Stock recommendation of an analyst who trades on own account

CORE Discussion Paper

Saltuk Ozerturk*

SMU and CORE

Abstract

This paper analyzes how to provide information acquisition and truthful reporting incentives to a financial analyst who privately trades on own account. The analysis exploits the observation that for a given report, the analyst's reward scheme essentially provides him with a portfolio endowment traded in the market. For every signal, the analyst makes the report that corresponds to the portfolio endowment with maximum market value, given security prices. The principal cannot make the analyst strictly prefer to report the true signal: the analyst is truthful only when indifferent between the two reports. The analyst's information acquisition incentive is driven only by private portfolio considerations: he acquires information only if he will be holding a large enough position in the stock he covers. The paper also presents a general 'separation of the optimal report from private information' result and illustrates that performance based reward schemes can fail to induce any information revelation when the analyst privately trades.

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1 Introduction

An important function of security analysts in financial brokerage firms is to provide unbiased information to investors. Following the poor performance of the stock market in general and of the analysts' recommendations for the year 2000, the credibility of stock analysts' recommendations came under attack by the popular press.[1] The debate on the credibility of the analyst's recommendations mainly focused on the internal pressure from the analyst's firm particularly with respect to increasing the investment banking business. This objective calls for pleasing the underwriting clients by issuing optimistic reports. A conflict of interest arises because the brokerage clients (investors) want unbiased research but investment banking clients (issuers or underwriters) want optimistic research. Therefore, the analyst may feel pressure to boost or maintain the stock price by issuing positive recommendations.[2] According to Boni and Womack (2002), a much less emphasized but equally important source of conflict regarding the credibility of analyst recommendations is the analyst's own personal investments. In an article titled 'Should Analysts Own Stock in Companies They Cover?', Schack (2001) also makes this point: 'Wall Street research analysts increasingly are accused of ditching their objectivity to please underwriting clients. But largely overlooked in all of the complaints has been perhaps the most fundamental conflict of interest for all Wall Street analysts- owning the stock of companies they cover. It is not illegal; nor by Wall Street's standards is it unethical. In fact it is a common industry practice...' (page 60).

The issue of whether the analysts should be allowed to trade in the stocks they cover is a controversial one. The opponents of analyst trading argue that the whole practice is unethical because the analysts have a clear incentive to manipulate the stock price with false recommendations if they can trade on own account. Some practitioners, however, are in favor of the analyst's stock ownership, arguing that the analysts's credibility would be enhanced if they are allowed to 'put their money where their mouth is.' (see Boni and Womack (2002)).

The theoretical literature on the credibility of analyst recommendations have largely overlooked the implications of analyst's personal trades. This paper examines how the analyst's ability to privately trade on own account affects his information acquisition and reporting incentives. Another point of departure from the literature is that the credibility issues are addressed primarily in models where the analysts are

[1] Newspaper headlines such as "Shoot All the Analysts" (by Financial Times, March, 2001) and "Can We Trust Wall Street Again?" (the cover of the Fortune magazine) expressed a popular concern on analyst credibility. Alarmed by the growing media attention and public discomfort, in the summer of 2001, the U.S. Congress held hearings, titled "Analyzing the Analysts", to find remedies for the potential conflict of interests analysts face when making their stock recommendations.

[2] In 2002, the SEC approved new NASD (National Association for Security Dealers) rules which mandate separation of research and investment banking and prohibit the compensation of analysts from specific investment banking deals.

concerned with the stock price induced by their recommendations. This paper takes an alternative approach and analyzes a model where the recommendation does not affect the stock price. This approach allows to introduce analyst trading perhaps in the most innocuous way and abstracts away from the incentives to misreport merely to manipulate the stock price. I describe a model where a risk averse analyst is hired by a principal (an investor or an investment bank) to provide information on a risky security return. The analyst has to pay a private cost to acquire information. If he does so, he receives a private and unverifiable information signal. A high (low) signal indicates that the high (low) return is more likely. Given this signal or based on no private information at all, the analyst issues a report, high or low, to the principal. Subsequent to his report, the analyst privately trades the risky security along with a safe security. The competitive analyst has no a priori bias in choosing his report. The reporting and private portfolio choices take the risky security price as given. In this setting, I analyze the principal's problem of providing costly information acquisition and truthful reporting incentives to the analyst. The principal optimally sets a reward scheme that ties the analyst's compensation to his report and to the realization of the risky security return. The analyst's information acquisition decision, his information signal and portfolio choice are all unobservable to the principal. The problem combines ex ante moral hazard (information acquisition) and ex post adverse selection (truthfulness) with the additional feature that the analyst also chooses an unobservable portfolio ex post.

In the benchmark case when the analyst *cannot* trade, the truthful reporting constraints are not binding: if the analyst acquires information ex ante, he strictly prefers to report the signal truthfully ex post. The principal can induce information acquisition only by offering a reward scheme that makes the analyst *strictly* prefer to report the true signal. If the analyst is ex post indifferent between the two reports, he does not acquire costly information. The optimal contract rewards the analyst if his report proves accurate. The information acquisition incentives are based on 'reporting performance'. This creates an ex-post rent from making informed reports and constitutes the ex ante incentive for costly information acquisition.

The optimal contracting analysis when the analyst privately trades yields the following results.

(i) The principal cannot make the analyst *strictly* prefer to report the true signal. If the analyst acquires information, he truthfully reveals it only when indifferent between the two reports.

(ii) The analyst's information acquisition incentives are driven only by his private portfolio considerations. The analyst acquires information only if he will be holding a large enough position in the risky security, i.e., if he will be putting his money in the risky security he covers, but not because he is strictly better off from reporting the true signal.

(iii) The analyst's ability to privately trade is a bigger problem for the principal if the analyst is too risk averse. This result follows because the principal can provide information acquisition incentives only to the extent that she can induce the analyst to hold a large enough risky security position. If the analyst is too risk averse, he tends to hold very little exposure to the risky security and inducing information acquisition can be prohibitively costly. If the analyst is sufficiently risk tolerant, the principal may be better off from the analyst's ability to trade, since once employed the analyst has a priori incentives of his own to acquire information and use it in his private portfolio decision.

(iv) When the analyst privately trades, a compensation scheme that rewards the accuracy of the analyst's report performs no better than a flat wage scheme in terms of inducing truthful reporting and information acquisition incentives.

These results indicate that the superiority of reward schemes based on the analyst's reporting performance depends crucially on the trading opportunities available to the analyst. More strict trading restrictions on analysts may result in more frequent use of explicit schemes that reward reporting performance. Furthermore, if the trading restrictions on analysts are lax, it is better to hire a relatively more risk tolerant analyst who tends to put his money in the security he covers, rather than a more risk averse analyst who tends to hold little exposure to the risky security in his private portfolio.

To characterize the reporting incentives when the analyst privately trades, the analysis exploits the following observation which holds for any reward scheme in a binary report and state space. For any given report, there is a portfolio of safe and risky securities such that this portfolio and the analyst's reward scheme generate the same payoff. Therefore, for a given report the analyst's reward scheme essentially provides him with a portfolio endowment traded in the market: by choosing a report the analyst essentially chooses between portfolio endowments. Taking security prices as given, for every signal the analyst chooses the report that corresponds to the portfolio endowment with the highest market value. If reporting the high (low) signal corresponds to a more valuable portfolio endowment, then the analyst always reports the high (low) signal, regardless of the true signal. The report that corresponds to the portfolio with the highest market value is optimal because the analyst can subsequently sell this portfolio as part of his trades at this market value. He can then use the proceeds as additional wealth to allocate in an optimal portfolio according to the true signal. For every signal the analyst hence chooses the report that maximizes his wealth endowment (since reports correspond to portfolio endowments that he can sell at market prices as part of his trades) and allocates this maximized wealth in an optimal portfolio given the true signal.

The paper generalizes the above observation to a general message and state space and presents a 'separation of the optimal reporting strategy from private information' result. This result applies to any reward scheme where for every report the part of the reward scheme that depends on the report corresponds to a portfolio of safe and risky securities traded in the market. This property of the reward scheme gives rise to reporting incentives that does not use the private information signal. For every signal, taking security prices as given the analyst makes the report that corresponds to the portfolio endowment with maximum market value. This result indicates that reward schemes which create similar payoff structures as the financial claims that the analyst can trade in the market can be inadequate in inducing credible recommendations. Such schemes can fail to induce any information revelation even if they are designed purely to reward the analyst's performance. I provide an example of this general result by using a scoring type reward scheme which ties the analyst's reward to his performance. This scheme is known to illicit truthful reporting in the absence of analyst trades (see Bhattacharya and Pfleiderer (1985)). I show that the scoring rule completely fails to induce any information revelation when the analyst privately trades. Under this rule, regardless of the true signal and its precision, the analyst always makes a report equal to the prevailing risky security price.

1.1 Related literature

As mentioned, the theoretical literature that examines the incentive problems between financial analysts and their clients has largely overlooked the possibility that analysts may also trade on own account. One exception is Biais and Germain (2002) who consider a model where a portfolio manager has conflicting interests with his client, since the manager also trades on own account. In that setting, however, the portfolio manager uses his information to select a portfolio on behalf of the client. Since their manager does not disclose any information to the client, they do not address the credibility of recommendations. Instead they focus on whether the manager creates a portfolio that maximizes the client's welfare.[3]

Benabou and Laroque (1992) and Morgan and Stocken (2003) address an analyst's incentives to misreport his information in cheap-talk frameworks. In those papers, the analyst is primarily concerned with the price impact of his recommendation. Morgan and Stocken (2003) consider the credibility of an analyst's recommendation when the investors are uncertain about the pressure that the analyst faces to boost the stock price. The analyst may be biased to issue a favorable report to win busi-

[3] Admati and Pfleiderer (1986, 1990) study the problem of an information seller in a noisy rational expectations framework. In Brennan and Chordia (1993) a brokerage firm sells financial market information by charging a brokerage commission fee. In those papers, information seller does not trade on own account. It is also assumed that the seller has the information ex ante and reports it truthfully ex post.

ness for the investment banking branch of his company. In that sense, they address precisely the misalignment of the analyst's incentives due to ties with the investment banking business. To focus on the information that analysts communicate via their reports and the responsiveness of stock prices to analyst recommendations, they purposely rule out the possibility that the analyst may trade on own account. Instead, I focus on the implications of the analyst's private trades for the information acquisition and reporting incentives in an optimal contracting setting where the stock price does not depend on the analyst's recommendation. Therefore, the analysis in this paper complements theirs by addressing the relatively less emphasized source of conflict identified by Boni and Womack (2002) and Schack (2001), namely the analyst's private trades. Benabou and Laroque (1992) analyze the reporting incentives of a privately informed agent (like a market guru, a journalist or a corporate insider) who can trade without being detected, but can influence and manipulate the price through public announcements. They show that with noisy private information, an informed agent can manipulate prices repeatedly by false reports, since the market cannot tell if he is dishonest or just wrong. In Benabou and Laroque (1992), misreporting incentives arise to manipulate prices, whereas in this paper the analyst is competitive and takes the price as given in choosing his report and his trades.

