Insider Trading and Communication among Peers

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Abstract

This paper investigates how insiders in financial markets might profit from sharing information with their peers. In order to analyze this question I develop a three period model based on the seminal Kyle (1985) paper on strategic insider trading, where in contrast to the previous literature, informed traders can share information about the fundamental value of the asset with their peers without disclosing it publicly to the whole market. I show that in such environment it can be ex-ante profitable for a trader to share some of its information with others. The intuition is the following: By sending information with some noise, the trader introduces noise into the economy and only he knows the precise realization of. This helps him to better interpret prices and he thus learns more about information of other traders compared to the market maker and thus makes a more profitable trade in the last period.

1 Introduction

In October 2014 Goldman Sachs together with 14 other financial institutions invested \$66M in launching the messaging platform "Symphony" that allows participants in the financial markets to communicate with each other. It must be their underlying belief that by enabling traders to share information with each-other, they provide a valuable service to the clients of Symphony for which the latter are willing to pay an annual subscription fee. In fact it can be frequently observed in the financial markets that some of the most successful investors like to share their insights with other investors. With the emergence of the powerful hedge fund industry, which is sometimes portrayed as an "old boy network", this raises a number of questions. Why do investors share information at all? Does communication among already better informed investors have detrimental effects on financial markets in general or on those that are less informed? Or on the contrary, does it lead to better informed decisions among investors, and thus to more financial stability?

In standard models of insider trading, following the seminal Kyle (1985) model, traders profit from having proprietary information that the rest of the market does not have. In these models, traders would not give away any information for free, as it would reduce their informational advantage and thus decrease their profits. The theory is thus at odds with what we can observe. The aim of this works is to reconcile the observation of communication among privately informed traders with the theory by providing a model where a strategic insider trader benefits from sharing (some) information with others. I then continue to analyze implications for the market as a whole.

In particular, I construct a three period version of the extended Kyle (1985) model of insider trading, where in contrast to the original model, I allow for long-term and short-term information about the liquidation value of the asset. The characteristic of short-term information is that it becomes publicly known in an intermediate period, so that the knowledge of it becomes worthless for trading after this period. Long-term information on the other hand is never perfectly revealed. Before the first round of trading, each informed trader is endowed with two signals, one which contains short-term information and one which contains long-term information. I show that if one trader is able to communicate its short-term information to other traders with some noise, he can profit from this communication. The intuition is the following: By sharing his information he introduces noise into the economy and only he himself knows its precise realization. All future trading decisions depend on the realization of this noise. In particular even when the short-term information becomes obsolete, the noise is not being revealed so that it continues to have impact on trading decisions. At this point the sender however still wants to infer the long-term information of other informed traders from the market price. Since he is better able to separate the noise from the real information contained in the price, he has an advantage in extracting information from the price compared to the market maker. By sending a noisy signal of short-term information he thus has endogenously created an informational advantage about the long-term information and consequently increased its profit.

Since traders who receive information also increase their profits, both types of informed traders, senders and receivers, can be better off communicating. This is to the cost of the uninformed noise traders, which has an important policy implication: If a regulator wanted to protect small, non-professional investors he might want to do anything possible to limit communication among informed traders. Regarding informational efficiency, I find that even though long-term price efficiency is lower (as this is exactly how the sender is profiting), in the short-term informational efficiency may actually improve. This is due to an equilibrium effect: Since in the long-term liquidity decreases and trading thus becomes more costly, the sender prefers to shift some trading on the long-term signal to the first period. By increasing his trading intensity he reveals more information about the long-term signal earlier on which increases informational efficiency in the short-term.

This paper falls into the broader literature of strategic manipulation in asset markets. This literature can be distinguished into three main categories depending on how manipulation is achieved (Allen and Gale (1992)): In the first category of models manipulation is obtained by actions which change the real or perceived value of assets, in the second category by communication of information that is relevant to the payoff of the asset and in the third category by manipulating the price through trading only. This paper falls into the second category, as the sender increases his profit by sending messages. Other example in this strand of literature are e.g. Vila and Jean-Luc (1989), where a trader can make a profit by shorting a stock first, then spreading incorrect information and afterwards buying back the asset at a lower price. Benabou and Laroque (1992) on the other hand show in a reputational cheap-talk game that an informed trader can profit by communicating misleading information, as long as he is perceived as being honest. This paper differs to this line of research in that the insider trader profits not from communicating incorrect information, but from communicating noisy but true information. Adding noise to the economy thereby hinders endogenous learning of the market.

