fund managers could commit to trading on an analyst's signal with the same intensity with which they trade on their own signals (that is, maintain a such that na equals the equilibrium β) they would earn greater trading profits, *ceteris paribus*.

The boundaries set out in Proposition 8 imply a positive subsidy and thus provide a rationale for bundling sell-side research with investment-banking services. Even when sell-side research is provided, it follows intuitively from Proposition 7 that it should be less profitable than producing information as a fund manager. Proposition 9 establishes this fact and suggests an avenue for empirical investigation.

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

$$\pi_b(m^*) > \pi_r(m^*). \tag{24}$$

4 Social Welfare and Sell-Side Research

In this section we study the welfare effects of the distribution of information production across buy-side and sell-side firms with particular emphasis on whether welfare is compromised if sell-side research is undermined. Our analysis rests on the finding that analyst information is incorporated more fully into asset prices in our financial market than is information produced by fund managers. Thus increasing the number of analysts could promote welfare by increasing the information content of prices and thus improving corporate investment decisions.[12]

4.1 Information Efficiency and Social Welfare

To study the relation between the information efficiency of asset prices and corporate investment efficiency, we introduce a firm that sells its stock in the financial market.[13] We assume that at date 0, the firm has one project and 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 firm's investment cost of setting up q units of production capacity is $f(q)$, $f'(q) > 0$ and $f''(q) > 0$. The firm invests $f(q)$ at date 2 by raising capital from the financial market with the sale of its shares. The firm's owner retains for his own consumption any proceeds not required to finance the project.

[12] See Baker, Stein, and Wurgler (2003) for a review of the literature on the relation between asset prices and corporate investment.

[13] We follow Leland (1992) closely in our approach to modeling social welfare.

For simplicity, we assume that the firm's equity is divided into q shares implying a date-3 share price of $V+\delta$. We model the firm's equity issuance parsimoniously by assuming that the number shares issued, q, and thus the firm's production capacity depends on the date-2 market price for its shares. In essence, the firm sells its stock through limit orders. The firm's limit order is public information implying that condition (4) holds – market makers provide liquidity at the expected value of the stock, conditional on the total order flow. Finally, the issuing firm pays each analyst an exogenously determined investment-banking fee π_I.

Thus the firm's optimization problem is

$$\max_{q} \; qP_2 - f(q) - n\pi_I.^{14} \tag{25}$$

The firm's optimal production capacity, q^*, is uniquely determined by:

$$q^* = f'^{-1}(P_2). \tag{26}$$

The convexity of the firm's production function, $f(q)$, implies that the firm's optimal production capacity, q^*, is increasing in the second-period price, P_2. [15]

The firm's limit order is public information and has no information content. Therefore, market makers consider only the total market orders when they set the second-period price. The date-3 stock value is $V+\delta$ so that fund managers again solve problem (2) and the results in section 3 carry over as before.

We define social welfare, W, as the sum of all agents' ex ante expected payoffs.[16] It is straightforward to show that

$$W = E[q^* P_2 - f(q^*)]. \tag{27}$$

[14] If the second-period price, P_2, is less than zero, the problem does not have a well defined economic meaning. However, 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.

[15] Because the firm's investment decision depends only on the stock price, the firm's decision to sell shares has no information content. Therefore, whether the firm has private information about δ or not makes no difference in the model.This result arises because we assume that the firm's owner sells all of his shares in the primary market. Withholding some fraction of the firm's shares from the market could provide a signal for private information as in Leland and Pyle (1977).

[16] This definition warrants the caveat that failing to specify liquidity traders' utility functions or their motives for trading means that the social welfare definition may not reflect all agents' welfare. However, because our welfare definition measures the informational efficiency of the security prices, as long as their informational efficiency is important to social welfare, the analysis here remains valid.

In words, social welfare equals the firm's profit from production.

Trading in the financial market influences welfare indirectly through its influence on the second-period price but the risk-neutrality of all agents in the model prevents any direct benefit arising from improved risk sharing. Thus welfare effects rest on the informational efficiency of the financial market at date 2. We define informational efficiency as the ex post reduction in uncertainty about firm value provided by the market price. From the market makers' point of view, δ can be written as

$$\delta = E[\delta|y] + e. \tag{28}$$

The uncertain per share value of the firm can thus be decomposed into a revealed portion, $E[\delta|y]$, and a concealed portion, e. The revealed portion of the firm's share value is the market price minus V and thus is public information. e remains unknown to uninformed agents.

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

$$1 = Var[\delta] = Var[\eta y] + Var[e]. \tag{29}$$

We denote $\Sigma_r \equiv Var[\eta y]$. Greater values for Σ_r indicate less uncertainty about δ conditional on the market price and thus a more informationally efficient stock price. 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 10 states the relation between the share price's informational efficiency and social welfare:

Proposition 10 *Social welfare increases with the informational efficiency of the firm's share price at date 2.*[17]

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

[17] This result is not true in general if more information destroys risk-averse agents' incentive to share risk optimally. This is the well-known Hirshleifer (1971) Effect which does not apply in our model because all agents are risk neutral.

4.2 Sell-Side Research and Informational Efficiency

Increasing the number of sell-side analysts, m, has offsetting effects on the revealed uncertainty in share prices, Σ_r. Corollary 3 shows that having more analysts improves informational efficiency because analysts' information is impounded more aggressively into the stock price than is fund managers' information. Call this the sell-side effect. On the other hand, there is an offsetting (competition) effect that arises because competition among fund managers is diminished as the number of analysts increases. Because the total number of information-producing agents is fixed in the economy, a larger number of analysts implies fewer fund managers who, in turn, bid less aggressively (as a group) in the financial market. The relative magnitude of the sell-side and competition effects determines whether increasing the number of analysts improves or diminishes welfare.[18] As the number of information-producing agents, N, grows, ambiguity in the welfare analysis diminishes. 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 sell-side analysts unambiguously improves the informational efficiency of the economy.

5 Conflicts of Interest among Analysts

The preceding analysis ignores any agency problems that might arise when analysts sell information to fund managers because we assume that analysts report their signals truthfully to fund managers. Obviously, it is difficult for fund managers to verify the quality of such information. We model the consequent incentive conflict by assuming that an analyst j has the option to report r_j, a real number, to fund managers upon receiving his signal, s_j. We define the bias in analyst $j's$ report as $b_j \equiv r_j - s_j$. This additional structure enables an analysis of a conflict of interest arising from sell-side research being subsidized by investment-banking services.