Another related strand of literature consider situations where the analysts are concerned with convincing investors of their forecasting expertise. In Trueman (1994) the analysts have different forecasting abilities unobservable to the market and they choose their reports with the objective of maximizing the clients' posterior probability that the analyst has high forecasting ability. Trueman shows that analysts with precise signals report truthfully, whereas low ability analysts with less precise signals mimic the high types. Ottaviani and Sorensen (forthcoming) formulate a cheap talk framework where an expert with private information is concerned about being perceived to have accurate information. They show that experts can credibly reveal only part of their information. Those papers consider reputation driven reporting environments and do not allow the analyst/expert to trade on own account.

The paper proceeds as follows. The next section lays out the model and describes the optimal contracting problem. Section 3 analyzes the case when the analyst cannot trade. Section 4 considers the principal's problem of providing information acquisition and truthful reporting incentives when the analyst privately trades. Section 5 provides a general separation of the reporting strategy from the true signal result and illustrates this result with a scoring type rule that rewards reporting performance. Section 6 concludes. The Appendix collects the proofs which are not presented in the text.

2 The model

The model considers a security analyst (agent) who can provide information on a risky security return by issuing a report to his client (principal). The details of the set-up are explained below.

The Security Market. Consider a financial market where two securities are traded: a safe security (normalize its gross return to 1) and a risky security. A portfolio is described by a pair $(x, y) \in R^2$ where x and y are the shares of the safe and risky securities, respectively. Trading takes place at date 3 and portfolios are liquidated at date 4. The liquidation value of a portfolio (x, y) is given by $x + \theta y$ where θ is the stochastic final value of the risky security to be realized at date 4. Assume that θ can take two values, $\theta \in \{\theta_h, \theta_l\}$ with $\theta_h > \theta_l$. The prior distribution of θ is summarized by the ex ante probability $\Pr(\theta_h) = \alpha \in (0, 1)$.

Costly Information Acquisition and Reporting. At date 0, the principal (an investor or an investment bank) hires the security analyst to acquire information on the risky security return.[4] Upon expending a private cost $c > 0$ measured in expected utility terms, the analyst can observe a private signal s correlated with θ.[5] The information signal can take two values, $s \in \{h, l\}$ where h and l refer to high and low signals, respectively. The signal is noisy. Denote by ϕ the signal's precision defined as $\phi \equiv \Pr(h|\theta_h) = \Pr(l|\theta_l) \in (\frac{1}{2}, 1)$. For ease of reference, also let σ_h and $\sigma_l \equiv 1 - \sigma_h$ describe the prior distribution of s where $\sigma_h \equiv Pr(s = h) = \alpha\phi + (1 - \alpha)(1 - \phi)$.

Whether the analyst acquires information or not, and the particular information signal he receives are not observable and ex post verifiable by the principal. Therefore, the analyst is not constrained in any way to report his private signal truthfully, if he has one. Given the signal realization s (if information is acquired) or based on no information at all, the analyst makes a report $m \in \{h, l\}$ to the principal prior to trading.[6]

Analyst's Private Portfolio: The analyst can trade on his own account. Let (F, d) denote the private portfolio that the analyst creates for own account at the trading stage. This portfolio choice is also unobservable to the principal. The assumption that the analyst's personal trades are unobservable captures the potential conflict of interest that undermines the credibility of the analyst's recommendations.[7]

[4] The framework with only one risky security can be extented to multiple risky securities. In practice, a security analyst is responsible from covering a few stocks in a certain industry. Therefore, a single risky security framework does not seem to be too restrictive.

[5] Similar to Osband (1989), this private cost can be interpreted as costly effort that the analyst has to exert to obtain information.

[6] Benabou and Laroque (1992) also employ a a binary specification of the state space and the message space.

[7] Following the negative media coverage, some financial firms adopted new disclosure rules and restrictions of their own (see Gasparino and Opdyke (2001)). Even with increased disclosure requirements, full transparency of analyst trades may be hard to implement.

Security Prices: The analyst is a competitive price taker in the securities market. In particular, the analyst's reporting and private portfolio choices have no price impact. Each share of the risky security trades at a price p in the market where $\theta_l < p < \theta_h$. Normalize the share price of the safe security to 1. Accordingly, a portfolio (x, y) trades in the market at a price $x + py$. When he trades on own account, an analyst who can affect the price by his recommendation may have an incentive to produce favorable reports to maintain or boost the value of the securities in his portfolio. Similarly, the analyst may engage in speculative announcements to cause the stock price fall (rise) while secretly buying (selling) the stock, a scheme analyzed in Benabou and Laroque (1992) which they call 'post-announcement speculation'. My purpose is not to overrule these relatively better understood possibilities.[8] As a point of departure from the existing literature and also to weaken misreporting incentives, I abstract away from the effect of the recommendation on the risky security price. This approach prevents any incentives to misreport merely to manipulate the price and instead focuses on reporting incentives that take the price as given.

Preferences and the analyst's compensation: The risk averse analyst values consumption of final wealth and incurs a disutility from information gathering. The analyst's utility is specified as $u(\omega) - c$, where ω is the final wealth and $c > 0$ is the cost of information acquisition, measured in utility terms without loss of generality. $u(.)$ is twice differentiable, strictly increasing and strictly concave. To keep the model simple, I do not explicitly model how the principal uses the information provided to her by the analyst. The principal's objective is to induce information acquisition and truthful revelation at a minimum expected monetary transfer to the analyst, subject to the additional consideration that the analyst privately trades on own account. The analyst's reward scheme is described by a non-negative vector of monetary transfers $t(m, \theta) \geqslant 0$ for $m \in \{h, l\}$ and $\theta \in \{\theta_h, \theta_l\}$ that tie the analyst's compensation to his report and to the final verifiable return of the risky security.[9]

Sequence of Events. At date 0, the principal sets an explicit monetary reward scheme $t(m, \theta) \geqslant 0$ for $m \in \{h, l\}$ and $\theta \in \{\theta_h, \theta_l\}$. At date 1, the analyst chooses whether or not to acquire costly information, a choice which is not observable to the principal. If he acquires information, the analyst observes a private signal $s \in \{h, l\}$. At date 2, the analyst makes a report $m \in \{h, l\}$ to the principal. At date 3, the analyst privately chooses his portfolio taking security prices as given. At date 4, the security returns are realized and the analyst is compensated.

[8] A study by the SEC's Office of Investor Education and Assistance emphasizes the power that the analysts can have on stock prices: 'The mere mention of a company by a popular analyst can temporarily cause its stock to rise or fall-even when nothing about the company's prospects recently has changed.' (cited in Boni and Womack (2002, page 7).

[9] Note that I impose a limited liability constraint on the reward scheme and assume that the transfers to the analyst must be non-negative.

2.1 The optimal contracting problem

This section formulates the principal's optimal contracting problem by establishing the ex-ante information acquisition and the ex-post truthfulness constraints. These constraints must also take into account the fact that the analyst privately trades on own account. Suppose the analyst expends c and acquires information. Given some initial wealth w_0, the risky security price p, the reward scheme $t(m, \theta)$ in place and conditional on the signal $s \in \{h, l\}$, the analyst chooses a report $m \in \{h, l\}$ and a personal portfolio $(F, d) \in R^2$ to maximize

$$E[u(t(m, \theta) + d\theta + F)|s] \text{ subject to } F + pd \leq w_0. \tag{P1}$$

For future reference call this problem (P1). Substituting for F from the budget constraint, (P1) can be rewritten as choosing $m \in \{h, l\}$ and $d \in R$ to maximize $E[u(\omega(m, d))|s]$ where

$$\omega(m, d) \equiv t(m, \theta) + d(\theta - p) + w_0 \tag{1}$$

is the analyst's final wealth. Clearly, the analyst's optimal private portfolio choice depends on his reward scheme $t(m, \theta)$ and hence on his report m. Let $d^*(m, s)$ describe the optimal private portfolio choice after observing $s \in \{h, l\}$ and reporting $m \in \{h, l\}$. $d^*(m, s)$ must be such that

$$d^*(m, s) \in \arg\max E[u(\omega(m, d))|s] \text{ for } m \in \{h, l\} \text{ and } s \in \{h, l\}. \tag{2}$$

Ex-post Truthfulness Constraints: Upon observing $s = h$, the analyst must prefer to report $m = h$ and trade $d^*(h, h)$ rather than reporting $m = l$ and trading $d^*(l, h)$, which requires

$$E[u(\omega(h, d^*(h, h)))|h] - E[u(\omega(l, d^*(l, h)))|h] \geq 0 \tag{3}$$

where $d^*(h, h)$ and $d^*(l, h)$ are described by (2). Similarly, upon observing $s = l$, the analyst must prefer to report $m = l$ and trade $d^*(l, l)$ rather than reporting $m = h$ and trading $d^*(h, l)$:

$$E[u(\omega(l, d^*(l, l)))|l] - E[u(\omega(h, d^*(h, l)))|l] \geq 0. \tag{4}$$

Ex-ante Information Acquisition Constraints: Consider now an uninformed analyst's private portfolio choice $d^*(m, n)$ following a report m where n stands for 'not informed'. $d^*(m, n)$ is given by

$$d^*(m, n) \in \arg\max E[u(\omega(m, d))] \text{ for } m \in \{h, l\}, \tag{5}$$