The observation that traders can profit from their information even after is has been revealed is thereby not new to the finance literature. Brunnermeier (2005) investigates the question of how an insider trader that receives noisy information before it is announced to the public can exploit on it even after its announcement. After the revelation of information the insider realizes with which noise he previously received the signal. Also in this model the trader thus benefits from knowing the realization of the noise that is incorporated into the price and thus giving him an advantage in interpreting the price. The insider is however passive in this model and his advantage comes form "mingling" with the entrepreneur and receiving the information before it becomes public. In this work on the other hand the sender creates this advantage actively by communicating his information to other traders with some noise, while ex-ante not having any superior information.

Another strand of literature related to this work investigates the effect of mandatory order disclosure on insider trading. Huddart et al. (2001) modify the standard Kyle model so that the (monopolistic) insider has to disclose his order before the next round of trading. The finding of that paper is that disclosure always decreases the informed trader's profits, leads to more liquidity and better market efficiency. Cao et al. (2013) extend this work to a multi-trader stetting where traders have heterogeneous signals. In this setting traders may increase their profits as trade disclosure lets them learn other traders signals at a faster pace than the market maker.

The effect of short-term information has first been investigated by Admati and Pfleiderer (1988). In contrast to the standard Kyle model the insiders' information remains private only for one period and then is publicly revealed. Additionally, they introduce a second type of noise trader that can decide on the timing of his trade but not on the actual order size. This leads to an equilibrium where there is a strategic complementarity to trade at the same time (as all traders prefer to trade when the market is liquid and the more traders trade the more liquid the market). This may explain the empirically documented U-shape in trading volume within a day.

This paper proceeds in the following way: Section 2 introduces the structure of the economy. Section 3 defines what is meant by equilibrium and characterizes an equilibrium in this economy. Section 4 presents the results.

2 Model

The model is an extension of the static Kyle (1985) model, where other than in the original model there are two informed traders, but each trades only in one period and the trader of the second period can send a signal to the trader of the first period. The single asset in fixed supply is thus traded in two trading rounds and liquidates thereafter. There are three types of market participants: informed traders which similarly as in internalize the impact of their trading strategies on prices, noise traders and a competitive market maker. All market participants are risk neutral and none of them can observe the liquidation value of the asset v perfectly before it has realized at the end of period 2.

The role of the market maker is to execute the orders of the informed and noise traders. When receiving orders, the market maker cannot distinguish between informed and noise trading, since he can only observe the aggregate order X_t. There is free entry into market making and he thus earns zero profits. This implies that the market clearing price equals to the market makers expectation of the liquidation value v of the asset given the information he can extract from the history of aggregate orders up until period t, $\{X_s\}_{s=1}^{t}$.

Informed traders receive signals about the liquidation value of the asset before the first round of trading and trade in order to exploit their informational advantage. The trader of the first period receives the signal r and the trader of the second period receives the signal s. As commonly assumed in the literature (e.g. Brunnermeier (2005), Cao et al. (2013) among others) I assume that information is dispersed among informed traders, in the sense that the sum of the signals of the two traders equals the liquidation value of the asset

$$v = s + r$$

. Both signals are independently normally distributed with mean 0 and variance σ_f^2 and σ_s^2 repsectively. . The signal of the second trader s becomes publicly known after the first round of trading.

The new feature of this model is that before the first round of trading the second trader, can send a noisy message

$$m = s + \delta$$

about his information to the other informed trader which trades in the first period. It is assumed that the first trader cannot send his signal, but even if he could it would such message would be worthless to the second trader as it becomes publicly revealed before second trader trades. The receiver receives the sender's information disturbed by a different noise term δ, whereby δ is assumed to be independently normal distributed with mean 0 and variance σ_δ^2, which is exogenously given and not a strategic choice of the sender. Messages are assumed to be sent truthfully in the sense that the sender cannot lie about the signal it has received in order to mislead others.

. Furthermore I assume that the sender of the message is able to observe the noise terms δ with which he is communicating his information. This allows him to exactly understand how his message will be used by the first trader and gives him an advantage in interpreting the second period price as will be explained in more details below and will be an important driver of the results. The information structure is assumed to be common knowledge among all market participants. Based on his information, each informed trader i chooses his order size x_t^i when it is his turn to trade.

