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Is Talk Cheap Online: Strategic Interaction in A Stock Trading Chat Room

Jie Lu
and
Bruce Mizrach*

Department of Economics
Rutgers University

January 1, 2007

Abstract:
We consider a model of an internet chat room with free entry but secure identity. Traders exchange messages in real time of both a fundamental and non-fundamental nature. We explore conditions under which traders post truthful information and make trading decisions. We also a describe an equilibrium in which momentum traders profit from their exposure to informed traders in the chat room. The model generates a number of empirical predictions: (1) unskillful traders post more often than skillful traders; (2) skillful traders will not follow unskillful traders in stock picking; (3) The optimal strategy for unskillful traders is to follow skillful traders in stock picking. We test and affirm all three predictions using a unique data set of chat room logs from the Activetrader Financial Chat Room.

Keywords: chat room; strategic information;

JEL Codes: G14;

* Corresponding author: Bruce Mizrach, Department of Economics, Rutgers University, New Brunswick, NJ 08901, mizrach@econ.rutgers.edu. We would like to thank Susan Weerts for research assistance and Colin Campbell for helpful discussions.

1. Introduction

There is now an established literature on the performance of individual traders. Odean (1999) documents poor returns in a sample of more than 35,000 households. He attributes the underperformance to both overtrading and the disposition effect, the tendency to sell winners and hold losers.

Some recent papers, including Coval, Hirshleifer, and Shumway (2005) and Niccolosi, Peng, and Zhu (2003), have suggested that traders might gain experience that improves their performance over time. Mizrach and Weerts (2006) show that skill may be stock specific.

This paper studies the influence of communications among individual traders on their trading decisions. We model their interactions as a dynamic game and establish three strong empirical predictions: (1) Less informed traders communicate more often; (2) All but the most informed traders learn from public information about prices, and they optimally follow informed traders; (3) Traders follow the skillful traders more often.

We typically don't observe the message traffic between traders and their broker or fellow traders. Antweiler and Frank (2004) study Internet bulletin board posts, but these are not observed in real time. We also don't see trading decisions linked directly to their posts.

This paper takes advantage of a unique data set of the chat room posts of more than 1,000 individual traders. We confirm the three main empirical predictions of our model.

The paper is organized as follows: Section 2 describes the equilibrium if traders cannot communicate; Section 3 describes the equilibrium with communication and its empirical implications. Section 4 introduces the data; Section 5 presents our empirical results; Section 6 concludes and speculates about the generalizability of the results.

2. Model

Price setting in the model is based on Back (1992), which is a continuous-time version of Kyle (1985). Details from that paper are introduced in Appendix A.

2.1 Model Settings

2.1.1 Environment

There are two assets: risky asset V and riskless asset M. Time runs continuously from 0 to Γ.

There is to be a public release of information at a known date which will affect the value of risky asset V. Define the time point when some traders in the market receive private signals about the information as time $t = 0$, and the time point when the information is announced to the public as time $t = \Gamma$.

The information is represented as $\widetilde{v}$, the value at which the risky asset will trade after the information release at time $t = \Gamma$. $\widetilde{v} \sim N(v_0, \sigma_v^2)$ is public information, where v_0 is the initial price of the risky asset at time $t = 0$. Define the state of the world $\widetilde{\omega} = \Omega = \left\{\omega^+, \omega^0, \omega^-\right\}$ as following: if $\widetilde{v} \geq v_0 + v_\omega$, the world is in state ω^+, if $v_0 - v_\omega \leq \widetilde{v} < v_0 + v_\omega$, the world is in state ω^0; and if $\widetilde{v} < v_0 - v_\omega$, the world is in state ω^-. The prior probability of each state $\left\{\omega^+, \omega^0, \omega^-\right\}$ is $\{p, 1-2p, p\}$ where $p = \frac{1-2\Phi(\frac{v_\omega}{\sigma_v})}{2}$ and $\Phi(\cdot)$ is standard normal distribution function. All these are public information.

2.1.2 Traders and Signals

There are three kinds of individual traders in the market: fundamental traders S_I, hybrid traders S_H and technical traders S_T.

These individual traders have private information: $\widetilde{v} = v_0 + \widehat{v}$ in state ω^+, $\widetilde{v} = v_0$ in state ω^0 and $\widetilde{v} = v_0 - \widehat{v}$ in state ω^-, where $\widehat{v} > v_\omega = \sigma_v \cdot \Phi^{-1}\left(\frac{1}{2} - p\right)$.

Each trader i also receives a signal $\theta_i \in \Theta = \left\{\theta^1, \theta^2, \theta^3, \theta^4, \theta^5, \theta^6\right\}$, where $\theta^1 = \{0, +\}$, $\theta^2 = \{0, -\}$, $\theta^3 = \{+\}$, $\theta^4 = \{-\}$, $\theta^5 = \{0\}$, $\theta^6 = \{+, 0, -\}$. Signal $+$ indicates state ω^+, signal $-$ indicates state ω^-, and signal 0 indicates state ω^0.

[INSERT Table 1 HERE]

Please change Table 1 as this one, the old one has a typo.

A trader's type and signal are private information to her/him.