Ex-ante, the analyst must not choose to remain uninformed to subsequently report $m = h$ and trade $d^*(h, n)$ which requires

$$\sigma_h E[u(\omega(h, d^*(h, h)))|h] + \sigma_l E[u(\omega(l, d^*(l, l)))|l] - c \geq E[u(\omega(h, d^*(h, n)))], \tag{6}$$

and must not prefer to remain uninformed to subsequently report l and trade $d^*(l,n)$:

$$\sigma_h E[u(\omega(h, d^*(h,h)))|h] + \sigma_l E[u(\omega(l, d^*(l,l)))|l] - c \geq E[u(\omega(l, d^*(l,n)))]. \tag{7}$$

The Principal's Problem: The principal's problem is to choose the reward scheme $t(m,\theta) \geqslant 0$ for $m \in \{h,l\}$ and $\theta \in \{\theta_h, \theta_l\}$ to minimize the ex ante expected transfer $\sigma_h E[t(h,\theta)|h] + \sigma_l E[t(l,\theta)|l]$ subject to the two truthful reporting constraints (3) and (4), the two information acquisition constraints (6) and (7) and a participation constraint

$$\sigma_h E[u(\omega(h, d^*(h,h)))|h] + \sigma_l E[u(\omega(l, d^*(l,l)))|l] - c \geq \bar{u} = 0, \tag{8}$$

where the analyst's expected outside utility $\bar{u}$ is normalized to zero. All the above constraints take into account the analyst's private portfolio choices when informed, described by (2) and when uninformed, described by (5).

3 No private trading by the analyst

As a benchmark for comparison, this section describes the properties of the optimal contract when the analyst cannot privately trade on own account. An important observation is that in this case the ex-post truthfulness constraints are *not* binding. The ex-ante incentives for information acquisition imply that the analyst is ex-post truthful: if the analyst acquires information, he strictly prefers to report the true signal ex post. To establish this observation formally, note that with no private trading by the analyst the two ex-post truthful reporting constraints (3) and (4) reduce to

$$E\left[u(t(h,\theta))|h\right] - E\left[u(t(l,\theta))|h\right] \geqslant 0, \tag{3a}$$
$$E\left[u(t(l,\theta))|l\right] - E\left[u(t(h,\theta))|l\right] \geqslant 0, \tag{4a}$$

and the two ex ante information acquisition constraints (6) and (7) become

$$\sigma_h E\left[u(t(h,\theta))|h\right] + \sigma_l E\left[u(t(l,\theta))|l\right] - c \geqslant E[u(t(h,\theta))], \tag{6a}$$
$$\sigma_h E\left[u(t(h,\theta))|h\right] + \sigma_l E\left[u(t(l,\theta))|l\right] - c \geq E[u(t(l,\theta))]. \tag{7a}$$

Since $E[u(t(m,\theta))] = \sigma_h E\left[u(t(m,\theta))|h\right] + \sigma_l E\left[u(t(m,\theta))|l\right]$ for $m \in \{h,l\}$, the information acquisition constraint (6a) can be rewritten as

$$E\left[u(t(l,\theta))|l\right] - E\left[u(t(h,\theta))|l\right] \geqslant \frac{c}{\sigma_l} > 0, \tag{6aa}$$

and therefore (6a) implies (4a). Similarly, (7a) can be rewritten as

$$E\left[u(t(h,\theta))|h\right] - E\left[u(t(l,\theta))|h\right] \geqslant \frac{c}{\sigma_h} > 0, \tag{7aa}$$

and hence (7a) implies (3a). Accordingly, the ex post adverse selection (the truthtelling) problem becomes irrelevant if the ex ante moral hazard problem (information acquisition) is resolved. This observation also implies that under a reward scheme where the two truthful reporting constraints remain binding, the analyst does not acquire costly information. The principal can induce information acquisition only by offering a reward scheme that makes the analyst *strictly* better off from reporting the truth once he observes the signal. This can be readily observed from (6aa) and (7aa). For example, the information acquisition constraint (6aa) simply says that for the analyst to have incentives to acquire the low signal, he must be given an ex-post rent, measured in expected utility terms, of at least c/σ_l for reporting the low signal truthfully. If the analyst is ex post indifferent between reporting the high or low signal, ex ante he does not incur the cost of information acquisition.[10]

Observation 1: If the analyst cannot privately trade, he acquires information only if truthful reporting gives a strictly higher expected utility compared to misreporting, i.e., if the two ex post truthfulness constraints are not binding.

This observation rules out the optimality of flat wage schemes, since with a flat scheme the truthful reporting constraints remain binding: the analyst is indifferent between the two reports ex-post and hence has no incentive to acquire information ex-ante. One can further characterize the optimal contract by using the two relevant constraints; the ex-ante information acquisition constraints (6a) and (7a). For brevity, I present the formal arguments in the Appendix and here only describe the qualitative properties of the optimal contract. The two information acquisition constraints are both binding in the optimal contract: the principal sets the reward scheme such that the analyst is ex ante indifferent between acquiring information and remaining uninformed. This ensures that the analyst receives the minimum possible rent compatible with information acquisition. The optimal contract must have $t^*(h, \theta_l) = t^*(l, \theta_h) = 0$, since rewarding the analyst when his recommendation proves inaccurate does not provide any incentives for information acquisition and is not optimal. The optimal transfers $t^*(h, \theta_h)$ and $t^*(l, \theta_l)$ can then be determined by solving (6a) and (7a) as an equality. $t^*(h, \theta_h)$ and $t^*(l, \theta_l)$ are both increasing in the cost of information acquisition c and are decreasing in the precision of the signal ϕ. The optimal contract rewards the analyst if his report proves accurate: the incentives are hence based on 'reporting performance'.

[10] Iossa and Legros (2004) obtain a similar result in the context of a model with costly auditing: to induce information acquisition, the auditor needs to be given a rent when his report is informative that is greater than what he obtains when his report is uninformative. To grant the auditor property rights when he reports the high signal is the only way to provide this rent and ensure information acquisition.

4 Analyst trades on own account

This section turns to the main focus of the paper, the information acquisition and reporting incentives of an analyst who can privately trade on own account.

4.1 Reporting and private portfolio choice

The following observation proves crucial in characterizing the analyst's optimal reporting and private portfolio choice. Consider *any* reward scheme $t(m, \theta)$ for $m \in \{h, l\}$ and $\theta \in \{\theta_h, \theta_l\}$ that the principal offers. For a given report m, it is always possible to find a corresponding portfolio $(x_m, y_m) \in R^2$, that I index by m, such that this portfolio and the reward scheme $t(m, \theta)$ generate the same payoff at state $\theta \in \{\theta_h, \theta_l\}$. To see this, suppose the analyst reports $m = l$. If the realized state is θ_l, the reward scheme pays $t(l, \theta_l)$, whereas at state θ_h it pays $t(l, \theta_h)$. Consider now the following portfolio of safe and risky securities:

$$\left(x_l \equiv \frac{\theta_h t(l, \theta_l) - \theta_l t(l, \theta_h)}{\theta_h - \theta_l},\ y_l \equiv \frac{t(l, \theta_h) - t(l, \theta_l)}{\theta_h - \theta_l} \right).$$

One can easily verify that at state θ_l, the portfolio (x_l, y_l) also pays $t(l, \theta_l)$, whereas at state θ_h it pays $t(l, \theta_h)$. Therefore, for $m = l$, the reward scheme $t(m, \theta)$ and the portfolio (x_l, y_l) described above yield the same payoff. This argument applies to reporting $m = h$ as well. Formally, for a given report $m \in \{h, l\}$, one can find a portfolio (x_m, y_m) such that

$$x_m + y_m \theta_h = t(m, \theta_h), \tag{9a}$$

$$x_m + y_m \theta_l = t(m, \theta_l). \tag{9b}$$

Solving for x_m and y_m yields the following instrumental observation.

Lemma 1. (*Reward scheme corresponds to a portfolio*) Consider any reward scheme $t(m, \theta)$ for $m \in \{h, l\}$ and $\theta \in \{\theta_h, \theta_l\}$ that the principal offers. For a given report $m \in \{h, l\}$, there is a portfolio

$$\left(x_m \equiv \frac{\theta_h t(m, \theta_l) - \theta_l t(m, \theta_h)}{\theta_h - \theta_l},\ y_m \equiv \frac{t(m, \theta_h) - t(m, \theta_l)}{\theta_h - \theta_l} \right) \tag{10}$$

such that $t(m, \theta) = x_m + y_m \theta$ at state $\theta \in \{\theta_h, \theta_l\}$.