The envelope theorem implies that the firm's production profit, $q^* P_2 - f(q^*)$, is increasing in its stock price. Thus, the firm has incentive to increase its stock price. Suppose the firm can directly link payments for investment-banking service to the sell-side analyst's report to fund managers thus providing the analyst incentive to optimally bias his report. In equilibrium, fund managers should rationally expect such bias and therefore discount the analyst's report but noise introduced by the biased report will undermine welfare.

[18] An earlier version of the paper provides a sufficient condition under which increasing the number analysts improves informational efficiency.

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

$$\pi_j r_j + I_j \tag{30}$$

so that it 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, we assume that $I_j = I$ for all j. π_j is chosen by the firm and is not observable by other analysts or by fund managers.

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

$$\max_{b_j} \pi_j r_j + I_j - \frac{b_j^2}{2t_j}, \tag{31}$$

where $\frac{b_j^2}{2t_j}$ represents analyst j's cost of bias. This cost function embodies an analyst's personal characteristics such as litigation risks, reputation risks, or psychological costs associated with providing biased reports. We let t_j vary across analysts to capture the idea that some analysts have more at stake than others when misrepresenting their signals. We assume that t_j is normally distributed with mean T, precision v_t, and that it is i.i.d. across analysts and independent of other random variables in the model.[19] Finally, we assume that t_j is realized after date 1 but before analysts report to fund managers so that only analyst j observes t_j. All other agents know only 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

$$\max_{\pi_j, q(P_2)} E[P_2 q(P_2) - f(q(P_2))] - \sum_j^m [\pi_j E[r_j] + I]. \tag{32}$$

For tractability, we 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 been realized yet.

After receiving reports from analysts, fund managers filter out perceived biases. Although the fund managers do not observe π_j, in equilibrium they correctly infer the fee paid to analyst j, π_j^*. But because

[19] t_i can be negative, in which case the cost function is not well defined. However, the parameters of the distribution can be chosen 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.

fund managers cannot perfectly observe the analysts' personal characteristics, t_j, they cannot precisely determine their bias, b_i. As a result, fund managers infer s_j only with noise.

Proposition 11 summarizes the equilibrium.

Proposition 11 *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 (78) 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

$$a = \frac{2\widehat{v}}{\eta[2(1+m)\widehat{v} + (1+n)v](1+n)}, \tag{33}$$

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

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

$$\widehat{v} = \frac{vv_t}{\pi^{*2}v + v_t}; \tag{35}$$

(iii) analyst chooses $b_j^* = t_j \pi^*$ for all s_j.[20]

Note that after fund managers filter out the analyst's bias, the precision of the analyst's report is $\widehat{v}$, which is smaller than v, the precision of an analyst's own signal. In other words, information is lost as a consequence of the conflict of interest. Equation (35) shows that the quality of an analyst's report decreases with the magnitude of the conflict, π^*. If $\pi^* = 0$, there is no conflict of interest and the analyst's report has the same precision as his own signal.

Adding up the ex ante expected payoffs for all agents yields the social welfare measure:

$$W = E[P_2 q^*(P_2) - f(q^*(P_2))] - mE[\frac{b_j^{*2}}{2t_j}]. \tag{36}$$

The social welfare measure now includes an extra term, $mE[\frac{b_j^{*2}}{2t_j}]$, reflecting the analysts' cost from providing biased reports. Thus, the conflict of interest creates a direct cost borne by the analyst and an indirect

[20] 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 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 $b_j = \infty$.

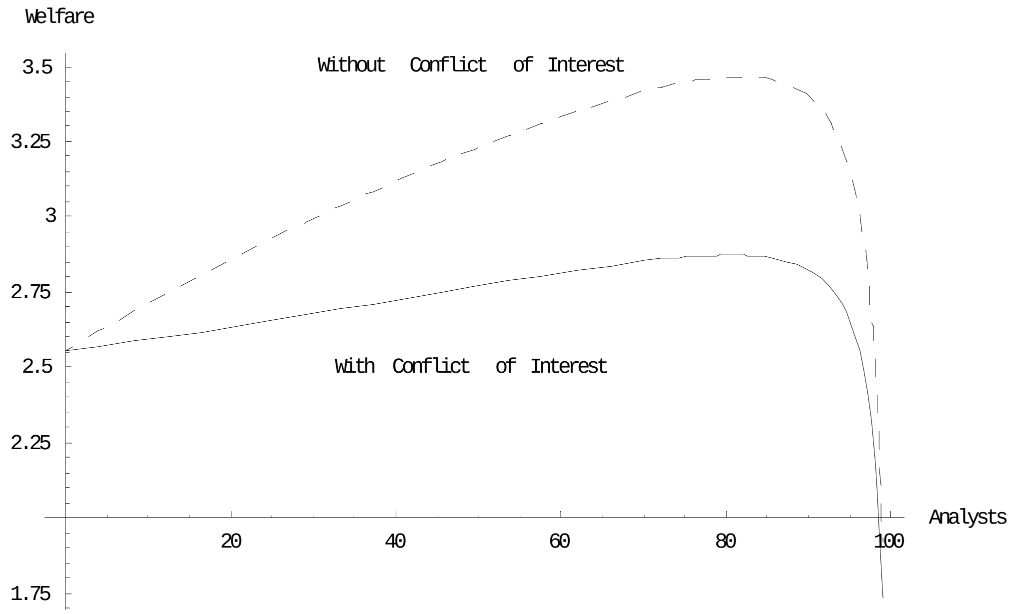

Figure 2: Social Welfare and Number of Analysts

cost associated with lost information. The latter compromises welfare by diminishing the informational efficiency of the firm's stock price and therefore the quality of its investment decision. 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. These opposing forces makes the general welfare effects of subsidizing sell-side research ambiguous. However, there are conditions under which social welfare is greater when there are some analysts than when there are none. Figure 2 illustrates this feature of the model.