Noise traders on the other hand do not receive any private information and inelastically demand the asset. The noise traders' aggregate demand in period t, ϵ_t is assumed to be a random variable, normally distributed with mean zero and variance σ_ϵ^2. The presence of noise traders is a common assumption in models of heterogeneous information. Their role is to camouflage the informed traders' information. Without them, as noted by Grossman and Stiglitz (1980) the informed traders' information would be immediately revealed by the market price. Note that in this model the receiver is trading on his own signal as well as message which is itself perturbed by a noise. As the marketmaker will not be able to backengineer the indivivual signals from his demand, the noise traders are not strictly necessary in the first period, however in the second period they are, as the sender will be left with only the noise he previously added to the message as his private information and it is this information that gives him his informational advantage. If no other noise was assumed this would be revealed through his demand and he would not have any informational advantage.

Timing

There are two periods of trading. Before the first period both informed traders receive their signals s and r respectively. The sender sends a noisy message of his signal to the receiver. In the first round of trading only the receiving trader is allowed to trade. Based on his own signal and the message m he has received, he submits his order x_1^r. Noise traders submit a random order ϵ_1. The market maker observes the aggregate order $X_1 = x_1^r + \epsilon_1$ and sets the market price p_1, which is observed by everyone. After the first period the sender's signal becomes publicly known.

After observing the price p_1 the sender updates his beliefs about the receiver's signal. Based on his updated beliefs the sender submits his order for the second period x_2^i. Noise traders demand again a random order ϵ_2. As in the first period the market maker observes the aggregate order $X_2 = x_2^s + \epsilon_2$ and sets the market price p_2. After the second round of trading the asset liquidates and each trader receives an amount of v for each unit hold in the asset. These timing assumptions are chosen for the following reasons: The central trader needs to trade in the second period in order to enable him to profit from sending his signal as it is in the second period of trading where he gains from communication. This is not the case for the first trader who gains only when receiving information in the first period of trading. A more general version of the model would allow both types of traders to trade in each period.

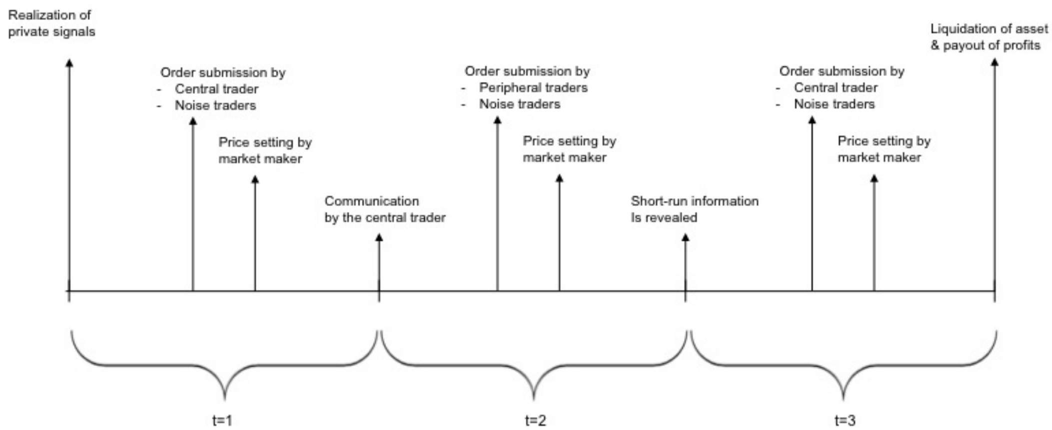

Figure 2.1: Timing

A model where the sender can submit an order only at the same time or or after the first trader take advantage of his information might not lead to the same result as this would lead to a decline in profits in the first period (due to the short-term signal being less valuable as it is used by many traders) which might outweigh his future gain.