2.1.3 Price Path

The price path is a continuous process $P_t = v_0 + \frac{t}{\Gamma}\widehat{v} + \varepsilon_t$, where $\varepsilon_t \sim N(0, \sigma_u^2 t)$. We can regard the price P_t as the market aggregate expectation of risky asset's value $v_0 + \frac{t}{T}\widehat{v}$ plus a noise process ε_t, where the market aggregate expectation of risky asset's value adjusts linearly from v_0 to the realization of $\widetilde{v}$ during time period $[0, \Gamma]$ and the noise process ε_t is a Brownian Motion $d\varepsilon_t = \sigma_u^2 dW_t$.

2.1.4 Market Impact

To simplify the problem, suppose individual traders can only check prices and submit orders at time points $t = 0, \Delta t, 2\Delta t, \ldots, T\Delta t$. Here, we divide $[0, \Gamma]$ into T time periods with time interval Δt and $\Delta t \cdot T = \Gamma$.

Assume the market adopts a linear pricing rule which makes order flows have linear impacts on price: the price changes by λ for one unit of net order flow.

Considering individual traders have strict capital limits, we assume each individual trader can only long/short q units of risky asset and thus, each trader's market impact is λq.

Suppose the number of traders S_F, S_H and S_T in the market are QQ_F, QQ_H and QQ_T. Assume $\lambda q QQ_F$ is traders S_F's private information, $\lambda q QQ_H$ is traders S_H's, and $\lambda q QQ_T$ is traders S_T's. The intuition behind this assumption is that, through their trading experiences, traders know the approximate market impacts when they trade. (Actually, $\lambda = \frac{\sigma_v}{\sigma_u}$)

The settings of price path and market impact can fit into Back's 1992 model. Please refer to Appendix A to see the details.

2.1.5 Actions

To simplify the problem, we assume they can only trade once over time period $[0, \Gamma]$ since individual traders have small capital, and suppose individual traders are myopic, i.e. they trade immediately when their expected returns from trading are positive.

At period s, trader i's action is denoted as $a_s^i \in \Lambda_1 = \{L, S, N\}$, where $\{L, S, N\}$ is the action set, L means long q of risky asset V, S means short, and N means no trade. And thus, trader i's strategy in periods $s = 0, 1, 2, \ldots, T$ is $a^i = \left\{a_1^i, a_2^i, \cdots, a_T^i\right\}$, which can be denoted as $a^i = L_{s_1}$ or S_{s_2} or N_{all} because i can only trade for one time, where L_{s_1} means L at period $s = s_1$ and no trade at all other periods $s \neq s_1$, S_{s_2} means S at period $s = s_2$ and no trade at all other periods $s \neq s_2$, and N_{all} means N at all periods $s = 0, 1, 2, \ldots, T$.

2.1.6 Optimal Strategy

For myopic trader i, who can be S_F, S_H or S_T, given private signal θ_i and the price path $\{P_\varsigma\}_{\varsigma=0,1,\ldots,T}$,

L_{s^*} is i's optimal trading strategy if $E[\pi_D\,(L_{s^*})\,\theta_i,\ \{P_\xi\}_{\xi=0,1,\ldots,s^*-1}] > 0$ while $E[\pi_D\,(L_{ss})\,\theta_i,\ \{P_\xi\}_{\xi=0,1,\ldots,ss-1}] \leq 0$ for all $ss < s^*$ and $E[\pi_D\,(S_{st})\,\theta_i,\ \{P_\xi\}_{\xi=0,1,\ldots,st-1}] \leq 0$ for all $st \leq s^*$;

$S_{s'}$ is i's optimal trading strategy if $E[\pi_D(S_{s'})\,\theta_i, \{P_\xi\}_{\xi=0,1,\ldots,s'-1}] > 0$ while $E[\pi_D(S_{st})\,\theta_i,$ $\{P_\xi\}_{\xi=0,1,\ldots,st-1}] \leq 0$ for all $st < s'$ and $E[\pi_D(L_{ss})\,\theta_i,\ \{P_\xi\}_{\xi=0,1,\ldots,ss-1}] \leq 0$ for all $ss \leq s'$;

and N_{all} is i's optimal strategy if there does not exist such a s^* or s' in all periods $s = 0, 1, 2, \ldots, T$.

2.2 Equilibrium without Communications

Without communications with each others, traders use their private signals and the price path, which is public inofrmation, to make their trading decisions. Accoring to our settings, the trading volume and the trading time are not informative.

Simply assume transaction cost is fixed, denoted as C, which includes brokerage fee, capital interest and other costs. Here is an important assumption: we need $p \leq \frac{C}{2\widehat{v}}$ i.e. S_H's signal is not informative enough, compared with cost C. The intuition behind the assumption is that, as long-lived information, $\widehat{v}$ needs to be very large, and thus, $p < \frac{1-2\Phi(\frac{\widehat{v}}{\sigma_v})}{2}$ must be very small.

Lemma 1: Fundamental traders S_F trade only on their signals. And their optimal strategy is $a^F(\{+\}) = L_0$, $a^F(\{-\}) = S_0$ and $a^F(\{0\}) = N_{all}$, i.e. they trade at the very beginning on the same direction with their signal.