Thus our model suggests that although separating sell-side research from investment banking eliminates (costly) conflicts of interest, doing so has potential for diminishing welfare by reducing the informational efficiency of financial markets. Our analysis suggests that efforts to manage this tradeoff should focus on breaking linkages between individual analysts' compensation and the fees that issuing firms pay to their investment banks. In the model, this involves keeping π^* close to zero, in which case a positive subsidy could sustain the benefits of sell-side research at minimal costs associated with conflicts of interest. Ljungqvist, Marston and Wilhelm (2005) provide evidence that this linkage existed during the 1990s in the sense that analyst's were more aggressive in their recommendation behavior at times when more fee income was at stake for their firms. During 1999-2000, when the stakes were particularly high, even all-star analysts (as defined by the *Institutional Investor*) engaged in unusually aggressive behavior. On the other hand, they found, as our theory would predict, that reputational considerations moderated analyst behavior. The structural reforms imposed by the 2003 Global Settlement involving the SEC, the New York Attorney General's office and ten of the most prestigious sell-side firms clearly are aimed at preventing any direct linkage between investment banking fees and analyst behavior.[21] Left unanswered is the whether sell-side firms will continue to find it in their interest to subsidize research.

6 When can Independent Research be Sustained?

In this section we examine the robustness of our claim that sell-side research requires subsidization. In the preceding analysis, we assume that contracts between analysts and fund managers are only privately observable. In equilibrium, this means that analysts cannot commit to sell their information to only a subset of fund managers. Hart and Tirole (1990) and McAffee and Schwartz (1994) show that in general it is costly to be unable to commit against opportunistic behavior. We examine the sensitivity of our findings to this assumption by studying a simple case in which analysts can commit to sell to only a subset of fund managers. Specifying all of the possible analyst and fund manager relations is complicated for the general N agents case, so we limit the analysis to the special case where $N = 3$. The following proposition summarizes the results for this case:

Proposition 12 *If $N = 3$ and analysts can commit to sell to any subset of the fund managers, the only equilibrium outcome is one in which all information producing agents choose to be fund managers.*

Thus even when there is no competition among fund managers, analysts cannot survive in our model without a subsidy.[22] As we show in the appendix, this result is driven by substitutability among agents' signals. As the precision of agents' signals increases, so that they become closer substitutes for one another, the fraction of the fund manager's total profit captured by the analyst, $\frac{1}{2(1+v)}$, declines.[23]

[21] This is easier said than done. As we write, the SEC is considering action against firms criticized for "bullying" uncooperative analysts (See the *Wall Street Journal*, Sept. 23, 2005, C3). Such tactics involve excluding an analyst from access to key executives, conference calls and implicit threats that unfavorable reports will result in the analyst's firm not receiving future underwriting mandates. This approach can be thought of as using a "stick" to elicit the desired behavior instead of the "carrot" of a behavior-linked payment assumed in our model.

[22] More generally, it can be shown that in a n fund manager, $N - n$ analysts setting, analysts always do better by trading on their own information, under the restriction that analysts alternatively can sell their information to no more than one fund manager.

[23] Suppose instead that information-producing agents could coordinate ex ante to maximize their joint profit and share them equally. Assume also that anti-trust considerations require at least n fund managers among information-producing agents

Given the importance of our assumption regarding the substitute nature of agents' information, it is natural to consider the alternative case in which signals are complementary. Our notion of signals substituting for one another presumes that both sell-side and buy-side analysts engage in similar forms of analysis given the information at hand. But suppose, for example, that fund managers (or sell-side analysts, for that matter) could produce more precise signals by acquiring factual information, such as accounting numbers, and could do so more efficiently by acquiring the information through other parties rather than directly. Such information is no substitute for careful analysis. Rather, it is complementary to production of the sort of information we envision agents trading upon in the financial market. This perspective suggests modeling complementarity by assuming that a fund manager's signal precision is increasing in the precision of factual signals produced agents who opt into this realm of information production.[24] If complementarity of this sort is sufficiently high, such indirect information providers may be able to extract sufficient surplus from fund managers to sustain their presence in equilibrium without a subsidy.

To incorporate this idea formally into the model, we assume that without an indirect factual information 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 is γ, the poorer the quality of the information-producing agents' signals without s_I and the more important s_I is to their information production. Thus, γ measures the complementarity between s_I and other agents' signals. Because we think of s_I as factual information such as company news, we assume that if two or more information-producing agents produce s_I, they obtain the same signal. We further assume that s_I has no value when traded upon directly. Generating tradable information, such as an estimate of a company's value, requires information-producing agents to analyze and interpret the indirect information, i.e., produce their own signals conditional on the factual information.

(Without this constraint, the optimal composition is one in which there is only one fund manager and all other agents are analysts.). In this case information producing agents determine who should work for fund managers and who should work as analysts to maximize their joint trading profit. Also assume that multiple agents may work for one fund manager but once committed to a fund management, the agent cannot sell his information to any one else. In this case, the optimal symmetric allocation calls for every agent to work for one fund manager. Once again, there are no sell-side analysts. The proof is available upon request.

[24] It is perhaps more accurate to think of such agents as specializing in formatting and distribution of such information. The fund manager's signal precision would then be more nearly a function of the speed and ease with which such information can be used rather than strictly its precision. Thomson Financial is the extreme example of the type of information-producing agent we envision in this example.

The model is the modified so that at date 0, an information-producing agent can choose to be a fund manager, or a provider of indirect factual information. We refer to the latter as an independent analyst.[25] At date 1, independent analysts sell their information to fund managers. Here, the quality of information is contractible so there is no conflict of interest. The events at dates 2 and 3 remain the same.

Proposition 13 shows that if s_I is important to the information production of other agents, then even without a subsidy there exists 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.

Fund managers acquire s_I because they would otherwise be at a competitive disadvantage in the financial market. Thus fund managers are willing to pay a high price for the independent analyst's information.

In contrast to the result in Proposition 7, which rests on substitutability among signals, the ability to generate complementary signals enables the independent analyst to 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). We envision firms like Standard & Poor's, First Call, and Bloomberg as examples of firms providing indirect, factual information and thus able to sustain themselves as independent research operations. Their capacity for doing so rests with their ability to do something that managers cannot do for themselves, at least not at the same cost. It is noteworthy that each of these firms operates relatively large-scale but low margin businesses consistent with the fact that they deal primarily in public information. Their competitive advantage appears to lie largely in the efficiency with which they can deliver such information.