Market Maker's Pricing Rule

The market maker fulfills the orders of the informed and noise traders by acting as an intermediary and taking on any potentially arising net position. Since he is competitive he sets the market price equal to the expected liquidation value v of the asset. In order to form expectations he tries to infer information from the informed traders orders. He can however not observe individual orders but only the aggregate order of informed and noise traders X_t and thus a noisy signal of the informed traders demand. The prices of the asset in period 1 and 2 are then given as

$$p_1 = \mathbb{E}\left[v \mid X_1\right]$$

After the first round of trading, the short-term information s becomes publicly known, so that the market maker takes this into account when setting the second period price so that

$$p_2 = \mathbb{E}\left[v \mid X_1, X_2, s\right]$$

Informed Traders Problem

According to their own valuation of the asset and conjecturing the market maker's as well as the other trader's strategies, each informed trader decides on how many units x_t^i of the asset he wants to demand when it is his turn to trade, depending on the information he has available. When making his decision in period 1 the receiver takes into account how his current order impacts the current price, he does not care about future periods as he is only allowed to trade once. This leads to the following static optimization problem in period 1 for the receiver r

$$x_1^{r,*} \in argmax_{x_1^c} \mathbb{E}\left[x_1^r \left(v - p_1\left(x_1^r\right)\right) \mid r, m\right] \tag{2.1}$$

When the sender gets to trade in the second period he will have observed the period 1 price additionally to the information he has had already in period 1: the signal s he has received as well as the noise with which he has sent the message. Since after the second round of trading the asset liquidates, also his optimization problem is of static nature and can be written as

$$x_2^{s,*} \in argmax_{x_2^s} \mathbb{E}\left[x_2^s \left(v - p_2\left(x_2^s\right)\right) \mid s, \delta, p_1\right] \tag{2.2}$$

3 Equilibrium

This section first establishes what is meant by an equilibrium and then proceeds to characterize a linear equilibrium of the trading game described above.

Definition 1. A sequentially rational Bayesian Nash equilibrium of the trading game is given by a strategy profile

$\{x_1^{r,*}, x_2^{s,*}, p_1^*, p_2^*\}$ such that

1. the receiver chooses his first period asset demand optimally as defined in (2.1)
2. the sender chooses his second period asset demand optimally as defined in (2.2)
3. the market maker sets the price according to $p_1^* = \mathbb{E}\left[v \mid X_1^*\right], p_2^* = \mathbb{E}\left[v \mid X_1^*, X_2^*, s\right]$ and beliefs are consistent.

In what follows I will focus on a symmetric equilibrium in linear strategies, where each participant makes decisions based on a linear combination of the information available to him. The following proposition demonstrates that such kind of strategies are indeed consistent with an equilibrium as defined above.

Proposition 1. *A sequentially rational Bayesian Nash equilibrium in which all pure trading strategies are of the linear form*

$$x_1^r = \beta l + \gamma m$$

$$x_2^s = \vartheta \delta + \theta T$$

and the market maker's pricing rule is of the linear form

$$p_1 = \lambda_1 X_1 \tag{3.1}$$

$$p_2 = s + \mathbb{E}\left[l \mid T\right] + \lambda_2 \left[X_2 - \mathbb{E}\left[X_2 \mid T\right]\right] \tag{3.2}$$

where the price signal T is given as

$$T = \frac{1}{\beta}\left[X_1 - \gamma s\right]$$

is characterized by the following equations

Receiver

$$\beta = \sqrt{\frac{\Omega}{\mu\Sigma + \Lambda}} \tag{3.3}$$

$$\gamma = \mu\sqrt{\frac{\Omega}{\mu\Sigma + \Lambda}}$$

where

$$\mu = \frac{\Sigma}{\Delta + \Sigma}$$

Sender

$$\vartheta = -\sqrt{\frac{\Omega}{\Delta}}\frac{D}{C} \tag{3.4}$$

$$\theta = \frac{\mu}{D}\frac{1}{C}\sqrt{\Omega}\sqrt{\Delta}$$

Market maker's pricing rule

$$\lambda_1 = \frac{1}{2}\sqrt{\frac{\Omega}{\mu\Sigma + \Lambda}}^{-1}$$

$$\lambda_2 = \frac{1}{2}\frac{\Lambda}{C}\frac{\mu}{D}\sqrt{\frac{\Delta}{\Omega}}$$

where

$$C = \sqrt{2\Lambda + \mu\Sigma}$$

and

$$D = \sqrt{2\Lambda + \Delta\mu^2 + \mu\Sigma}$$

Proof. [to complete] □

Having determined the equilibrium prices and

[show graph]

4 Results

This section presents the main findings of this paper. I illustrate that it can be profitable for an insider trader to share information and provide some intuition for the mechanism of the result. Since the profits and price efficiency are inseparable from each other, they are discussed in the same section. Then some implications on the market as a whole are discussed.