Proof: Because fundamental traders S_F receive perfect information about $\widetilde{v}$, their optimal strategy is to benefit from their signals immediately, i.e. to long at period 0 as soon as possible if receiving a positive signal, short as soon as possible if receiving a negative signal and always hold 0 position when receiving a neutral signal.

And their expected returns are $E[\pi_F(L_0)|\{+\}] = E[\pi_F(S_0)|\{-\}] = \widehat{v} - (\lambda q Q Q_F + C)$ and $E[\pi_F(N_{all})|\{0\}] = 0$.

Intuition: Fundamental traders depend only on their informative signal to make trading decisions.

Lemma 2: Hybrid traders S_H trade not only on their signal but also on the price path. Suppose their signal is not informative enough, i.e. $p \leq \frac{C+\lambda q Q Q_H}{2\widehat{v}}$, they enter the market later than fundamental traders S_F.

Proof: See Appendix B.

Intuition: Hybrid traders S_H depend not only on their signal but also on the price path to make trading decisions.

Signal $\{+, 0\}$ excludes state ω^- which occurs with the possibility p and signal $\{-, 0\}$ excludes state ω^+ which also occurs with the possibility p. Thus, p indicates the informativeness of S_H's signal. If S_H's signal is informative enough, i.e. $p > \frac{C+\lambda q Q Q_H}{2\widehat{v}}$, they enter the market at the very beginning, as fundamental traders S_F; if signal θ^H is not informative enough, S_H have to wait for the price path to make trading decisions. And their beliefs about the state of the world update with the price path by Bayes rule.

Lemma 3: Technical traders S_T trade only on the price path. They enter market later than fundamental traders S_F. With one price path, they enter the market later than hybrid traders S_H if trading on the same direction as signal θ^H.

Proof: See Appendix C.

Intuition: Technical traders S_T receive uninformed signal and depend only on the price path to make trading decisions.

S_T also update their beliefs about the state of the world with the price path by Bayes rule. And they never trade at the very beginning and so, they always enter the market later than S_F. With one price path, S_T have less information than S_H because S_H receive signal $\{+, 0\}$ or $\{-, 0\}$ at the beginning. Updating with the same price path, S_H have stronger beliefs on ω^+ than S_T if receiving signal $\{+, 0\}$ at the beginning; and S_H have stronger beliefs on ω^- than S_T if receiving signal $\{-, 0\}$ at the beginning. Therefore, S_H long earlier than S_T when receiving signal $\{+, 0\}$, and short earlier than S_T when receiving signal $\{-, 0\}$.

In the equilibrium without communications, we exclude the interactions among individual traders in the market by assuming each type of traders' market impacts are that type of traders' private information.

3. Equilibrium with Communications

3.1 Model Settings

3.1.1 Information Group

Suppose some individual traders form a group with free entries and unique identities, where traders can exchange trading, fundamental, non-fundamental and other information with each other without any cost. And such a group is unknown to other traders outside the group.

The number of fundamental, hybrid and technical traders S_F, S_H and S_T in the group are Q_F, Q_H and Q_T, where $Q_F \ll QQ_F$, $Q_H \ll QQ_H$ and $Q_T \ll QQ_T$. Assume $Q_F \ll Q_H$ and $\lambda q\left(Q_T - Q_F - Q_H\right) > C$, which are public information to the group.

3.1.2 Actions

The action space is two-dimensional, including trader i's trades and posts. At period s, trader i's action is denoted as $a_s^i = \left\{at_s^i, ap_s^i\right\} \in \Lambda_2 = \{\{L, S, N\} \times \{l, s, n\}\}$, where ag refers to actions within the communication group, at_s refers to trades at period s and ap_s refers to posts at period s, L, S, N are defined as previous part, and l means posting positive comments or long positions, s means posting negative comments or short positions, and n means no post at all. Individual trader i's strategy in periods $s = 0, 1, 2, \ldots, T$ can be denoted as $a^i = \{\{L_{s_1}, S_{s_2}, N_{all}\} \times \{\{l_\xi, s_\varsigma\}_{\xi=0,1,\ldots,T,\varsigma=0,1,\ldots,T,\varsigma\neq\xi}, \{n_{all}\}\}\}$, where L_{s_1}, S_{s_2} and N_{all} are explained in previous part, and $\{l_\xi, s_\varsigma\}_{\xi=0,1,\ldots,T,\varsigma=0,1,\ldots,T,\varsigma\neq\xi}$ means l at periods ξ and s at periods ς, and n_{all} means no post for any period.

To clarify the time order of traders' actions, we assume if a trader posts at period s, then another trader can only use this post to make trading decision at period $\tau \geq s + 1$. The intuition behind this is to assume that followers cannot trade at the same time as the being-followed posters because traders always try to avoid the market impact from followers and post only after their trades complete if they post truthfully.

Assume two tie-breaking rules about posts: (1) traders do not lie unless lying is profitable (cooperating); and (2) traders do not try to hide their trades unless they make profits from other traders in the group by those trades (reputation).