Therefore, for a given report $m \in \{h, l\}$ the analyst's reward scheme $t(m, \theta)$ is equivalent to the portfolio endowment (x_m, y_m) described in (10). Now consider the market value of the portfolio (x_m, y_m). For a risky security price p that the analyst and all market participants take as given, the portfolio (x_m, y_m) that generates the same payoff as $t(m, \theta)$ is valued in the market at

$$v(m) \equiv x_m + p y_m.$$

Using (10), one obtains

$$v(m) = \frac{(\theta_h - p)t(m, \theta_l) + (p - \theta_l)t(m, \theta_h)}{\theta_h - \theta_l} \text{ for } m \in \{h, l\} \tag{11}$$

Lemma 1 implies that for a given report m, the analyst's reward scheme $t(m, \theta)$ essentially provides the analyst with a portfolio endowment (x_m, y_m) which is valued in the market at $v(m)$. By choosing a report the analyst essentially chooses between different portfolio endowments. Let me now illustrate the implication of Lemma 1 for the analyst's optimal reporting choice. Consider (P1), the analyst's reporting and private portfolio problem. Using Lemma 1, substitute for $t(m, \theta) = x_m + y_m\theta$ and rewrite (P1) as choosing $m \in \{h, l\}$ and $(F, d) \in R^2$ to maximize

$$E[u((d + y_m)\theta + F + x_m)|s] \quad \text{subject to } F + pd \leq w_0.$$

Using a transformation $F \equiv K - x_m$ and $d \equiv \tau - y_m$, this problem can be equivalently stated as choosing $m \in \{h, l\}$ and $(K - x_m, \tau - y_m)$ to maximize

$$E[u(K + \tau\theta)|s] \text{ subject to } K + p\tau \leq w_0 + v(m). \tag{P2}$$

Note that the effect of the report m and hence the reward scheme $t(m, \theta)$ on the analyst's problem is only through $v(m)$ which serves as additional wealth to be allocated in a privately optimal portfolio (K, τ). This follows, because subsequent to reporting m the analyst can always sell the portfolio (x_m, y_m) *as part* of his private trades and generate a wealth $v(m)$. He can then allocate this wealth $v(m)$ plus any initial wealth w_0 in an optimal portfolio of risky and safe securities according to the true signal, as stated in the equivalent problem (P2). But then for every signal the analyst's optimal reporting choice is driven completely to maximize $v(m)$: the optimal report must correspond to the portfolio endowment with the maximum market value given security prices. For every signal the analyst chooses the report that maximizes his wealth endowment (since his reports correspond to portfolio endowments that he can sell at market prices as part of his trades) and allocates this maximized wealth in an optimal portfolio given the true signal. We have the following optimal reporting and private portfolio choice stated in two parts for ease of exposition.

Proposition 1a. Given a reward scheme $t(m, \theta)$, the analyst reports

$$m^* \in \underset{m \in \{h,l\}}{\arg\max}\; v(m) \text{ for } s \in \{h, l\}.$$

Proposition 1b. Subsequent to reporting $m^* \in \arg\max\, v(m)$ for $s \in \{h, l\}$, the analyst chooses a portfolio $(K - x_{m^*}, \tau - y_{m^*})$ where $(K, \tau) \in R^2$ maximize $E[u(K + \tau\theta)|s]$ subject to $K + p\tau \leq w_0 + v(m^*)$.

Proof. See the Appendix.

Using Proposition 1a, one can explicitly describe the analyst's optimal reporting strategy. The analyst reports $m^* = h$ for both signals if $v(h) > v(l)$, or using the expression for $v(m)$ in (11), if

$$(p - \theta_l)\left(t(h, \theta_h) - t(l, \theta_h)\right) > (\theta_h - p)\left(t(l, \theta_l) - t(h, \theta_l)\right),$$

and reports $m^* = l$ for both signals if $v(l) > v(h)$, i.e., if

$$(\theta_h - p)\left(t(l, \theta_l) - t(h, \theta_l)\right) > (p - \theta_l)\left(t(h, \theta_h) - t(l, \theta_h)\right).$$

Therefore, the principal cannot make the analyst strictly prefer to report the true signal. To induce truthfulness, the principal is restricted to reward schemes for which the market value $v(m)$ of the corresponding portfolio endowment is the same for $m \in \{h, l\}$. Only if $v(h) = v(l)$, the analyst is indifferent and reports the true signal if he has acquired information ex ante.[11] This follows under the standard assumption that when indifferent, the agent reports the truth.

Corollary 1 (Truthfulness). If the analyst acquires information, he reports his signal truthfully only if $t(m, \theta)$ is set such that $v(h) = v(l)$, i.e.,

$$(\theta_h - p)\left(t(l, \theta_l) - t(h, \theta_l)\right) = (p - \theta_l)\left(t(h, \theta_h) - t(l, \theta_h)\right) \tag{12}$$

Flat wage schemes clearly belong to the set that induce truthfulness. Consider the schemes of the form $t(l, \theta_l) > 0$, $t(h, \theta_h) > 0$ and $t(h, \theta_l) = t(l, \theta_h) = 0$, which reward the analyst when his report is confirmed by the realization of θ. Section 3 illustrated that if the analyst cannot privately trade, this type of scheme optimally induces information acquisition and truthful revelation, since it makes the analyst strictly prefer to report the true signal ex post. If the analyst privately trades, such a scheme can induce truthfulness provided that $t(h, \theta_h)(p - \theta_l) = t(l, \theta_l)(\theta_h - p)$. However, it no longer makes the analyst strictly prefer to report the true signal. In terms of relaxing the ex post truthfulness constraints and hence providing 'reporting based' incentives for information acquisition, a scheme that ties the analyst's reward to his performance fares no better than a flat scheme.

Corollary 2. The principal cannot make the analyst strictly prefer to report the true signal when the analyst privately trades. The ex post truthfulness constraints (3) and (4) are binding.

Proof. See the Appendix.

[11] Since the optimal reporting choice maximizes $v(m)$ for every signal, an analyst who has not acquired information also reports $m^* = h$, if $v(h) > v(l)$, reports $m^* = l$ if $v(l) > v(h)$ and is indifferent between the two reports if $v(l) = v(h)$.

It is worth emphasizing the driving force behind the characterization in Propositions 1a and 1b. The risk averse analyst's private trades take into consideration the risk exposure stemming from the reward scheme. The optimal portfolio choice $d^*(m,s)$ for a given report m and signal s is formulated in (2) to emphasize this dependence. For example, it can be shown that $d^*(m,h)$ is decreasing in $t(m,\theta_h)$ due to the analyst's risk aversion. If the reward at state θ_h increases, $d^*(m,h)$ goes down to smooth consumption: the analyst holds less exposure to the risky security and transfers some wealth to the low state by holding more of the safe security.[12] Such consumption smoothing trades affect the reporting incentives of the analyst.

The characterization in Propositions 1a and 1b reflects these considerations, but is able to say something stronger by relying on a particular observation on the analyst's reward scheme (Lemma 1). For a given report m, the analyst's reward scheme essentially provides him with a portfolio endowment (x_m, y_m) which trades at a value $v(m) \equiv x_m + py_m$ in the market. Using this observation, Proposition 1a identifies the objective that drives the optimal report for every signal: it says that for every signal, the analyst chooses the report that corresponds to the portfolio endowment with the maximum market value *given security prices* and hence maximizes $v(m)$. The report m^* that corresponds to the portfolio (x_{m^*}, y_{m^*}) with the maximum market value is optimal for every signal, because the analyst can sell this portfolio as part of his trades at its market value $v(m^*)$ and use the proceeds $v(m^*)$ as additional wealth to allocate in an optimal portfolio given the true signal, as stated in Proposition 1b. In other words, the analyst simply chooses the report that maximizes his wealth endowment and allocates this maximized wealth in a privately optimal portfolio according to the true signal. As I illustrate in Section 5, this characterization generalizes to any setting where for any given report the part of the analyst's reward scheme that depends on the report corresponds to a portfolio traded in the securities market.

This result is also consistent with the insurance function of private trades mentioned above. As an example, consider a very risk averse analyst who tends to hold very little, if any, exposure to θ. Reporting $m^* \in \arg\max\, v(m)$ for every signal and selling the portfolio (x_{m^*}, y_{m^*}) as part of the private trades, (i) insures the risk exposure from the reward scheme by generating a fixed wealth $v(m^*)$, (ii) since m^* maximizes $v(m)$, it also generates the maximum wealth given security prices. This analyst then allocates almost all his available wealth $v(m^*) + w_0$ in the *safe* security. This observation proves helpful in analyzing the provision of information acquisition incentives.

[12] For a similar reason, $d^*(m,h)$ in (2) is increasing in $t(m,\theta_l)$. If the analyst is rewarded more in the low state for a given m, the downside risk from holding the risky security decreases and the optimal investment in the risky security increases.

4.2 Information acquisition incentives

The following observation follows from Proposition 1b.

Corollary 3. A reward scheme that induces truthfulness serves as fixed additional wealth $v(h) = v(l) = \bar{v}$ that the analyst allocates in an optimal portfolio. An informed analyst's optimal risky security position $\tau^*(s)$ under a reward scheme that induces truthfulness is given by

$$\tau^*(s) \in \arg\max E[u(w_0 + \bar{v} + \tau(\theta - p))|s] \text{ for } s \in \{h, l\}. \tag{13}$$

Proof. See the Appendix.

If the analyst remains uninformed at the information acquisition stage, he is also indifferent between the two reports for $v(h) = v(l) = \bar{v}$. His optimal risky security position $\tau^*(n)$, where n again stands for 'not informed', is given by

$$\tau^*(n) \in \arg\max E[u(w_0 + \bar{v} + \tau(\theta - p))]. \tag{14}$$

Accordingly, the analyst ex ante prefers to acquire information if and only if

$$\begin{aligned} &\sigma_h E[u(w_0 + \bar{v} + \tau^*(h)(\theta - p)|h] + \sigma_l E\left[u(w_0 + \bar{v} + \tau^*(l)(\theta - p)|l\right] - c \\ \geqslant\ & E[u(w_0 + \bar{v} + \tau^*(n)(\theta - p))] \end{aligned} \tag{15}$$

where $\tau^*(h)$ and $\tau^*(l)$ are described by (13) and $\tau^*(n)$ is described by (14). The left hand side of (15) is the ex ante expected utility from acquiring information under a reward scheme $t(m, \theta)$ which induces truthfulness, whereas the right hand side is the ex ante expected utility without information. It is clear from (15) that when the analyst trades on own account, his ex ante information acquisition decision is driven only by his private portfolio considerations. Since ex post truthful reporting constraints are binding (Corollary 2), ex ante information acquisition incentives are no longer 'reporting based', but 'private portfolio based.'

Corollary 4. When he can privately trade on own account, the analyst's ex ante information acquisition incentives are driven only by his private portfolio considerations.

The analyst acquires information only if he will be holding a large enough position in the risky security, but not because he is ex post strictly better off from reporting the true signal. To analyze the information acquisition incentives, one needs to focus on the analyst's private portfolio position in the risky security, which in turn, is driven by his degree of risk aversion. Since a more risk tolerant agent holds a larger position in the risky security, such an agent values information more (see for example Grossman and Stiglitz (1980) and Peress (2004)). One possibility is that for a given cost and precision of information, the analyst may be sufficiently risk tolerant so that once he is employed he has a priori incentives of his own to acquire information without any additional incentives from the principal. In this case, the information acquisition constraint in (15) is satisfied for any $\bar{v} \geq 0$.