Profits of the sender and informational efficiency

Given the equilibrium allocation it is now straightforward to calculate the profits of the sender.

Proposition 2. *The equilibrium profits of the sender are given by*

$$\pi = \frac{1}{2}\mu\Lambda\sqrt{\Delta}\sqrt{\Omega}\frac{D}{C^3}$$

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Figure 1 panel A depicts the ex-ante profits of the sender with and without communication depending on the precision with which the sender shares information. It can

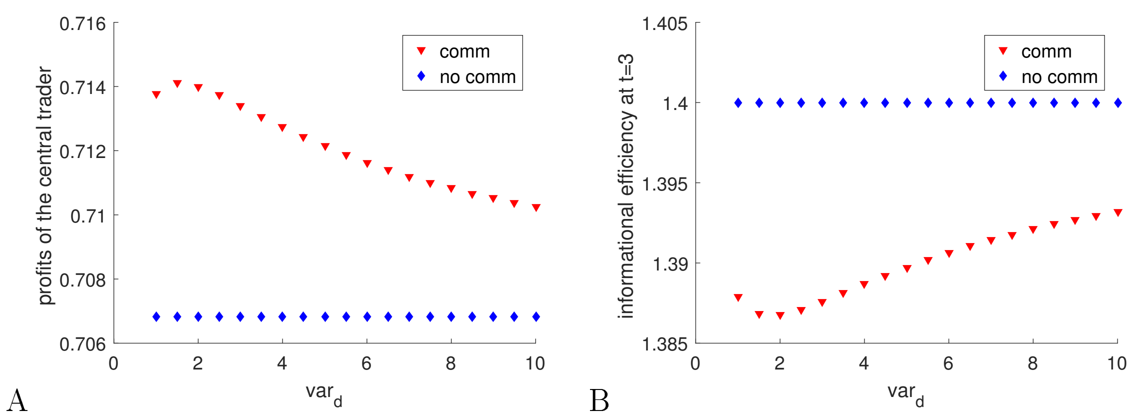

Figure 4.1: Ex-ante profits of the sender and informational efficiency at t=3 measured as $1/\text{var}(v \mid S, T)$

be seen that, independently with how much noise the signal is being sent, the sender is always increasing profits by sharing information. The intuition for this result is the following: by sharing his short-term information the sender adds noise to the economy, and only he knows the exact realization of this noise. When inferring information about the other traders long-term information from the price signal T he can take advantage of this fact and can thus extract more information from it. In order to formalize this intuition let us look at the price signals that are observable to the market maker and the sender in turn. While the market maker can observe

$$T = \beta_2^p \sum_{i \neq c} l_i + \gamma^p \sum_{i \neq c} \delta^i + \epsilon_2$$

about the long-term signals of the peripheral traders, the sender also knows the precise realization of the noise term $\sum_{i \neq c} \delta^i$, and can thus infer

$$T_c = \beta_2^p \sum_{i \neq c} l_i + \epsilon_2$$

. This gives him a more precise estimate of the information he is missing $\sum_{i \neq c} l_i$, which increases his informational advantage compared to the market maker. This intuition can be confirmed by looking at the graph. Figure 4.1 panel B shows the price informativeness at the beginning of t=3. While the actual profits depend on the informational advantage of the sender over the market maker, i.e. the difference in posterior variances between them, we can see from the very similar shape of this graph, that the increase in profits of the sender is mainly due to an decrease in price informativeness in period 3[1].

[1]in fact also the posterior variance of the sender increases due to the lower trading intensity β_2^p of the peripheral traders in period 2 which is a result of the decreased liquidity as described in the next section. This effect is however much smaller compared to the increase in the posterior variance of the market maker, and hence the all-over effect is that the difference in posterior variance and hence the informational advantage increases

It can thus be summarized that by communicating his short-term information to other traders the sender is deteriorating the long-term price informativeness and through this is increasing his profits.