3.1.3 Reputations

Suppose some traders stay in the group for a long time while the others just enter. The former know the types of all traders within the group, denoted as S^k; and the latter know neither others' types nor the number of various kinds of traders in the group, denoted as S^{uk}. Here, S_F^{uk}'s and S_H^{uk}'s optimal strategies are almost the same as S_F and S_H outside the group, and S_T^k act very similar to S_H^k. So we focus on S_F^k, S_H^k and S_T^{uk} by simply assuming S_F and S_H know the types of all traders in the group while S_T know neither others' types nor the number of various kinds of traders in the group.

3.2 Equilibrium Analysis

Within the group, besides their signals and the price path, traders have another information source: other traders' posts.

Let's consider S_F first. S_F have no reason to wait to see others' posts because they receive the most informative signal. In state ω^+ or ω^-, S_F still trade at the very beginning, period 0.

Since each trader can trade only once during the time period $[0, \Gamma]$, S_F have no incentive to bluff in state ω^+ or ω^- because they cannot trade again to make profits from followers. The intuition behind that is, in the state ω^+/ω^-, S_F have already longed/shorted as much as their capitals allow at the very beginning, and so, they cannot trade again and benefit from cheating others. Thus, according to the second tie-breaking rule, S_F always post truthfully to gain reputation in the state ω^+ or ω^-: l in the state ω^+ and s in the state ω^-. (If S_F choose to not post in the state ω^+ or ω^-, then there is no equilibrium.) The intuition here is S_F release their information after building their postions. Here, we need to assume $\lambda q \left(Q_H + Q_T\right) < \frac{\widehat{v}}{T}$ to exclude the situation under which S_F choose to not trade at the very beginning but wait one more period to make higher profits by cheating S_H and S_T in the group to move the price to the anti-direction with S_F's signal.

In the state ω^+/ω^-, given S_F always post truthfully, S_H cannot cheat S_T by posting anti-signal, that is, posting s when receiving $\{+, 0\}$ or posting l when receiving $\{-, 0\}$. The reason is that, considering $Q_F \ll Q_H$ is public information, S_T can distinguish S_F's posts from S_H's posts whenever S_F and S_H post contradictorily. Thus, S_H are not able to bluff in the state ω^+/ω^- to make S_T trade on the anti-direction as S_H's signal shows.

In the state ω^0, S_H have incentives to cheat S_T by posting l or s because S_H's posts make it easier for S_T to long or short with the same price paths, and then, S_H can trade against S_T to make profits if they know the state is ω^0. Under such a situation, S_H are indifferent with posting l or s.

Therefore, S_H's optimal posting strategy is to always post l if receiving $\{+, 0\}$ and post s if receiving $\{-, 0\}$. We can explain this as following: Firstly, in the state ω^+/ω^-, S_H are indifferent with posting truthfully or not posting or bluffing because S_F always post truthfully in the state ω^+/ω^- and S_T can identify S_F's posts if S_F and S_H post contradictorily; Secondly, in the state ω^0, S_H have incentives to post l or s to cheat S_T and make profits from trading against S_T; Thirdly, when receiving $\{+, 0\}$, S_H cannot distinguish state ω^+ from state ω^0 and thus, they can adopt only one action; Lastly, according to the first tie-breaking rule, S_H should choose to post l when receiving $\{+, 0\}$ and post s when receiving $\{-, 0\}$.

Moreover, S_H cannot post later than S_F, otherwise S_T would distinguish S_F's posts and attain perfect information about the state. Thus, S_H have to post at period 0 too.

Do S_F bluff in the state ω^0? They have incentives to do this but they cannot cheat S_H. In the state ω^0, if S_F want to bluff, they do not know which they should post, l or s. They cannot cheat S_H because they do not know which signal S_H receive $\{0, +\}$ or $\{0, -\}$. Then, can they cheat S_T? They can cheat S_T but they do not need to. S_F can also benefit from S_H's posts in the state ω^0 because they can also trade against S_T; and if S_F chose to post l or s in the state ω^0, then their posts might contradict with S_H's posts and make it hard for S_T to follow. Therefore, S_F's optimal posting strategy in the state ω^0 is not to post.

Given S_F post truthfully in the state ω^+/ω^- and do not post in the state ω^0, S_H can attain perfect information about the state of the world at period 1 after observing S_F's posting action at period 0. (As we assumed, traders have to wait until period 1 to use posts at period 0.)

Seeing the posts in the group at period 0, S_T's problem is very similar with S_H outside the group. After observing l posts in the group, S_T can exclude the possibility of state ω^-; and after observing s posts in the group, S_T can exclude the possibility of state ω^0. S_T should depend on both others' posts and the price path to make trading decisions. Here, we need another assumption. Although S_T do not know if the posts are posted by S_F or S_H, we still need to assume $Q_F \ll Q_H$ to make sure the inference from the number of the posts is not strong enough for S_T to change the optimal strategy, given Q_F or Q_H are unknown to S_T.

Let's summarize the equilibrium at each period:

Period 0: private signals arrive.

S_F long and post l if receiving signal $\{+\}$; short and post s if receiving signal $\{-\}$; do not trade or post if receiving signal $\{0\}$,

S_H do not trade, but post l if receiving signal $\{+, 0\}$ and post s if receiving signal $\{-, 0\}$;

S_T do not trade or post;

Period 1: traders can use the posts at period 0.