The alternative and perhaps more interesting possibility is when the analyst is sufficiently risk averse and absent additional incentives provided by the principal, he does not have a priori incentives of his own to acquire information, since he will not hold a large enough position in the risky security. In this case the principal can provide information acquisition incentives to the extent that she can induce the analyst to hold a large enough position in the risky security. This is only possible through a wealth effect, since a reward scheme $t(m, \theta)$ that induces truthfulness serves as fixed additional wealth $\bar{v}$ that the analyst allocates in an optimal private portfolio (Corollary 3). If the analyst's preferences exhibit decreasing absolute risk aversion (DARA), i.e., if the coefficient of absolute risk aversion $r_A(\omega) \equiv -u''(\omega)/u'(\omega)$ is decreasing in ω, the principal can induce information acquisition by increasing $\bar{v}$ in (15) sufficiently enough.[13] DARA preferences imply that the risky security is a normal good: more available wealth to allocate in a portfolio implies a larger position in the risky security. Formally, as $\bar{v}$ increases the optimal exposure to the risky security described by $\tau^*(s)$ in (13) increases, which in turn increases the analyst's ex ante expected utility from acquiring information.

I formalize this assertion and describe the optimal reward scheme by considering the specific functional form, $u(\omega) = \omega^{1-a}/(1-a)$ where $0 < a < 1$ for the analyst's preferences. This functional form exhibits DARA; $r_A(\omega) = a/\omega$ is decreasing in ω. The parameter a measures the agent's risk aversion at a given wealth level, with higher values of a implying more risk aversion. To simplify the algebra, I also assume that $\alpha = 1/2$ and $p = E[\theta]$, i.e., there is risk neutral pricing.[14] The optimal risky security positions in (13) and (14) are given by (see the Appendix)

$$\tau^*(h) = \frac{2(z-1)(w_0 + \bar{v})}{(z+1)(\theta_h - \theta_l)}, \ \tau^*(l) = -\frac{2(z-1)(w_0 + \bar{v})}{(z+1)(\theta_h - \theta_l)} \text{ and } \tau^*(n) = 0, \tag{16}$$

where $z \equiv (\phi/(1-\phi))^{1/a}$. Due to DARA preferences, the size of the analyst's optimal risky security positions $\tau^*(h)$ and $\tau^*(l)$ in (16) are increasing in his total available wealth $w_0 + \bar{v}$. Furthermore, $\tau^*(h)$ and $\tau^*(l)$ are increasing in the precision ϕ of the signal and decreasing in the measure of risk aversion a. The following Lemma derives the information acquisition decision in (15) in closed form.

[13] If the analyst's preferences exhibit constant absolute risk aversion (CARA), the principal *cannot* induce the analyst to allocate more of his available wealth in the risky security through a wealth effect. With CARA preferences the optimal portfolio in the risky security does not depend on wealth. Therefore, if the analyst does *not* have a priori incentives of his own to acquire information, i.e., if (15) is not satisfied for $\bar{v} = 0$, the principal cannot induce information acquisition to an analyst with CARA preferences by increasing $\bar{v}$.

[14] Assuming $p = E[\theta]$ is not necessary. It just implies that a risk averse agent with no information does not hold the risky security since there is no risk premium, i.e., $\tau^*(n)$ in (14) is equal to zero. This simplifies the algebra.

Lemma 2. Suppose $u(\omega) = \omega^{1-a}/(1-a)$, $\alpha = 1/2$ and $p = E[\theta]$. The analyst acquires information if and only if

$$\begin{aligned} \frac{(w_0 + \bar{v})^{1-a}}{1-a} (A(\phi, a) - 1) &\geqslant c \\ \text{where } A(\phi, a) &= 2^{1-a} \left[\phi^{1/a} + (1-\phi)^{1/a}\right]^a. \end{aligned} \tag{17}$$

Proof. See the Appendix.

The left hand side of (17) is the analyst's expected utility gains from acquiring information, which is increasing in the available wealth $w_0 + \bar{v}$ to allocate in an optimal private portfolio. The constant $A(\phi, a) > 1$ measures the value of acquiring information: it is increasing in precision ϕ of information and decreasing in analyst's risk aversion a. It can be shown that $\lim_{a \to 0} A(\phi, a) = 2\phi$ and $\lim_{a \to 1} A(\phi, a) = 1$. One can see from (17) that it is less costly to induce the analyst to acquire information (i) the higher the precision ϕ of information, (ii) the lower the cost c of information, (iii) the more risk tolerant the analyst (lower a) and (iv) the higher is his initial wealth w_0. Again, for a given cost and precision of information the analyst may be initially wealthy enough and/or sufficiently risk tolerant, so that he may acquire information at $\bar{v} = 0$. Consider the case when the analyst does not have a priori incentives of his own to acquire information and hence $\bar{v} > 0$. To remove the effect of initial wealth, also set $w_0 = 0$. For $u(\omega) = \omega^{1-a}/(1-a)$, $w_0 = 0$, $\alpha = 1/2$ and $p = E[\theta]$, the optimal reward scheme $\hat{t}(m, \theta) \geq 0$ for $m \in \{h, l\}$ and $\theta \in \{\theta_h, \theta_l\}$ is described by

$$\hat{t}(h, \theta_h) + \hat{t}(h, \theta_l) = \hat{t}(l, \theta_l) + \hat{t}(l, \theta_h) = 2\bar{v} \tag{18a}$$

where

$$\frac{\bar{v}^{1-a}}{1-a} = \frac{c}{A(\phi, a) - 1} \tag{18b}$$

(18b) solves the information acquisition constraint in (17) as an equality when $w_0 = 0$. (18a) follows from the truthfulness requirement $v(h) = v(l) = \bar{v}$ in (12) when $\alpha = 1/2$ and $p = E[\theta]$. As stated in Corollary 3, a reward scheme that induces truthfulness serves as a fixed wealth transfer, denoted by $\bar{v}$, that the analyst allocates in an optimal private portfolio. What matters for inducing information acquisition incentives is the size of this transfer. A fixed wage scheme that satisfies (18a) is also optimal, as well as a scheme which solves (18a) by setting $\hat{t}(h, \theta_l) = \hat{t}(l, \theta_h) = 0$. Therefore, unlike the case when the analyst cannot trade, explicit incentive schemes based on reporting performance do not fare better than flat schemes in terms of inducing acquisition and truthful revelation of information.

A comparison of principal's contracting costs. An implication of the above analysis is that when the analyst privately trades, the cost of inducing acquisition and truthful revelation of information depends on the analyst's degree of risk aversion parametrized by a. Since the analyst's ex ante information acquisition incentives are now driven only by his private portfolio considerations, it is costlier to induce such incentives to a more risk averse analyst. In particular, it may prove prohibitively costly to contract with an analyst who is too risk averse.[15] On the other hand, if the analyst is sufficiently risk tolerant, information acquisition incentives can be provided with an expected transfer lower than the case with no analyst trading. Under the assumptions $u(\omega) = \omega^{1-a}/(1-a)$, $w_0 = 0$, $\alpha = 1/2$ and $p = E[\theta]$, one can provide the following comparison of the principal's optimal contracting costs in the two cases.

Corollary 5. For a given precision ϕ, the principal's expected contracting cost when the analyst can privately trade is higher compared to the case with no analyst trading if $a > a^*$ and lower if $a < a^*$ where a^* solves

$$(A(\phi, a) - 1)\, \phi^{1-a} = \phi - \frac{1}{2}.$$

Proof. See the Appendix.

This comparison illustrates that the principal may benefit from the analyst's ability to trade if the analyst is sufficiently risk tolerant. The analyst's private trades introduce a 'private portfolio' based incentive for information acquisition which can lower the principal's contracting cost. However, the 'private portfolio' channel is the only channel available to the principal to induce information acquisition incentives when the analyst privately trades (Corollary 4). As mentioned, if the analyst is excessively risk averse, using this channel may prove too costly for the principal. Therefore, the analyst's private trades become a bigger problem for the principal when the analyst is too risk averse. This result may seem surprising. One might be tempted to argue that if the analyst is too risk averse he will not trade the risky security, so his private trading ability is not relevant. This reasoning does not take into account the fact that the ability to trade does not necessarily imply creating exposure to the risky security. The analyst can use his trades to insure the risk exposure stemming from his reward scheme: he holds only a privately optimal exposure (Proposition 1b). Consider again, as an example, contracting with a very risk averse analyst who tends to hold very little, if any, exposure to θ. When he can privately trade, this analyst trades the risky security but only to sell the portfolio endowment that corresponds to his reward scheme, and allocates the proceeds of this sale plus any initial wealth almost exclusively in the safe security. In effect, this

[15] This can be readily verified from the information acquisition constraint in (17) by noting that $A(\phi, a)$ decreases and approaches to 1 as a increases.

analyst does not care much to learn more about θ which makes it much costlier to provide incentives to acquire information.

If the analyst seeks to hold a sufficiently large exposure to the risky security in his private portfolio, then his private trading ability may be beneficial to the principal in terms of lowering the cost of inducing information acquisition. If, on the other hand, the sole function of the analyst's private trade is to reduce the exposure to the risky security, then the principal is worse off. In this case, the implication of private trading ability is only to mute the 'reporting performance' based channel of providing information acquisition incentives. Therefore, if trading restrictions on analysts are lax, it is better to hire a relatively risk tolerant analyst who tends to put his money in the security he covers, instead of a more risk averse analyst who uses his trading ability to reduce his exposure to the security. Another implication is concerned with the structure of the analyst's reward scheme when the analyst can trade on own account. The analysis illustrates that the superiority of incentive schemes based on the analyst's reporting performance crucially depends on the trading opportunities available to the analyst. The recent restrictions in the U.S. that aim to prevent the analysts from privately trading on own account may lead to an increase in the use of explicit incentive schemes based on the analyst's performance.