The resulting increase in profits is thereby the highest at the point where the market maker's posterior variance (the inverse of the price informativeness) increases most compared to his own, in this example at a value around 2. If the sender was able to choose the amount of noise with which he was communicating his information, this would be the level he would choose. This hump shape comes about from the overall impact of a change in the variance of the noise σ_δ^2 on the disturbance $\gamma^p \sum_{i \neq c} \delta^i$ of the price signal T in equilibrium. Everything else being equal, the higher σ_δ^2 , the less informative is the message to the peripheral traders and thus the less weight γ^p do they attach to the information they receive. The overall effect on the variance of noise the sender adds to the economy $var\left(\gamma^p \sum_{i \neq c} \delta^i\right)$ is thus non-monotonic. For lower values the increase in the variance σ_δ^2 dominates, while for higher values the decrease of the weight γ^p is stronger so that it leads to total decrease in the variance of the added noise.

Profits of the peripheral traders

The peripheral traders are receiving additional information about a signal they cannot observe, which unambiguously increases their profits. Figure 4.2 panel A shows the profits of a peripheral trader in the economy with and without communication Clearly, the more noise the sender sends his signal with, the less valuable is this information to the peripheral trader and thus the lower is the resulting increase in profits.

When comparing the increase in profits from communication between the two types

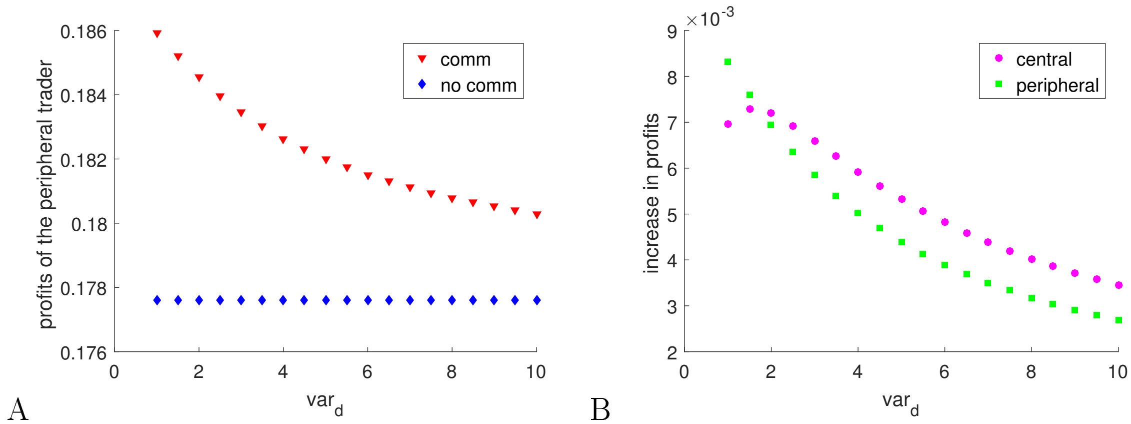

Figure 4.2: Ex-ante profits of a peripheral trader and comparison of profits

of traders, I find an ambiguous result. Even though only the peripheral trader receives any information about the fundamental value of the asset, it is not always him who profits more. Figure 4.2 panel B shows that this is only the case when the signal is sent very precisely, for larger values of the communication noise however, the sender's increase in profit exceeds the peripheral traders increase. It is a surprising result that adding confusion to the market can be more valuable than receiving real information about the asset.

In this section we have seen that all informed traders profits increase after communication, those who sent and those who receive information. Since the market maker makes zero profit in expectation, this gain in profit is to the cost of the uninformed traders. This finding has an important policy implication: If a regulator's goal was to protect small, non-professional traders he should put his best efforts into limiting the amount of secret communication between informed traders.

Liquidity

The effects on market liquidity follow the intuition of the standard Kyle (1985) model: since the informational advantage of insider traders increases with communication, the market maker decreases the liquidity in order to compensate himself for bad trades due to the deterioration of the adverse selection problem he is facing. This is the case for both periods two and three as we can see in Figure 4.3. It is an interesting feature of the model though that communication about short-term information has still consequences for the liquidity of the asset even when this information has already become obsolete.