Although we have cast independent research firms as the alternative to fund management for information-producing agents in our model, it is plausible that at least some sell-side research analysts have unique capacity relative to their buy-side peers. If so, they too could appear in equilibrium without being subsidized. Thus the preceding analysis provides a rationale for the appearance of star analysts, like Mary

[25] We also analyze the case where agents can choose to be sell-side analysts. The results are qualitatively the same.

Meeker, who dominate their area of expertise. Unfortunately, the industry practice of folding stars into large research departments would appear to cut against separating unique research from the mundane.[26]

7 Conclusion

We examine the industrial organization of information production in the securities industry assuming that information-producing agents can opt either to produce their information for sale (sell-side producers) or trade on information they produce and that purchased from sell-side producers. The former we characterize as sell-side analysts working, typically, within large investment banks and the latter as buy-side, fund-management firms. In equilibrium, when agents produce substitutive information, information is produced from the sell-side only if it can be subsidized by profits from elsewhere within the investment banking organization from which it is produced. Absent opportunities for subsidizing sell-side research, agents always prefer to operate from the buy-side where they can trade on their private information in the financial market. This result arises because sell-side agents cannot commit to narrow dissemination of the their information among buy-side agents. Thus buy-side agents compete aggressively with one another with respect to sell-side information via trading in the financial market and thereby diminish trading profits from sell-side information relative to those associated with (private) information produced from the buy-side.

In equilibrium, information can only be produced from the sell-side without a subsidy when it is complementary to information produced by agents on the buy-side of the market. In this setting, which we envision as representative of independent research firms that specialize in efficient aggregation and dissemination of factual information (as opposed to analysis of such information), sell-side agents produce information that enhances the value of analysis carried out from the buy-side of the market. But by virtue of the fact that any sell-side agent would produce the same factual information, only one sell-side agent will produce such information in equilibrium. Thus the model predicts large-scale, dominant producers, such as Bloomberg or Thompson Financial, in distinct dimensions of factual information.

[26] The analysis of Morrison and Wilhelm (2004) suggests a possible rationale for this business model if star researchers benefit from firm-specific assets, such as the firm's reputation or mentoring from senior researcher, over which contracts cannot be written. In this setting, a high degree of opacity or other mechanism for limiting the agent's mobility may be necessary to sustain investment in the agent under the threat of holdup once the agent achieves star status.

We show that production of substitutive information from the sell-side can enhance welfare by increasing the informational efficiency of financial market prices which, in turn, leads the superior real investment decisions. On the other hand, generating the necessary subsidy by bundling sell-side research with other investment-banking services introduces a conflict of interest that can diminish the informational efficiency of financial market prices. We establish conditions under which the net welfare effect from bundling sell-side research with investment-banking services is positive. The analysis emphasizes that the key to managing the tradeoff rests with weakening linkages between investment-banking fees and compensation paid to (or other incentives faced by) individual analysts.

Our model suggests that the long standing tradition of bundling equities research with investment banking in major securities firms is one rational institutional response to the difficulty of contracting over information. Reputational concerns appear to have been effective in moderating the negative consequences of the conflict of interest throughout much of the industry's recent history. The 2003 Global Settlement reached in the aftermath of a period during which this clearly was not the case, seeks to address the need for subsidizing sell-side research identified in our model by forcing sell-side firms to contribute to pool to fund independent research .[27] In this sense, the Settlement aims to break the linkage between investment-banking fees and an individual analyst's compensation. Our model identifies this as the appropriate focus for any effort to manage the tradeoff between the costs and benefits of subsidizing sell-side research. On the other hand, the existing structure provides little private incentive (other than the threat of legal or regulatory intervention) for producing high-quality sell-side research. Efforts that aim only to satisfy the letter of the law will not likely contribute significantly to welfare.

Our model can also be usefully applied to the credit rating industry where the bulk of revenues comes from bond issuer fees rather than from selling research to institutional investors.[28] Obviously, this structure suggests potential for conflicts similar to those observed within investment banks. But until the late 1960s, credit-rating agencies financed their operations solely through the sale of publications and information provided to prospective investors. Cantor and Packer (1995) and White (2001) suggest that wide-spread availability of copy machines triggered the change by reducing industry profit margins. Our analysis suggests an alternative explanation.

[27] 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 the Securities and Exchange Commission press release at http://www.sec.gov/news/press/2003-54.htm for details.

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

Until the mid 1960s, institutional investors played a less prominent role in financial markets. Individual wealth constraints would prevent the aggressive competition among financial market traders that undermine the profitability of sell-side research in our model and effectively achieve the sort of buy-side coordination that might sustain sell-side research in our model. With the rise of institutional investment during the 1960s, our model's assumption that buy-side traders can take arbitrarily large positions in the financial market is more realistic. In this setting, potential rating agencies would not only observe erosion in their profit margins but might also be tempted to operate from the buy-side by growing demand for professional portfolio management services. Sustaining independent credit rating agencies thus required support from issuing firms. By and large, reputational concerns among rating agencies appear to check conflicts of interest arising from their fees being paid by the firms they evaluate.

Appendix: Proofs of Propositions

Proof of Lemma 1: Suppose instead that there existed an equilibrium in which analyst j did not sell to fund manager i. Because having analyst j's information can never reduce fund manager i's profit, this alternative implies that fund manager i values analyst j's information at zero. Otherwise analyst j would gain by making an offer to i at a positive price and i would accept the offer. This contradicts the equilibrium definition.

Under passive beliefs, if i values j's information at zero, i's trading strategy x_i must be the same with s_j as without s_j given the uniqueness of the fund manager's problem $\max_{x_i} E[x_i(V+\delta-(V+\eta y))|F_i]$, where F_i is i's equilibrium information set defined in the main text. The first order conditions for x_i thus imply that

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

for any F_i and s_j. $E[\delta|F_i]$ and $E[\delta|F_i, s_j]$ are linear in agent i's signals. The linear equilibrium implies that $E[x_k|F_i]$, and $E[x_k|F_i, s_j]$ are also linear in i's signals. Matching coefficients yields a set of linear equations on the 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 defined by the set of equations is of measure zero in the Euclidean space. Therefore, Lemma **1** holds generically.