The analyst's private portfolio based incentive to acquire information relates the analysis to the 'put your money where your mouth is' argument mentioned in the Introduction. Some practitioners in the U.S. favor analysts' ownership in stocks they cover, arguing that this possibility will allow the analysts to 'put their money where their mouth is' and enhance their credibility. The implicit suggestion in this argument is that an analyst can back up the credibility of his recommendation by holding the stock he recommends in a way *observable* to his client. This observable portfolio makes the recommendation credible.[16] In this paper, the analyst's trades are unobservable: the analyst cannot use his trades as a credible mechanism to ensure that his report is truthful. Furthermore, the analyst does not necessarily seek exposure to the stock in his private portfolio and he may rather use his private trading ability to insure any 'contractually imposed' exposure to the stock value. When the analyst's trades are unobservable, the question becomes whether the analyst will be putting his money in the security he covers, because he has the incentive to acquire information only to the extent he does so.

[16] For example, Schack (2001) quotes the research head at a major firm saying; 'I like seeing stock ownership in the industries, particularly in the names that the analyst recommends. If you are going to recommend it to your clients, then why on earth don't you own it yourself?'

5 A general separation result

This section shows that the optimal reporting and private portfolio choice in Propositions 1a and 1b generalize to any setting where for any given report the analyst's reward scheme corresponds to a portfolio endowment that is traded in the securities market.

Suppose now that the risky security return θ is distributed with a general distribution function $F(\theta)$. Realizations of θ are drawn from a generic set Θ. The analyst's private signal s is correlated with θ according to some joint distribution function, and the posterior distribution of θ conditional on s is given by $G(\theta|s)$. The signal realizations are drawn from a set S. In this general specification, the risky security return θ and the information signal s are assumed to be continuous random variables. Denote the analyst's reward scheme by $\pi(m, \theta)$ for $\theta \in \Theta$ and $m \in S$. Without loss of generality, let me write the reward scheme $\pi(m, \theta)$ as

$$\pi(m, \theta) \equiv h(m, \theta) + g(\theta)$$

where $h(m, \theta)$ is the part of the reward scheme that depends on the report. I also include the part $g(\theta)$ independent of m for generality. Upon observing the signal, the analyst makes a report $m \in S$ and privately chooses a portfolio (F, d) on own account. Given the risky security price p, the signal s, the reward scheme $\pi(m, \theta)$ in place and some initial wealth w_0, the analyst's problem is to choose a report $m \in S$ and a private portfolio $(F, d) \in R^2$ to maximize the expected utility

$$E[u(h(m, \theta) + g(\theta) + F + d\theta)|s] \text{ subject to } F + pd \leq w_0 \tag{P3}$$

The following assumptions describe the class of reward schemes $\pi(m, \theta)$ for which the separation result holds.

Assumption 1. For every report $m \in S$, there is a portfolio $(\alpha(m)$,$\beta(m))$ of safe and risky securities such that this portfolio and the reward scheme $h(m, \theta)$ generate the same payoff. Hence $h(m, \theta)$ can be written as $h(m, \theta) \equiv \alpha(m) + \beta(m)\theta$ where $\alpha(m)$ and $\beta(m)$ are real valued functions of m.

The key implication of Assumption 1 is that for every report m, the part $h(m, \theta)$ of the analyst's reward scheme that depends on the report corresponds to a portfolio $(\alpha(m), \beta(m))$ traded in the market. As in Lemma 1, by choosing a report the analyst essentially chooses between portfolio endowments. For a given risky security price p, the portfolio $(\alpha(m), \beta(m))$ is valued in the market at $V(m) \equiv \alpha(m) + p\beta(m)$. Now define $Z \equiv \arg\max V(m)$ as the set of reports that correspond to portfolio endowments with maximum market value given security prices.

Assumption 2. The set $Z \equiv \arg\max V(m)$ is non-empty.

The following Proposition states a more general version of the 'separation of the optimal report from private information' result.

Proposition 2. Suppose the analyst's reward scheme $\pi(m, \theta)$ satisfies Assumptions 1 and 2. For every signal s, the analyst reports $m^* \in \arg\max V(m) \equiv \alpha(m) + p\beta(m)$ and chooses a portfolio $(K - \alpha(m^*), \tau - \beta(m^*))$ where K and τ maximize $E[u(K + \tau\theta + g(\theta))|s]$ subject to $K + p\tau \leq w_0 + V(m^*)$.

Proof. See the Appendix.

This result again follows because for different reports the analyst's reward scheme essentially provides him with portfolio endowments that he can sell at market prices as part of his trades (Assumption 1). For every signal realization and independent of the signal's precision, the analyst chooses the report that corresponds to the portfolio endowment with maximum market value given security prices and hence maximizes his wealth endowment. He then allocates this maximized wealth plus any initial wealth in an optimal portfolio given the true signal. This optimal reporting choice is based only on public information, while the analyst's private information is used for the private portfolio decision. The analyst's optimal report is driven by the market's beliefs, which is embedded in the prevailing security price, and by the specifics of his reward scheme, but not by his private information.

It follows from the above result that when they can privately trade on own account, analysts employed under similar reward schemes can pool and make similar recommendations based on completely different private signals and precisions. Since the way the optimal reporting strategy ignores private information has a flavor akin to the results found in the literature on 'reputation induced herding', it may be useful to relate the above result to that literature. For example, in a model where analysts are solely concerned with convincing the market of their forecasting accuracy, Trueman (1994) shows that analysts with more precise signals truthfully reveal their information, whereas analysts with low precision mimic the high types. In the current setting, the separation of the signal and the optimal report applies regardless of precision of the signal and it is driven not by reputational concerns, but by the fact that the analyst trades on own account. Another feature that bears some similarity with the reporting outcomes obtained in reputation/career concern driven environments is that the reporting strategy uses the public information, summarized by the prevailing market prices, more than the private information (here it uses only public information). Due to this effect, the analyst's recommendation may be tilted towards public expectations. For example, in the reputational cheap talk model of Ottaviani and Sorensen (forthcoming) concern for reputation drives experts to herd on the prior belief, since extreme predictions are too likely to be perceived as coming from uninformative signals. Again in Trueman (1994), analysts may prefer to release forecasts much closer to prior expectations than justified by their private information.[17]

One should however be cautious before suggesting an empirical link between analysts' trading ability and the tendency to pool with the crowd or report conformistly based on Proposition 2. The above result depends on the extent that for a given recommendation the analyst can privately trade financial claims that can generate the same payoff as his reward scheme.[18] The result says that under such a reward scheme, the analyst's private trading ability separates his recommendation from his private information. But to the extent that an analyst can do that, a reward scheme that induces this kind of reporting incentives will not be offered in an optimal contracting setting. In that respect, Proposition 2 is more of a manisfestation of the inadequacy of explicit reward schemes which create similar payoff structures as the financial claims that the analyst can trade in the market. Such schemes can fail even if they are designed purely to reward the analyst's performance. The following is a practically and theoretically relevant example of such a scheme where regardless of the true signal and its precision, the analyst makes a report equal to the prevailing risky security price p.

Scoring Rules. Consider a scoring type of reward scheme of the form

$$-(m-\theta)^2 \tag{19}$$

which compensates the analyst based on his reporting performance.[19] This type of scheme is known to illicit truthful disclosure of the signal in the absence of any analyst trades (see Bhattacharya and Pfleiderer (1985) and Stoughton (1993)). Notice that this scheme satisfies Assumption 1, since it can be written as

$$-(m-\theta)^2 = \underbrace{-m^2 + 2m\theta}_{h(m,\theta)}\underbrace{-\theta^2}_{g(\theta)}.$$

The part of the scoring rule that depends on the report is given by $h(m,\theta) = 2m\theta - m^2$. In the language of Assumption 1, this part corresponds to a portfolio endowment of $\beta(m) = 2m$ shares of the risky security and $\alpha(m) = -m^2$ shares of the safe

[17] Hong, Kubik and Solomon (2000) find empirical support for the hypothesis that inexperienced security analysts, who are more likely to have career concerns, deviate less from the consensus forecasts.

[18] Proposition 2 also directly applies to a mechanism where the principal compensates the analyst by allocating him a portfolio according to what he reports. Consider a mechanism where the principal asks the analyst what signal he observed and allocates a portfolio $(x(m), y(m))$ to the analyst depending on his report m. If the analyst privately trades on own account, this mechanism too yields a separation of the optimal reporting strategy from the true signal.

[19] This scheme may be of interest for practical purposes as well. As discussed in Michaely and Womack (1999), the *Institutional Investor* All-American Research Team poll, based on a survey of money managers and institutions, ranks analysts on their forecasting performance. This poll is a commonly accepted measure of analyst's standing in the industry. Securities firms take this poll into consideration when setting analyst compensation.

security. The market value of this portfolio endowment is given by $V(m) = 2mp - m^2$ which has a *unique* maximum at $m^{**} = p$. Therefore, under the scoring rule the set $Z \equiv \arg\max V(m)$ contains a unique report. From Proposition 2, it follows that when the analyst can trade on own account, the scoring rule fails completely as far as truthful revelation is concerned. The analyst always reports $m^{**} = p$ regardless of the true signal and the precision of the signal.

Proposition 3. Suppose the analyst's reward scheme is given by $-(\theta - m)^2$ and the analyst can privately trade on own account. Then for every signal s, the analyst reports $m^{**} = p$.

Proof. The above result follows directly from Proposition 2, but one can also obtain it by working out the first order conditions of (P3) as shown in the Appendix.

6 Conclusion

This paper analyzes the implications of an analyst's private trading ability for information acquisition and truthful reporting incentives. In a setting with a binary report and state space, it is shown that any reward scheme offered to the analyst corresponds to a portfolio of the risky security he covers and a safe security. By choosing a report the analyst essentially chooses between portfolio endowments. The analysis exploits this observation to describe the analyst's optimal reporting and private portfolio choices. Taking security prices as given, for every signal the analyst chooses the report that corresponds to the portfolio endowment with the highest market value. This reporting choice is optimal because the analyst can sell this portfolio endowment at the market value as part of his trades and use the proceeds as additional wealth to allocate in a privately optimal portfolio given the true signal. Accordingly, the principal cannot make the analyst strictly prefer to report the true signal and the analyst's information acquisition incentive is driven only by private portfolio considerations. The analyst acquires information only if he will be holding a large enough position in the risky security he covers, but not because he is ex post strictly better off from reporting the true signal.