S_F try to trade against S_T if receiving signal $\{0\}$ and observing S_H post at period 0;

S_H long if observing S_F post l at period 0, short if observing S_F post s at period 0, and try to trade against S_T if observing S_F do not post at period 0;

S_T begin to infer from both the price path and the posts in the group at period 0 and trade when their expected returns are positive.

Period $\widehat{\tau}$:

given the posts in the group at period 0, S_T choose to long/short according to the price path, and post if they trade;

S_H and S_F trade against S_T if they have not traded;

Let's also summarize the optimal strategies for each type of traders:

(i) S_F: if receiving signal $\{+\}$, S_F long and post l at period 0; if receiving signal $\{-\}$, S_F short and post s at period 0; if receiving signal $\{0\}$, S_F do not post, and trade against S_T if/when S_T trade by inferring S_T's trades from the price path and S_T's posts at period 0, .

(ii) S_H: if receiving signal $\{+, 0\}$, S_H always post l at period 0 and if receiving signal $\{-, 0\}$, S_H always post s at period 0. S_H long at period 1 if observing S_F post l at period 0, short at period 1 if observing S_F post s at period 0, and try to trade against S_T if observing S_F do not post at period 0;

(iii) S_T: S_T depend on the price path and the posts in the group to make trading decision and post after they trade.

The following three propositions summarize the three types of traders' optimal strategies in the equilibrium. Proposition 1 is for fundamental traders S_F, Proposition 2 is for hybrid traders S_H, and Proposition 3 is for technical traders S_T.

There are other equilibria in the model, for example, no trader posts at all.

Proposition 1: With communications, fundamental traders S_F's optimal strategy is

$a^F(\{+\}) = \{L_0, l_0\}$;

$a^F(\{-\}) = \{S_0, s_0\}$;

$a^F\left(\{0\}, L_{\widehat{\tau}} \in ag^T\right) = \{S_{\widehat{\tau}}, n_{all}\}$;

$a^F\left(\{0\}, S_{\widetilde{\tau}} \in ag^T\right) = \{L_{\widetilde{\tau}}, n_{all}\}$;

$a^F\left(\{0\}, L_{\widehat{\tau}} \notin ag^T \ \forall\widehat{\tau} = 1, \ldots, T, S_{\widetilde{\tau}} \notin ag^T \quad \forall\widetilde{\tau} = 1, \ldots, T\right) = \{N_{all}, n_{all}\}$.

It is easy to show S_F better off within this group. In the states ω^+ and ω^-, S_F's returns are the same with or without the group. And in the state ω^0, with positive probability (on some price paths), S_F make profits π^* from S_T, where $\pi^* = \lambda q\left(Q_T - Q_F - Q_H\right) - C$.

Proposition 2: With communications, hybrid traders S_H's optimal strategy is

$a^H(\{+, 0\}, l_0 \in ag^F) = \{L_1, l_0\}$,

$a^H(\{-,0\}\,,\, s_0 \in ag^F) = \{S_1, s_0\},$
$a^H(\{+,0\}\,,\, n_{all} \in ag^F, L_{\widehat{\tau}} \in ag^T) = \{S_{\widehat{\tau}}, l_0\},$
$a^H(\{-,0\}\,,\, n_{all} \in ag^F,\, S_{\widetilde{\tau}} \in ag^T) = \{L_{\widetilde{\tau}}, s_0\},$
$a^H(\{+,0\}\,,\, n_{all} \in ag^F,\, L_{\widehat{\tau}} \notin ag^T\ \forall \widehat{\tau} = 1, \ldots, T) = \{N_{all}, l_0\},$
$a^H(\{-,0\}\,,\, n_{all} \in ag^F,\, S_{\widetilde{\tau}} \notin ag^T\ \forall \widetilde{\tau} = 1, \ldots, T) = \{N_{all}, s_0\}.$

S_H always post l when receiving signal $\{0,+\}$ and post s when receiving signal $\{0,-\}$. And after observing S_F's posts at period 0, S_H attain perfect information about the state.

We can easily show that S_H better off within the group. In the states ω^+ and ω^-, S_H benefit from S_F's informative posts and enter the market earlier than outside the group. And in the state ω^0, with positive probability (on some price paths), S_H make profits from π^* from trading against S_T, where $\pi^* = \lambda q\,(Q_T - Q_F - Q_H) - C$.

Intuition: S_H benefit from both S_F's informative posts and S_T's following behaviors.

Proposition 3: With communications, technical traders S_T trade on both the price path and the posts in the group.

Proof: See Appendix D.

From period 1 on, S_T face similar situations within the group as S_H face outside the group. At period 1, with l posts, S_T can exclude state ω^-; and with s posts, S_T can exclude state ω^+. Then, S_T need to depend on the price path to make their trading decisions.

We can easily show that S_T better off within the group. In the states ω^+ and ω^-, S_T benefit from S_F's informative posts and enter the market earlier than outside the group. Even though in the state ω^0, with positive probability (on some price paths), S_T lose $\pi^* = \lambda q\,(Q_T - Q_F - Q_H) - C$, S_T may lose much more in the state ω^0 when they are outside the group. In short, with more information, S_T cannot worse off.