Proof of Proposition 2: Substituting equations (3) and (6) into fund manager i's objective function (2) and simplifying yields:

$$\max_{x_i} \quad x_i\{E[\delta|F_i] - \alpha\eta(n-1)s_p - \beta\eta(n-1)E[\delta|F_i] - \eta x_i\}, \tag{37}$$

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

$$\begin{aligned} x_i^* &= \frac{[1-\beta\eta(n-1)]E[\delta|F_i] - \alpha\eta(n-1)s_p}{2\eta} \\ &= \frac{1}{2\eta}\{[[1-\beta\eta(n-1)]\frac{mv}{1+mv+v} - \alpha\eta(n-1)]s_p + [1-\beta\eta(n-1)]\frac{v}{1+mv+v}s_i\}. \end{aligned} \tag{38}$$

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

$$\alpha = \frac{1}{2\eta}[(1-\beta\eta(n-1))\frac{mv}{1+mv+v} - \alpha\eta(n-1)], \tag{39}$$

$$\beta = \frac{1}{2\eta}(1-\beta\eta(n-1))\frac{v}{1+mv+v}. \tag{40}$$

Solving equations (39) and (40) yields α and β in part (i).

For part (ii), fund manager i's expected trading profit is

$$E[\frac{[(1-\beta\eta(n-1))E[\delta|F_i] - \alpha\eta(n-1)s_p]^2}{4\eta}]. \tag{41}$$

Simplifying this using the facts $E[(E[\delta|F_i])^2] = \frac{v+mv}{1+mv+v}$, $E[(E[\delta|F_i])s_p] = 1$, and $E[s_p^2] = 1 + \frac{1}{mv}$, yields

$$\frac{1}{4\eta}\{[1-\eta\beta(n-1)]^2\frac{v+vm}{1+v+vm} + [\alpha\eta(n-1)]^2\frac{1+vm}{vm} - 2[1-\eta\beta(n-1)][\alpha\eta(n-1)]\}. \tag{42}$$

Substituting for α and β, yields (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,

$$E[\delta|y] = \frac{\frac{1}{n(\alpha+\beta)}y}{1 + (\frac{\alpha}{\alpha+\beta})^2\frac{1}{mv} + \frac{n\beta^2}{(n(\alpha+\beta))^2 v} + \frac{\sigma_z^2}{(n(\alpha+\beta))^2}}, \tag{43}$$

which implies

$$\eta = \frac{\frac{1}{n(\alpha+\beta)}}{1 + (\frac{\alpha}{\alpha+\beta})^2\frac{1}{mv} + \frac{n\beta^2}{(n(\alpha+\beta))^2 v} + \frac{\sigma_z^2}{(n(\alpha+\beta))^2}}. \tag{44}$$

Together with equations (39) and (40), solving for α, β, and η gives the desired results.

A unique linear equilibrium implies a general linear trading strategy defined as $x_i = \beta_i s_i + \sum_{j\in A^i} a_i^j s_j$. Equations (39) and (40) thus become

$$2\eta\beta_i = \frac{v}{1+mv+v}(1-\eta\sum_{j\neq i}\beta_j), \quad (45)$$

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

Substracting $\frac{v}{1+mv+v}\eta\beta_i$ from both sides of equation (45) and rearranging terms yields

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

Therefore, $\beta_i = \beta_j = \beta$, for any i and j. Similarly, substracting ηa_i^l from both sides of equation (46) and rearranging terms yields $a_i^l = \frac{1}{\eta}[\frac{v}{1+mv+v}(1-\eta(n-1)\beta) - \eta\sum_j a_j^l]$, or $a_i^l = a_j^l = a_l$ for any i and j. Substituting a_l and β into equation (46), yields $a_l = \frac{1}{(n+1)\eta}\frac{v}{1+mv+v}(1-\eta(n-1)\beta)$. Therefore, $a_l = a_q = a$ for any l and q. Thus the symmetry assumption is without loss of generality. Since α, β are uniquely determined, the uniqueness of the linear equilibrium follows.

Proof of Corollary 3: Proofs of Part (i), (ii), and (iii) follow directly. 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, $naE[|s_j|] > \beta E[|s_i|]$.

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

$$\max_{x_i} \ x_i(E[\delta|F_i] - \alpha\eta(n-1)E[s_p|F_i] - \beta\eta(n-1)E[\delta|F_i] - \eta x_i) \quad (47)$$

where α and β are as in Proposition 2. Also

$$E[s_p|F_i] = \frac{1}{m}(\sum_{j\in A^i} s_j + \sum_{k\notin A^i} E[s_k|F_i]) \quad (48)$$

$$= \frac{l}{m}s_l + \frac{m-l}{m}E[\delta|F_i]. \quad (49)$$

Substituting (49) into the objective function and taking the first-order condition yields fund manager i's optimal trading strategy

$$x_i^*(A^i) = \frac{(1 - \beta\eta(n-1) - \alpha\eta(n-1)\frac{m-l}{m})E[\delta|F_i] - \alpha\eta(n-1)\frac{l}{m}s_l}{2\eta}. \tag{50}$$

The expected profit under the optimal trading strategy is

$$\pi_i(A^i) = \frac{1}{4\eta}E[[1 - \beta\eta(n-1) - \alpha\eta(n-1)\frac{m-l}{m}]E[\delta|F_i] - \alpha\eta(n-1)\frac{l}{m}s_l)^2] \tag{51}$$

Substituting $E[\delta|F_i] = \frac{lvs_l+vs_i}{1+v+lv}$ into equations (50) and (51), 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 $E[s_l^2] = 1 + \frac{1}{lv}$ yields

$$\begin{aligned}\pi_i(A^i) &= \pi_i(l) = \frac{1}{4\eta}\{(1 - \eta\beta(n-1) - \eta\alpha(n-1)\frac{m-l}{m})^2\frac{v+v_l}{1+v+v_l} + [\alpha\eta(n-1)\frac{l}{m}]^2\frac{1+v_l}{v_l} \\ &\quad -2(1 - \eta\beta(n-1) - \eta\alpha(n-1)\frac{m-l}{m})\alpha\eta(n-1)\frac{l}{m}\},\end{aligned} \tag{52}$$

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: Fund manager i's problem is

$$\pi_b(S^i) \equiv \max_{A_i \subseteq S_i} \pi_i(l(A^i)) - \sum_{j \in A_i} p_j^i. \tag{53}$$

Recall that p_j^i is analyst j's offer price to fund manager i. The first step in solving (53) determines the optimal A^i for a fixed l. Because fund manager i's profit depends only on the number of analysts he buys from, not their identities, if fund manager i buys from l analysts, he buys from the analysts with the l lowest prices. In the second step we 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 information is increasing because as l increases, more expensive analysts will be included in A^i. Thus, (15) is a necessary and sufficient condition for the unique optimum for problem (53).