The comparison of the optimal contract when the analyst can and cannot trade illustrates that an incentive scheme that rewards the analyst's reporting performance, which is optimal when analyst cannot trade, does no better than a flat scheme when the analyst privately trades. Therefore, the superiority of incentive schemes based on reporting performance depends on the trading opportunities available to the analyst. Furthermore, the analyst's private trading ability is a bigger problem for the principal if the analyst is too risk averse. This follows because the principal can provide information acquisition incentives to the extent that she can induce the analyst to hold a large enough position in the risky security. If the analyst tends to hold very little exposure to the risky security he covers, providing information acquisition incentives might be prohibitively costly. Therefore, if the trading restrictions on analysts are lax, it may be better to hire a relatively risk tolerant analyst who tends to put his money in the security he covers, instead of a more risk averse analyst who seeks to hold little exposure to the risky security.

The paper also extends the argument which holds for any reward scheme in a binary report and state space to a general setting and establishes a separation of the optimal reporting strategy from private information result. This result applies to any reward scheme where for a given report the part of the reward scheme that depends on the report corresponds to a portfolio of safe and risky securities that the analyst can trade in the market. Under any such reward scheme, the analyst's optimal reporting strategy is separated from his private information. In general, the separation result indicates the inadequacy of explicit reward schemes which create similar payoff structures as the financial claims that the analyst can trade in the market: such schemes can fail to induce any information revelation even if they are designed to reward the analyst's performance. This point is illustrated with a performance based scheme which ensures truthful revelation in the absence of analyst's trades.

To abstract away from reporting incentives driven by the ability to manipulate the security price, the model in this paper does not allow the analyst's report to have a price impact. This approach departs from the existing literature which have analyzed the reporting incentives when an analyst, who is not allowed to trade by assumption, is concerned with the price impact of his recommendation. It would be interesting to combine the two approaches and analyze the implications of the analyst's private trades for the reporting incentives in a setting where the analyst's report can affect the security price. In particular, exploring the credibility of an analyst who can first trade and position himself ahead of his recommendation and then can affect security prices by his recommendation is an unexplored and interesting avenue left for future research.

Appendix

The derivation of the optimal contract when the analyst cannnot trade, the proofs of Propositions 1a, 1b, 2 and 3, Corollaries 2, 3 and 5, the derivation of optimal portfolios in (16) and the proof of Lemma 2 follow.

Optimal contract when the analyst cannot trade

First, let me explicitly write the posterior distribution given the signal realization:

$$\Pr(\theta_h|h) = \alpha\phi/\left[\alpha\phi + (1-\alpha)(1-\phi)\right] \text{ and } \Pr(\theta_l|l) = (1-\alpha)\phi/\left[(1-\alpha)\phi + \alpha(1-\phi)\right] \tag{A1}$$

Consider now the information acquisition constraints (6a) and (7a) in the text. Using (A1), (6a) can be written as

$$(1-\alpha)\phi\left[u(t(l,\theta_l)) - u(t(h,\theta_l))\right] + \alpha(1-\phi)\left[u(t(l,\theta_h)) - u(t(h,\theta_h))\right] \geqslant c \tag{A2}$$

and (7a) becomes

$$\alpha\phi\left[u(t(h,\theta_h)) - u(t(l,\theta_h))\right] + (1-\alpha)(1-\phi)\left[u(t(h,\theta_l)) - u(t(l,\theta_l))\right] \geqslant c \tag{A3}$$

The principal's problem is to choose the reward scheme $t(m,\theta) \geqslant 0$ for $m \in \{h,l\}$ and $\theta \in \{\theta_h, \theta_l\}$ to minimize the ex ante expected transfer

$$\phi\left[\alpha t(h,\theta_h) + (1-\alpha)t(l,\theta_l)\right] + (1-\phi)\left[\alpha t(l,\theta_h) + (1-\alpha)t(h,\theta_l)\right]$$

subject to (A2), (A3), and the participation constraint

$$\sigma_h E\left[u(t(h,\theta))|h\right] + \sigma_l E\left[u(t(l,\theta))|l\right] - c \geqslant \bar{u} = 0$$

which is implied by (6a) and (7a). Since $\phi > 1/2$ and hence $\Pr(\theta_l|l) > \Pr(\theta_h|l)$, one can keep the expected transfer constant and (A3) unchanged and relax the constraint (A2) by lowering $t(h,\theta_l)$. Similarly, since $\Pr(\theta_h|h) > \Pr(\theta_l|h)$, one can lower $t(l,\theta_h)$ and relax (A3) while keeping (A2) unchanged. Therefore, the optimal reward scheme must have $t^*(h,\theta_l) = t^*(l,\theta_h) = 0$. Furthermore, to minimize the ex ante expected transfer to the analyst, the principal gives just enough rent compatible with information acquisition. Accordingly, both of the information acquisition constraints (A2) and (A3) bind in equilibrium. To obtain closed form expressions for the optimal $t(h,\theta_h)$ and $t(l,\theta_l)$, assume that $u(0) = 0$. Solving (A2) and (A3) as an equality under this assumption, one obtains

$$u(t^*(h,\theta_h)) = c/\left[\alpha(2\phi-1)\right] \text{ and } u(t^*(l,\theta_l)) = c/\left[(1-\alpha)(2\phi-1)\right] \tag{A4}$$

Q.E.D.

Proofs of Proposition 1a and 1b

To prove that an optimal reporting strategy must maximize $v(m)$ regardless of the true signal, fix any signal $s \in \{h, l\}$ and let $m^* \in \arg\max v(m)$ for $m \in \{h, l\}$. Now suppose, contrary to the claim, that the analyst optimally reports $\bar{m} \notin \arg\max v(m)$ and follows $d^*(\bar{m}, s)$, which is the optimal private portfolio subsequent to reporting $\bar{m}$ at signal s as described in (2). Since $\bar{m} \notin \arg\max v(m)$, we have $v(m^*) - v(\bar{m}) = \delta > 0$. Using the portfolios corresponding to different reports in Lemma 1 one can define $\Delta_x \equiv x_{m^*} - x_{\bar{m}}$ and $\Delta_y \equiv y_{m^*} - y_{\bar{m}}$ and write

$$\begin{aligned} v(m^*) - v(\bar{m}) &= \Delta_x + \Delta_y p = \delta > 0 && \text{(A5)} \\ t(m^*, \theta) - t(\bar{m}, \theta) &= \Delta_x + \Delta_y \theta. && \text{(A6)} \end{aligned}$$

I now show that the strategy pair $(\bar{m}, d^*(\bar{m}, s))$ cannot be optimal, since reporting m^* and trading $d^*(\bar{m}, s) - \Delta_y$ gives a strictly higher expected utility conditional on any signal $s \in \{h, l\}$. To prove this, use the definition of analyst's final wealth $\omega(m, d)$ in (1) and write

$$\begin{aligned} \omega(m^*, d^*(\bar{m}, s) - \Delta_y) &= t(m^*, \theta) + (d^*(\bar{m}, s) - \Delta_y)(\theta - p) + w_0 && \text{(A7)} \\ &= \Delta_x + \Delta_y p + \omega(\bar{m}, d^*(\bar{m}, s)) = \delta + \omega(\bar{m}, d^*(\bar{m}, s)), \end{aligned}$$

which implies $E[u(\omega(m^*, d^*(\bar{m}, s) - \Delta_y))|s] > E[u(\omega(\bar{m}, d^*(\bar{m}, s)))|s]$ for any $s \in \{h, l\}$ and contradicts the initial assumption that reporting $\bar{m} \notin \arg\max v(m)$ is optimal. Therefore, the analyst's optimal report must maximize $v(m)$ for every signal as stated in Proposition 1a.

The analyst's problem now reduces to choosing a portfolio (F, d) to maximize $E[u(t(m^*, \theta) + F + d\theta)|s]$ subject to $F + pd \leq w_0$. Let $F \equiv K - x_{m^*}$ and $d \equiv \tau - y_{m^*}$. Applying Lemma 1, the problem becomes choosing a portfolio $(K - x_{m^*}, \tau - y_{m^*})$ where K and τ maximize $E[u(K + \tau\theta)|s]$ subject to $K + p\tau \leq w_0 + v(m^*)$ as stated in Proposition 1b. *Q.E.D.*

Proof of Corollary 2

First consider (2) in the text that describes the analyst's optimal portfolio after observing $s \in \{h, l\}$ and reporting $m \in \{h, l\}$. Using Lemma 1, one can substitute for $t(m, \theta) = x(m) + y(m)\theta$ and rewrite (2) as

$$\tau^*(m, s) \in \arg\max E[u(v(m) + w_0 + \tau(\theta - p)))|s] \qquad \text{(A8)}$$

for $m \in \{h, l\}$ and $s \in \{h, l\}$. Similarly, using Lemma 1 and the above definition of $\tau^*(m, s)$ in (A8), the two truthfulness constraints at $s = h$ and $s = l$, given by (3) and (4) in the text, can be respectively written as

$$\begin{aligned} E[u(v(h) + w_0 + \tau^*(h, h)(\theta - p)))|h] &\geq E[u(v(l) + w_0 + \tau^*(l, h)(\theta - p)))|h] \\ E[u(v(l) + w_0 + \tau^*(l, l)(\theta - p)))|l] &\geq E[u(v(h) + w_0 + \tau^*(h, l)(\theta - p)))|l]. \end{aligned}$$

Proposition 1a showed that if $v(h) > v(l)$, the analyst always reports h and if $v(l) > v(h)$, he always reports l, which implies that the above truthfulness constraints can only be satisfied if $v(h) = v(l)$. But from (A8), notice that $v(h) = v(l)$ implies $\tau^*(h,h) = \tau^*(l,h)$ and $\tau^*(l,l) = \tau^*(h,l)$. Therefore both of the above constraints, and hence (3) and (4) in the text, are binding. *Q.E.D.*