Intuition: S_T benefit from the informative posts in the group.

The equilibrium can be shown in the following graphs. We describe fundamental traders in Figure 1. Hybrid traders are described in Figures 2 and 3.

[INSERT Figure 1 to 5 HERE]

Technical traders profit in Figure 4, but in Figure 5, hybrid and fundamental traders exploit their lack of information.

3.3 Empirical Implications of the Model

This part summarizes the observable implications in the equilibrium of the model. We have three hypothesis indicated from the equilibrium:

Hypothesis 1. *Skills vs. Posting Behavior: The more skillful a trader is, the lower frequency he/she posts and the more informative his/her posts are.*

In the equilibrium, S_F post only in the states ω^+ and ω^-, while S_H and S_T post in all three states ω^+, ω^- and ω^0. However, S_F's posts should be more informative because they only post what will happen for sure. Thus, when observing the data, we should see that a trader's skill is negatively related with the frequency of his/her post and positively related with the quality of his/her posts. The posts we talk about here, of course, are the posts related with stock trading.

Hypothesis 2. *Skills vs. Following Behavior: The more skillful a trader is, the lower frequency he/she follows others.*

We define the trade after the same direction trade as a following trade. Based on this definition, in the equilibrium, S_F never follow while S_H and S_T follow others in stock picking. Thus, when observing the data, we should see that a trader's skill is negatively related with his/her following frequency.

Hypothesis 3. *Who is Followed: The more skillful a trader is, the higher frequency he/she is followed by others.*

We define the trade followed by a following trade as a "being followed" trade. In the equilibrium, S_F are always followed by S_H immediately while S_H are only followed by S_T if and after the price path confirms S_H's posts. Thus, when observing the data, we should see that a trader's skill is positively related with the number of his/her being followed trades.

4. Data and Environment

The second author collected the posts from the Active Trader Financial Chatroom at sporadic intervals over a four year period from 2000 to 2003. Our sample period is a complete trading month April 2002. The logs contain several interruptions when the chat client froze or when the author neglected to capture the feed. In April 2002, we have 18 trading days of information. Posts are time stamped to the second.

4.1 Posts

The posts contain information about fundamental and technical analysis, trades, and some irrelevant information.

Here is a sample chat log from 10:29 to 10:33 Eastern time on April xx, 2002.

[10:29:44] <TVLTECH> TQNT lower

[10:29:53] <jayluv> it fell a buck when it came out so i think it is

[10:30:10] <mas> gives KLAC a pe over 80

[10:30:37] <Commonman> EFII has pulled in but still looks like a possibility for later

[10:30:47] <El-Kabong> KLAC is esti 17 cents for next Q (june 02')

[10:30:59] <El-Kabong> FWIW

[10:31:56] <locust> ouch

[10:31:57] <locust> DJ Mechanic Fatally Sucked Into Jet's Wing Engine In Japan

[10:32:09] * Targetman Buys SP @ 1122.50

[10:32:32] <taLuis> NASDAQ next support level if 1795-1800 area doesn't hold is 1780-1785

[10:33:26] <Puma_Lunch> QQQ daily remains ugly, under 20day moving average

[10:33:30] <Parlay> stem cell plays look like their biding time, waiting for trigger

[10:33:33] <Connor> 1795 bounce

[10:33:34] * Targetman Covers QCOM @ 38.12 +0.96

We summarize the type of posts, number of posters and frequency in Table 2.

[INSERT Table 2 HERE]

Although day traders trade mostly on technical analysis, those traders did post and use fundamental information in making trading decisions. They analyzed typical fundamental indicators, stock's values, campanies' financial status, CEOs' performances and products' prospects. A typical fundamental post in the example log is ' [10:30:10] <mas> gives KLAC a pe over 80', which talked about PE ratio.

Most posts about stock trading are non-fundamental posts, including technical analysis and price statements mentioning the new updates on the price path. A typical technical analysis is

'[10:32:32] <taLuis> NASDAQ next support level if 1795-1800 area doesn't hold is 1780-1785'; and a typical price statement is '[10:29:44] <TVLTECH> TQNT lower', which is uninformative but repeating the information the price path known to the public.

Traders also post their trades in the chat room, which gives us the information about their real skills. A typical trade post is '[10:33:34] * Targetman Covers QCOM @ 38.12 +0.96', in which the trader 'Targetman' bought QCOM to cover his previous short position.

There are posts totally irrelevant with stock trading, such as ' <locust> ouch' in the sample chat log. However, since there are chatroom administrators who keep the room focus on stock trading withinm trading hours, most irrelevant posts appear after trading hours.

4.2 Trades

We summarize the trading activity for April 2002 in Table 3.

[INSERT Table 3 HERE]

Traders use a wide variety of slang for their trades. We used various forms of the keywords, including their abbreviations and misspelled variants, to indicate buying activity: Accumulate; Add; Back; Buy; Cover; Enter; Get; Grab; In; Into; Load; Long; Nibble; Nip; Pick; Poke; Reload; Take; and Try. Keywords for selling were: Dump; Out; Scalp; Sell; Short; Stop; and Purge.