Proof of Proposition 6: Simplifying (16) using 52, yields 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 available upon request. Simplification yields

$$\begin{aligned}
&\pi_s(m) - \pi_b(m-1) = \\
&\quad -\frac{4v}{(1+N-m)^4}\Big[\frac{4(m-1)^2}{1+(m-1)v} + \frac{(N-m-1)(1+N-m)(5+2N+N^2-2(3+N)m+m^2)}{(2+(N+m-1)v)^2} \\
&\quad + \frac{(N+m-1)(5+2N+N^2-2(3+N)m+m^2)}{2+(N+m-1)v} - \frac{4(N-m-1)(1+N-m)(N-m)}{(2+(N+m-1)v)^2} \\
&\qquad + \frac{4(N-m)m}{1+mv} - \frac{4(1+N+m)(N-m)}{2+(N+m-1)v}\Big].
\end{aligned}$$

Thus, $\pi_s(m) - \pi_b(m-1)$ and the term in square brackets have opposite signs. Combine the terms in square brackets into a single fraction. Because the denominator is positive, we need only show that the numerator is positive. The numerator is $(1+N-m)^2$ times:

$$\begin{aligned}
B(N,m) \equiv\ & 4(1+N-m)^2 + 4[5+N^3+N^2(m-1) - K(m+1)(5m-3) + m(m(7+3m)-7)]v \\
& + [13+24N-6N^2+N^4+8(3+N+N^2+N^3)m - 2(45+N(3N-8))m^2 - 8(2N-5)m^3 \\
& + 13m^4]v^2 + [-8(N-1)^2N + 2(21+N(4+N(-6+N(N+4))))m + 4(1+N(-7+N(7+N)))m^2 \\
& - 8(10+(-4+N)N)m^3 - 4(-7+N)m^4 + 6m^5]v^3 + [-(-1+N)^4 \\
& + (-1+N)(N+1)(3+(-12+N)N)m + (23+N(-8+N(-12+N(12+N))))m^2 \\
& + 2(-3+N(-14+11N))m^3 - (23+2(-10+N)N)m^4 + 9m^5 + m^6]v^4 \\
& + (-1+m)m(-1+N+m)^2(1+N+m)^2v^5. \qquad (54)
\end{aligned}$$

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

$$\begin{aligned}\frac{\partial^2 B}{\partial N^2} &= 4\{2 + 2(-1 + 3N + m)v + [-3 + 3N^2 + 12Nm + (4 - 3m)m]v^2 \\ &+2[4 + 3N^2 m + m(-3 + (7 - 2m)m) + 3N(-2 + m(2 + m))]v^3 \\ &+[-3 + m - m^2(6 + (-11 + m)m) + 6N(1 + 3(-1 + m)m) + 3N^2(-1 + m + m^2)]v^4 \\ &+(-1 + m)m(-1 + 3(N + m)^2)v^5\}. \end{aligned} \tag{55}$$

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

$$2m[-7 + m^2(19 + m)], \tag{56}$$

which is positive for $m \geq 1$. Thus, the coefficient of v^4 is positive and $\frac{\partial^2 B}{\partial N^2} > 0$.

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

$$\frac{\partial B}{\partial N}|_{N=m+1} = 16v(1 + v)(1 + v + mv)(1 + m(1 + (-1 + m)v)(1 + v + 2mv). \tag{57}$$

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

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

$$B|_{N=m+1} = 16v(1 + mv)^2(1 + v + mv)[2 + (-1 + m)m(1 + v + mv)], \tag{58}$$

which is positive. Thus, 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 reduces to

$$4v[(n^*+1)^2+[4m^{*2}+(1+n^*)^2+m^*(1+n^*(6+n^*))]v+m^*(1+2m^*+n^*)^2v^2-16n^*v(1+v+m^*v)] > 0. \quad (59)$$

Simplifying the left-hand side yields

$$4v[(-1+n^*)^2+[4m^{*2}+(-1+n^*)^2+m^*(1+n^*)^2]v+m^*(1+2m^*+n^*)^2v^2], \quad (60)$$

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

Proof of Proposition 12: There are two cases that must be analyzed: $m=1$ and $m=2$. Since the case where $m=2$ is identical to the non-commitment case studied earlier, we focus on the case where $m=1$. In this case, the analyst can sell to either one or two fund managers. Selling to two fund managers cannot be an equilibrium since, by Proposition 7, the analyst's profit is less than if he chose to become a fund manager. On the other hand, if the analyst opts to sell to only one fund manager, he will have an incentive to deviate.

Denote as agent 1 the fund manager who buys the analyst's signal, agent 2 the fund manager who does not buy the analyst's signal, and agent 3 the analyst. When trading in the financial market, the fund managers solve

$$\max_{x_i} E[x_i(V+\delta-(V+\eta y))|F_i], \quad (61)$$

The optimal solution is $x_i = \frac{E[\delta|F_i]-\eta E[x_j]}{2\eta}$. Assume that $x_1 = a_1s_3 + \beta_1 s_1$ and $x_2 = \beta_2 s_2$. Solving for a_1, β_1, and β_2 yields

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

Fund manager 1's profit 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 the analyst's information, his 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

$$\begin{aligned}
\pi_3 &= \pi_1(1) - \pi_1(0) = \frac{(1-\eta\beta_2)^2}{4\eta}[E(E[\delta|s_1,s_3])^2 - E(E[\delta|s_1])^2] \\
&= \frac{(1-\eta\beta_2)^2}{4\eta}[\frac{2v}{1+2v} - \frac{v}{1+v}] \\
&= \frac{(1-\eta\beta_2)^2}{4\eta}\frac{v}{(1+2v)(1+v)} \qquad (62)
\end{aligned}$$

Now consider the case where agent 3 chooses to be a fund manager. Solving for the symmetric equilibrium, $x_i = \beta_i' s_i$ yields

$$\beta_1' = \beta_2' = \beta_3' = \frac{v}{2\eta(1+2v)}$$

Agent 3's profit is

$$\begin{aligned}
\pi_3' &= \frac{E(E[\delta|s_3])^2(1-\eta\beta_2'-\eta\beta_1')^2}{4\eta} \\
&= \frac{1}{4\eta}\frac{v}{1+v}(1-\frac{v}{2+3v})^2(1-\eta\beta_2')^2
\end{aligned}$$

where the last equation follows because $\eta\beta_1' = \frac{1-\eta\beta_2'}{2+3v}$. Further algebraic manipulation yields $\beta_2 - \beta_2' > 0$. The proposition holds if $\pi_3' > \pi_3$ which is true if $\frac{v}{1+v}(1-\frac{v}{2+3v})^2 > \frac{v}{(1+2v)(1+v)}$. It is straightforward to show that this condition holds.