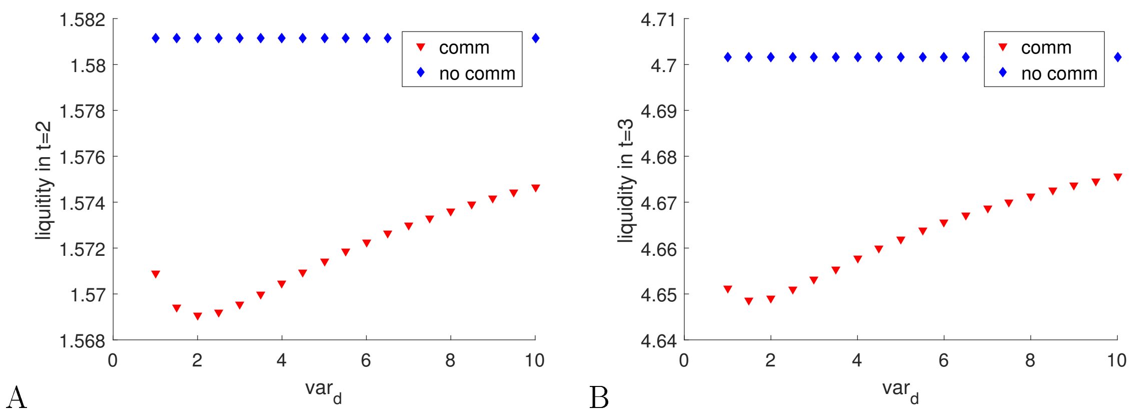

Figure 4.3: Liquidity

Informational efficiency in period 2

The decrease in liquidity in period 3 thereby also has some effect on the inter-temporal decision problem of the sender. Since it becomes relatively more costly to trade in the third period compared to the first period, he anticipates some of the trading to the first period by increasing the weight he puts on the long-term signal in the first period while decreasing it in the third period. This increase can be seen in Figure 4.4 panel A. By increasing his trading intensity on the long-term signal, he releases more information to the market compared to the economy with no communication. This improves the informational efficiency of the market in period 2 as the posterior variance of the market maker declines. It needs to be highlighted that this is a purely endogenous effect as no additional information has been traded upon at this point in time.

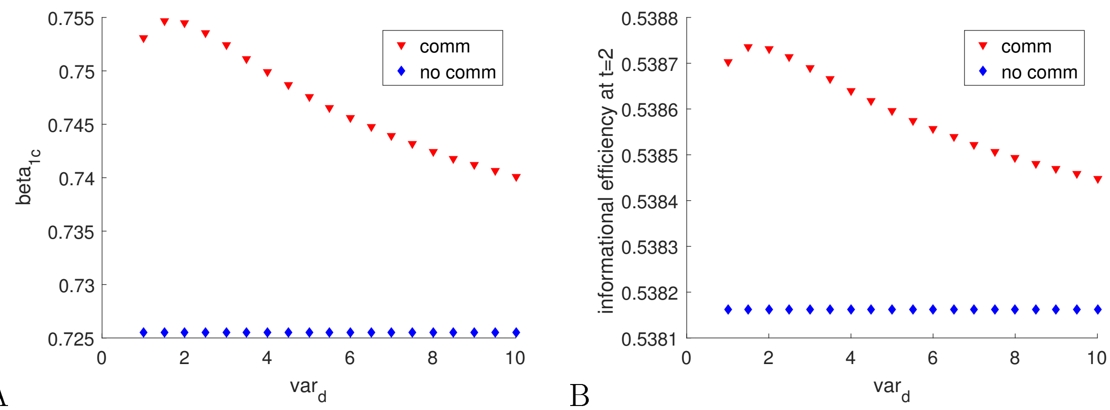

Figure 4.4: Trading intensity on the long-term signal in t=1 and informational efficiency in t=2 measured as $1/\text{var}(v \mid X_1)$

5 Summary

This work provides a theoretical explanation for the empirically observed phenomenon of communication among insider traders. I show that by sending a noisy message about his short-term signal, an informed trader can increase his profits as he adds noise to the economy and thus hinders learning of other market participants in the long-run, in particular of the market maker. Surprisingly though, communication leads to an increase in short-term informational efficiency due to an equilibrium effect. As liquidity becomes scarce in the final period, the sender anticipates some of his trading to the first period which leads to a stronger dissemination of his information earlier on. Compared to an economy where communication is not possible, both the senders and receivers of information are better off. This comes to the cost of uninformed noise traders. If a regulator's aim was to protect this latter type of investors he should do anything possible to prevent secret communication.

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