Proof of Corollary 3

From Corollary 1, the analyst is truthful if and only if $t(m,\theta)$ is set such that $v(h) = v(l) = \bar{v}$. Consider any reward scheme that induces trutfulness. Given Propositions 1a and 1b, if the analyst observes $s = h$, he reports truthfully, sells the corresponding portfolio (x_h, y_h) at $v(h)$ and chooses a risky security position $\tau \in R$ to maximize $E[u(w_0 + v(h) + \tau(\theta - p))|h]$. Similarly, if he observes $s = l$, he reports truthfully, sells the corresponding portfolio (x_l, y_l) at $v(l)$ and chooses $\tau \in R$ to maximize $E[u(w_0 + v(l) + \tau(\theta - p))|l]$. Since $v(h) = v(l) = \bar{v}$, one arrives at (13). *Q.E.D.*

The derivation of the optimal portfolios in (16)

Consider (13) that describes the optimal risky security portfolio when the analyst observes $s = h$. For $u(\omega) = \omega^{1-a}/(1-a)$, $\alpha = 1/2$ and $p = E[\theta]$, the problem in (13) can be written as choosing τ to maximize

$$\frac{\phi(w_0 + \bar{v} + \tau(\theta_h - p))^{1-a}}{1-a} + \frac{(1-\phi)(w_0 + \bar{v} - \tau(p - \theta_l))^{1-a}}{1-a}$$

which gives the following first order condition that describes $\tau^*(h)$:

$$\left(\frac{\phi}{1-\phi}\right)^{1/a} \equiv z = \frac{w_0 + \bar{v} + \tau^*(h)(\theta_h - p)}{w_0 + \bar{v} - \tau^*(h)(p - \theta_l)} \tag{A9}$$

For $\alpha = 1/2$ and $p = E[\theta]$, we have $\theta_h - p = p - \theta_l$.Solving for $\tau^*(h)$, one obtains the expression in (16). The derivation for $\tau^*(l)$ is similar and hence omitted. To obtain $\tau^*(n) = 0$, consider the uninformed analyst's portfolio problem in (14) for any concave $u(.)$ when $p = E[\theta]$ and $\alpha = 1/2$. The optimal $\tau^*(n)$ must solve the first order condition

$$u'(w_0 + \bar{v} + \tau^*(n)(\theta_h - p)) = u'(w_0 + \bar{v} - \tau^*(n)(p - \theta_l))$$

which yields $\tau^*(n) = 0$. This is because with risk neutral pricing, an uninformed and risk averse agent does not hold exposure to the risky security since there is no risk premium. *Q.E.D.*

Proof of Lemma 2

Substitute the optimal risky security portfolios $\tau^*(h), \tau^*(l)$ and $\tau^*(n)$ obtained in (16) into (15). Since $\alpha = 1/2$ we have $\sigma_h = \sigma_l = 1/2$. After simplification, the analyst acquires information if and only if

$$\frac{(w_0+\bar{v})^{1-a}}{1-a}\left[\phi\left(\frac{2z}{z+1}\right)^{1-a}+(1-\phi)\left(\frac{2}{z+1}\right)^{1-a}-1\right]\geq c \tag{A10}$$

The expression in the square brackets can be simplified further by substituting for $z \equiv (\phi/(1-\phi))^{1/a}$. First note that

$$2^{1-a}\left(\frac{\phi z^{1-a}+(1-\phi)}{(z+1)^{1-a}}\right)=2^{1-a}\left(\frac{\phi\left(\frac{\phi}{1-\phi}\right)^{\frac{1}{a}-1}+(1-\phi)}{\left(\left(\frac{\phi}{1-\phi}\right)^{\frac{1}{a}}+1\right)^{1-a}}\right)=2^{1-a}\left[\phi^{1/a}+(1-\phi)^{1/a}\right]^{a}.$$

Defining $A(\phi,a)$ as in the Lemma, one arrives at (17). *Q.E.D.*

Proof of Corollary 5

The principal's expected contracting cost when the analyst privately trades is simply given by $\bar{v}$ in (18b). Now consider the optimal reward scheme for the case when the analyst *cannot* trade described in (A4). For $u(\omega)=\omega^{1-a}/(1-a)$ and $\alpha=1/2$, this optimal reward scheme implies an expected contracting cost given by

$$\phi\left(\frac{2c(1-a)}{2\phi-1}\right)^{\frac{1}{1-a}} \tag{A11}$$

The principal's expected contracting cost is higher when analyst privately trades if $\bar{v}$ in (18b) is higher than (A11), which, after simplfying, implies

$$\phi-\frac{1}{2}>(A(\phi,a)-1)\,\phi^{1-a} \tag{A12}$$

Otherwise, expected contracting cost is lower when analyst privately trades. Now note that, for a given ϕ, the left hand side of (A12) is constant, whereas the right hand side is monotone decreasing in a. For $a=1$, the right hand side equals to zero and hence (A12) is satisfied, whereas for $a=0$, the right hand side equals $(2\phi-1)\,\phi>\phi-\frac{1}{2}$ and hence (A12) is not satisfied. Therefore, the principal's expected contracting cost when the analyst can privately trade is higher compared to the case with no analyst trading if $a>a^*$ and lower if $a<a^*$ where a^* solves $(A(\phi,a)-1)\,\phi^{1-a}=\phi-\frac{1}{2}$. *Q.E.D.*

Proof of Proposition 2

The proof follows from similar lines as in the proof of Propositions 1a and 1b. I first show that for all s, the optimal report m^* must belong to the set $Z\equiv \arg\max V(m)\equiv\alpha(m)+p\beta(m)$. Suppose for a contradiction that there is a signal s' such that $(\bar{m},\bar{d})$ is optimal and $\bar{m}\notin Z$. This implies, by Assumption 2, that there is a report $m^* \in Z$ such that $V(m^*) - V(\bar{m}) \equiv \delta > 0$. For convenience, again define $\Delta_\alpha \equiv \alpha(m^*) - \alpha(\bar{m})$ and $\Delta_\beta \equiv \beta(m^*) - \beta(\bar{m})$, and note that

$$V(m^*) - V(\bar{m}) = \Delta_\alpha + \Delta_\beta p = \delta > 0 \text{ and } h(m^*, \theta) - h(\bar{m}, \theta) = \Delta_\alpha + \Delta_\beta \theta. \quad \text{(A13)}$$

I now show that $(m^*, \bar{d} - \Delta_\beta)$ is a strictly better strategy than $(\bar{m}, \bar{d})$. To prove this, first define the analyst final wealth as $W(m, d) \equiv h(m, \theta) + d(\theta - p) + g(\theta) + w_0$. Now use Assumption 1 and (A13) to write

$$W(m^*, \bar{d} - \Delta_\beta) = \Delta_\alpha + \Delta_\beta p + W(\bar{m}, \bar{d}) = \delta + W(\bar{m}, \bar{d}) \quad \text{(A14)}$$

which proves that $E[u(W(m^*, \bar{d} - \Delta_\beta))|s'] > E[u(W(\bar{m}, \bar{d}))|s']$ and contradicts the initial assumption that $(\bar{m}, \bar{d},)$ is optimal at signal s'. Since the signal s' was arbitrarily chosen, it follows that for all $s \in S$ the optimal report must belong to Z, i.e., $m^* \in Z \equiv \arg\max V(m) \equiv \alpha(m) + p\beta(m)$. The analyst's problem now reduces to choosing (F, d) to maximize $E[u(h(m^*, \theta) + g(\theta) + F + d\theta)|s]$ subject to $F + pd \leq w_0$. Let $d \equiv \tau - \beta(m^*)$ and $F \equiv K - \alpha(m^*)$. Using Assumption 1, the problem becomes choosing $(K - \alpha(m^*), \tau - \beta(m^*))$ where K and τ maximize $E[u(K + \tau\theta + g(\theta))|s]$ subject to $K + p\tau \leq w_0 + V(m^*)$ as stated in the Proposition. *Q.E.D.*

Proof of Proposition 3

To illustrate that the optimal report maximizes $V(m) \equiv \alpha(m) + p\beta(m)$ for every s, I do not impose the reward scheme $-(m-\theta)^2$ into (P3) from the start, but work with a general reward scheme $h(m, \theta)$ that satisfies Assumptions 1 and 2. Additionally, I assume that the functions $\alpha(m)$ and $\beta(m)$ are continuous and differentiable, $V(m)$ is concave in m. Differentiating the objective function in (P3) with respect to d and m respectively one obtains the two first order conditions

$$E[u'(h(m, \theta) + g(\theta) + w_0 + d(\theta - p))(\theta - p)|s] \quad = \quad 0 \quad \text{(A15a)}$$
$$E[u'(h(m, \theta) + g(\theta) + w_0 + d(\theta - p))h'(m, \theta)|s] \quad = \quad 0 \quad \text{(A15b)}$$

Since $h(m, \theta) = \alpha(m) + \beta(m)\theta$ and $V(m) \equiv \alpha(m) + p\beta(m)$, one can write

$$h(m, \theta) = V(m) + \beta(m)(\theta - p) \Rightarrow h'(m, \theta) = V'(m) + \beta'(m)(\theta - p). \quad \text{(A16)}$$

Substituting the expression for $h'(m, \theta)$ in (A16) into (A15b), the first order condition with respect to m in (A15b) becomes

$$V'(m)E[u'(.)|s] + \beta'(m) \underbrace{E[u'(.)(\theta - p)|s]}_{0} = 0 \quad \text{(A17)}$$

But by (A15a) that describes the optimal d, we have $E[u'(.)(\theta - p)|s] = 0$. Therefore, the optimal report in (A17) is simply characterized by $V'(m) = 0$ for all s which implies, by the concavity of $V(.)$, that for every s the optimal report belongs to $Z \equiv \arg\max V(m)$. For the specific reward scheme $-(m-\theta)^2$, we have $\alpha(m) = -m^2$, $\beta(m) = 2m$ and hence $V(m) = 2mp - m^2$, which is maximized at $m^{**} = p$. *Q.E.D.*

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