The proof of Proposition 10: It is sufficient to show in two economies, denoted by 1 and 2, that 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

$$W_0 = E[P_2^0 q^*(P_2^0) - f(q(P_2^0))] = E[(P_2^1+\phi)q^*(P_2^1+\phi) - f(q^*(P_2^1+\phi))]. \qquad (63)$$

But

$$(P_2^1 + \phi)q^*(P_2^1 + \phi) - f(q^*(P_2^1 + \phi)) \geq (P_2^1 + \phi)q^*(P_2^1) - f(q^*(P_2^1)), \tag{64}$$

since $q^*(P_2^1 + \phi)$ uniquely maximizes $(P_2^1 + \phi)q - f(q)$. Furthermore, the inequality in (64) is strict for $\phi \neq 0$. Taking expectation of both sides yields

$$\begin{aligned} E[(P_2^1 + \phi)q^*(P_2^1 + \phi) - f(q^*(P_2^1 + \phi))] &> E[(P_2^1 + \phi)q^*(P_2^1) - f(q^*(P_2^1))] \\ &= E[E[(P_2^1 + \phi)q^*(P_2^1) - f(q^*(P_2^1))|P_2^1]] \\ &= E[P_2^1 q^*(P_2^1) - f(q^*(P_2^1))]. \end{aligned} \tag{65}$$

The last equality follows because $E[\phi|P_2^1] = 0$. Combining (63) and (65) yields $W_0 > W_1$.

Proof of Proposition 11: The first-order condition for analyst j's problem yields

$$b_j = \pi_j t_j. \tag{66}$$

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. So when trading fund managers use $\widehat{s}_j = r_j - \pi_j^* T$, which equals $s_j + \pi_j^*(t_j - T)$ in equilibrium. Thus, $\widehat{s}_j$ has precision

$$\widehat{v}_j = \frac{v v_t}{\pi_j^{*2} v + v_t} \tag{67}$$

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. The same analysis used in the proof of Proposition 2 yield the fund manager's trading strategy which is given by

$$a = \frac{2\widehat{v}}{\eta[2(1 + m\widehat{v}) + (1 + n)v](1 + n)}, \tag{68}$$

$$\beta = \frac{v}{\eta[2(1 + m\widehat{v}) + (n + 1)v]}. \tag{69}$$

The stock price is given by

$$P_2 = V + na\eta \sum_{j=1}^{m} \widehat{s}_j + \beta\eta \sum_{i=1}^{n} s_i + \eta z. \tag{70}$$

The first-order condition for the firm's optimization problem with respect to q yields

$$q(p) = \frac{P_2}{2F}. \tag{71}$$

Substituting (71), (66) and $E[s_j] = 0$ into the firm's problem yields

$$\max_{\pi_j} E[\frac{P_2^2}{2F} - \sum_j^m \pi_j^2 t_j]. \tag{72}$$

Taking the first-order condition yields

$$E[\frac{P_2}{F}\frac{\partial P_2}{\partial \pi_j} - 2\pi_j t_j] = 0 \tag{73}$$

But $\frac{\partial P_2}{\partial \pi_j} = na\eta t_j$. Substituting this into equation (73) yields

$$\frac{na\eta}{F}E[P_2 t_j] = 2\pi_j T. \tag{74}$$

Note also that in equilibrium

$$\begin{aligned} E[P_2 t_j] &= E[(V + na\eta \sum_{j=1}^m (s_j + \pi_j^*(t_j - T)) + \beta\eta \sum_{i=1}^n s_i + \eta z)t_j] \\ &= E[V t_j + na\eta \pi_j^*(t_j - T)t_j] \\ &= VT + na\eta \pi_j^* \frac{1}{v_t}. \end{aligned} \tag{75}$$

Substituting equation (75) and the equilibrium condition, $\pi_j = \pi_j^*$, into (74), yields

$$\frac{na\eta}{F}VT + \frac{(na\eta)^2}{F}\pi_j^* \frac{1}{v_t} - 2\pi_j^* T = 0 \tag{76}$$

Similarly, the firm's second-order condition is

$$\frac{na\eta}{F}(T^2 + \frac{1}{v_t}) - 2T < 0. \tag{77}$$

Because $na\eta \leq 1$, (77) is satisfied if $T + \frac{1}{Tv_t} \leq 2F$. Notice that because the objective function is quadratic, the second-order condition also guarantees that the first-order yields the unique global maximum for the firm's optimization problem.

Solving (76) and (67) yields $\pi_j^* = \pi^*$, which is a positive solution to the following fifth-order polynomial equation

$$2\{-n(1+n)TvVv_t[\pi^{*2}v(2+v+nv) + [2+(1+2m+n)v]v_t] + F\pi^*\{(1+n)^2\pi^{*4}Tv^2(2+v+nv)^2 + 2v[-n^2v + (1+n)^2\pi^{*2}T(2+v+nv)(2+(1+2m+n)v)]v_t + (1+n)^2T[2+(1+2m+n)v]^2v_t^2\}\} = 0. \tag{78}$$

There is always at least one positive solution to this equation because when $\pi^* = 0$, the left-hand side is negative but the coefficient of π^{*5} is positive. So for large enough π^*, the left-hand side is positive. By continuity, there must be a positive π^* such that (78) 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

$$p = \frac{4(1-\gamma)v(1+v)}{(2+v+nv)^2(1+\gamma v)}. \tag{79}$$

Therefore, the independent analyst's equilibrium profit is

$$\pi_i = \frac{4n(1-\gamma)v(1+v)}{(2+v+nv)^2(1+\gamma v)}, \tag{80}$$

and a fund manager's profit is

$$\pi_b = \frac{4\gamma v(1+v)^2}{(1+\gamma v)(2+v+nv)^2}. \tag{81}$$

First check the independent analyst's incentive-compatibility 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 receives

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

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

$$\lim_{\gamma \to 0} \left[\pi_i - \pi_b(n+1)\right] = \frac{4nv(1+v)}{(2+v+nv)^2} > 0. \tag{83}$$

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

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

References

[1] Admati, A. R., and Pfleiderer, P. (1986). A monopolistic market for information, *Journal of Economic Theory* 39, 400-438.