We cannot match open and closing trades for about 70% of the posts. We assume that all open positions whether long or short are closed at the end of the day. We do not consider after hours trades.

4.3 Profits

To compute dollar profit and losses for each trader, we make transaction cost assumptions for position size assumptions A and B. For position A, we assume a \$20 commission. This is a \$0.02 per share commission on the 1,000 share round trip. Numerous brokers offer commissions in this range. For position size B, we assume a \$0.005 per share commission and a 50 basis point slippage. These reflect the lower commissions typically paid on larger lot sizes, and some market impact on the larger trades. We find that none of the position or transaction costs assumptions has a qualitative impact on our profit estimates.

We examine profits for all trades in Table 3.2. The first profit measure is the aggregate difference between selling and buying prices so the reader can gauge the effect of the transactions costs. The second measure A uses the low cost estimate with flat commissions. The second measure B has higher transactions costs, but sometimes benefits from the larger lot sizes.

In our sample period, more than 50% of traders are profitable under A while 41.38% of the traders are profitable under B. These are much higher ratios of profitable traders found in other studies of retail investors or day traders. This is why we feel comfortable regarding some semi-professional and professional traders as informed traders.

While Anderson, Henker and Owen [2005] find that trading frequency improves relative performance, their sample from an Australian discount broker underperforms the market. The experts in our chat room are "Activetraders" for a good reason; trading, for them, is a profitable activity.

Our traders make money trading both long and short. When we break apart profits short versus long, we find that 74.7% of profits are made trading long and 25.3% short. Trades are equally likely to be profitable long versus short, 53.97% long compared to 56.07% short. The marginal profit per trade is substantially higher on the short side than the long, $210.84 per trade short versus $110.87 long in the pooled sample. Short traders are also more skillful overall. Over the four years, 51.55% of traders who never short are profitable under assumption A, compared with 62.21% for traders who trade both short and long.

For the remainder of this section, we will utilize the more conservative profit assumptions A.

5. Empirical Results

5.1 Hypothesis 1: Skills vs. Posting Behaviors

Our first test of the model is about posting frequency/quality by trader j for the four types of posts: (1) fundamental posts, FP_j;(2) non-fundamental posts, NFP_j;(3) trade posts, TRP_j; (4) irrelevant posts, IRR_j. Trader j's total posts are

$$NP_j = FP_j + NFP_j + TRP_j + IRR_j. \tag{1}$$

H1a tests the posting frequency of fundamental information, FP_j/NP_j, H1b, non-fundamental information, NFP_j/NP_j, H1c, trades, TRP_j/NP_j, and H1d, irrelevant information, IRR_j/NP_j.

We regress our standard skill measure, the profit per trade of trader j

$$\pi_j = \frac{\sum_{t=1}^{Tr_j} \pi_{j,t}}{\sum_{t=1}^{Tr_j} Tr_{j,t}} \tag{2}$$

on the relative frequency of each type of post,

$$FP_j/NP_j = \alpha_{1a} + \beta_{1a}\pi_j, \quad (3)$$

$$NFP_j/NP_j = \alpha_{1b} + \beta_{1b}\pi_j, \quad (4)$$

$$TRP_j/NP_j = \alpha_{1c} + \beta_{1c}\pi_j, \quad (5)$$

$$IRR_j/NP_j = \alpha_{1d} + \beta_{1d}\pi_j. \quad (6)$$

$$NP_j = \alpha_{1e} + \beta_{1e}\pi_j\ . \quad (7)$$

We find stastistically significant results $\beta_{1a} > 0$, $\beta_{1b} < 0$ and $\beta_{1d} > 0$.

.

[INSERT Table 4.1 HERE]

$\beta_{1a} > 0$ shows traders' skills are positively related with their posting frequency of fundamental information. $\beta_{1b} < 0$ shows traders' skills are negatively related with their posting frequency of non-fundamental information. Since Table 2 shows most posts about stocks are non-fundamental information and fundamental information indicates traders' posting quality, $\beta_{1a} > 0$ and $\beta_{1b} < 0$ actually means that the more skillful a trader is, the less he/she discuss stocks in the chat room but the more informative his/her posts are.

Also interesting is $\beta_{1d} > 0$, shows traders' skills are negatively related with their posting frequency of irrelevant information. Since the chat room is administrated to focus on stock discussion during trade hours, most irrelevant information is posted after hour. Therefore, $\beta_{1d} > 0$ means the more skillful a traders is, the more time he/she stay in this chat room after trading hours.

5.2 Hypothesis 2: Skills vs. following behavior

We first test hypothesis H2a: The more skillful a trader is, the less likely will follow others. We regress profits per trade π_j on the following rate, $F_j = TR_j^{(f)}/(TR_j^{(f)} + TR_j^{(nf)})$,

$$F_j = \alpha_{2a} + \beta_{2a}\pi_j\ . \quad (8)$$

We find that β_{2a} is significantly less than zero, consistent with the hypothesis.