[2] Admati, A. R., and Pfleiderer, P. (1988a). A theory of intraday trading patterns: Volume and price variability, *Review of Financial Studies* 1, 3-40.

[3] Admati, A. R., and Pfleiderer, P. (1988b). Selling and trading on information in financial markets, *American Economic Review* 78, 96-103.

[4] Admati, A. R., and Pfleiderer, P. (1990). Direct and indirect sale of information, *Econometrica* 58, 901–928.

[5] Allen, F. (1990). The market for information and the origin of financial intermediation, *Journal of Financial Intermediation* 1, 3-30.

[6] AIMR, (2001). Invitation to comment: AIMR issues paper, Preserving the integrity of research, *AIMR Advocate* 6, Sep/Oct.

[7] Baker, M., Stein, J., and Wurgler, J. (2003). When does the market matter? Stock prices and the investment of equity-dependent firms, *Quarterly Journal of Economics* forth coming.

[8] Benabou, R., and Laroque, G. (1992). Using privileged information to manipulate markets: Insiders, gurus and credibility, *Quarterly Journal of Economics* 107, 921-956.

[9] Bernhardt, D., Hollifield, B., and Hughson, E. (1994). Investment and insider trading, *Review of Financial Studies* 8, 501-543.

[10] Bhattachaya, S., and Pfleiderer, P. (1985). Delegated portfolio management, *Journal of Economic Theory* 36, 1-25.

[11] Biais, B., and Germain, L. (2002). Incentive-compatible contracts for the sale of information, *Review of Financial Studies* 15, 987-1003

[12] Bolton, P., and Dewatripont, M. (2005). Contract theory, The MIT Press, Cambridge, MA.

[13] Brennan, M. J., and Chordia, T. (1993). Brokerage commission schedules, *Journal of Finance* 48, 1379-1402.

[14] Cantor, R., and Packer, F. (1995). The credit rating industry, *Journal of Fixed Income*, 10-34

[15] Cheng, Y., Liu, M., and Qian, J. (2003). Buy-side analysts, sell-side analysts, and firm performance: Theory and evidence, working paper, Carroll School of Management, Boston College.

[16] Crawford, V., and Sobel, J. (1982). Strategic information transmission, *Econometrica* 50, 1431-1451.

[17] Easley, D., and O'Hara, M (2004). Information and the cost of capital, *Journal of Finance* 59, 1553-1583.

[18] Fischer, P. E., and Verrecchia, R. E. (2000). Reporting Bias, *The Accounting Review* 75, 229-245.

[19] Fishman, M. J., and Hagerty, K. (1992). Insider trading and the efficiency of stock prices, *Rand Journal of Economics* 23, 106-122.

[20] Fishman, M. J., and Hagerty, K. (1995). The incentive to sell financial market information, *Journal of Financial Intermediation* 4, 95-115.

[21] Hart, O., and Tirole, J. (1990). Vertical integration and market Foreclosure, *Brookings Papers on Economic Activity*, 1990, 205-86.

[22] Heinkel, R., and Stoughton, N. (1994). The dynamics of portfolio management contracts, *Review of Financial Studies* 7, 351-387.

[23] Hirshleifer, J. (1971). The private and social value of information and the reward to inventive activity, *American Economic Review* 61, 561-574.

[24] Hong, H., and Kubik, J. (2003). Analyzing the analysts: career concerns and biased earnings forecasts, *Journal of Finance* 58, 313-351.

[25] Kyle, A. S. (1985). Continuous auctions and insider trading, *Econometrica* 53, 1315–1335.

[26] Kyle, A. S. (1989). Informed speculation with imperfect competition, *Review of Economic Studies 56,* 317-355.

[27] Leland, H. E. (1992). Insider trading: Should it be prohibited? *Journal of Political Economy* 100, 859-887.

[28] Leland, H. E., and Pyle, D. H. (1977). Information asymmetries, financial structure, and financial intermediation, *Journal of Finance*, 32, 371-387.

[29] Ljungqvist, A., Marston, F., and Wilhelm, W. (2005). Competing for securities underwriting mandates: Banking relationships and analyst recommendations, *Journal of Finance*, forthcoming.

[30] McAfee, R. P., and Schwartz, M. (1994). Opportunism in mutilateral vertical contracting: Nondiscriminaion, exclusivity, and uniformity. *American Economic Review* 84, 210-230.

[31] Michaely, R., and Womack, K. (1999). Conflict of interest and credibility of underwriter analyst recommendations, *Review of Financial Studies* 12, 653-686.

[32] Michaely, R., and Womack, K. (2002). Brokerage recommendations: Stylized characteristics, market responses, and biases, *Advance in Behavioral Finance II,* Richard Thaler, editor, forthcoming.

[33] Morris, S., and Shin, H. S. (2002). Social value of public information, *American Economic Review* 92, 1521-1534.

[34] Morrison, A., and Wilhelm, W. (2004). Partnership firms, reputation and human capital, *American Economic Review* 94, 1682-1692.

[35] Smith, R.C., and Walter, I. (2001) Rating agencies: Is there an agency issue? working paper, Stern School of Business, New York University.

[36] Vishny, R. W. (1985). Market structure in speculation and brokerage, working paper, Graduate School of Business, University of Chicago.

[37] White, L. J.(2001). The credit rating industry: An industrial organization analysis, working paper, Stern School of Business, New York University.

[38] Womack, K. (1996) Do brokerage analysts' recommendations have investment values? *Journal of Finance* 51, 137-167.