[INSERT Table 4.2 HERE]

We next test hypothesis H2b: Do unskilled traders benefit more from following. We consider trades where an unskillful trader $\pi_j < 0$ follows a skilled trader, $\pi_j > 0$. We partition trade profits into following and non-following, $\pi_j = \pi_j^{(f)} + \pi_j^{(nf)}$ and regress total profits on the difference,

$$\pi_j^{(f)} - \pi_j^{(nf)} = \alpha_{2b} + \beta_{2b}\pi_j \ . \tag{9}$$

We find in the second panel of Table 4.2 that $\beta_{2b} < 0$.

$\beta_{2a} < 0$ and $\beta_{2b} < 0$ shows traders' skills are negatively related with their following frequency and their profits from following.

5.3 Hypothesis 3: Who is followed

Hypothesis 3 has two parts. Do skilled traders have more followers and how much do they profit from being followed. We start with H3a. Define the trades and following trades of traders other than j as Tr_{-j} and $Tr_{-j}^{(f)}$, and define the being followed rate,

$$F_{-j} = Tr_j^{(f)}/Tr_{-j} \tag{10}$$

In the first part of this hypothesis,we then regress the skill level on the being followed rate,

$$F_{-j} = \alpha_{3a} + \beta_{3a}\pi_j \ . \tag{11}$$

The results of this regression in Table 4.3

and find that $\beta_{3a} > 0$, indicating strong support of the hypothesis.

H3b then tests whether the skilled traders benefit from having more followers. We repeat regression (9) for the skilled traders,

$$\pi_j^{(f)} - \pi_j^{(nf)} = \alpha_{3b} + \beta_{3b}\pi_j \ . \tag{12}$$

The second panel finds support for this relationship with $\beta_{3b} > 0$.

$\beta_{3a} > 0$ and $\beta_{3b} > 0$ shows traders' skills are positively related with their being-followed rate and their profits from being followed by others.

6. Conclusions and Extensions:

This paper studies individual traders and their communications. An interaction game is built up to explain individual traders' strategic behaviors in an internet stock trading chat room. And we model how comminications influence traders' trading decisions and explain how the chat room is beneficial to all participants, even informed traders. Fundamental traders benefit from trading against technical traders. Hybrid traders benefit from both fundamental traders' informative posts and trading against technical traders. Technical traders benefit from informative posts in the group.

We motivate three empirical results: (1). Less informed traders communicate more often; (2). Both hybrid and technical traders learn from public information about prices; and (3). They optimally follow informed traders. And we do find out that traders have some knowledge of who the skillful traders are and follow more often the more skillful traders, instead of the more active ones.

It is interesting to speculate whether Wall Street is just a large version of the chatroom. For example, large financial institutions are doing two things which skillful traders did in this chat room: (1). building positions before releasing information (see e.g. Mizrach (2005); and (2) taking advantage of reputation as was disclosed in Elliot Spitzer's investigations in 2002.

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Appendix A: The Back (1992) Model

Kyle (1985) studied a market with one informed trader, competitive market makers and noise traders and describes a unique linear equilibrium in which the optimal trading strategy for the informed trader is linear and the efficient pricing rule for market makers is also linear. In the equilibrium, given market makers' information, or say public information, the price path is a martingale, which makes the market semi-strong efficient. Back (1992) solves a continuous-time version of the Kyle model and attain the explicit price paths in equilibrium as solutions with $\widetilde{v}$ following general distributions.

There are one single risk-neutral informed trader, competitive risk-neutral market makers and noise traders with random and price-inelastic demand of risky asset in the market. Assume $\widetilde{v} \sim N(v_0, \sigma_v^2)$ is public information, where v_0 is the initial price of the risky asset at time $t = 0$. Also assume the cumulative trades from noise traders are U_t at time t, and U_t is a Brownian motion with instantaneous variance σ_u^2, i..e $dU_t = \sigma_u^2 dW_t$. According to Back's paper, there exists a linear equilibrium in which market makers' rational pricing rule is $P(y,t) = v_0 + \lambda y$, $dP_t = \lambda dY_t$ and $dY_t = dX_t + dU_t$, and the informed trader's optimal trading strategy is $dX_t = \frac{\widetilde{v} - P_t}{\lambda(\Gamma - t)} dt$, where $\lambda = \sigma_v / \sigma_u$. With a drift $\frac{\widetilde{v} - P_{t-}}{(\Gamma - t_-)}$ and a diffusion $\sigma_v \sigma_u$, the price path can be regarded as a linearly increasing expected value $v_0 + \frac{t}{\Gamma}(\widetilde{v} - v_0)$ plus noise $\varepsilon_t \sim N(0, \sigma_u^2 t)$; and if we divide $[0, \Gamma]$ into T time periods, the price at each period $s = 1, 2, \ldots, T$ is $P_s = v_0 + \frac{s}{T}(\widetilde{v} - v_0) + \varepsilon_t$, where $t = s \cdot \Delta t$.

We can fit our settings of market impacts and the price path into Back's model by simply assuming individual traders, S_F, S_H and S_T, are ignored by the single informed trader. The intuition behind the assumption is that the single informed trader is an institutional trader without any capital limit and ignore individual speculators in the market because of their small trading volume.

Appendix B: Proof of Lemma 2

Case I: S_H receive signal $\{+,0\}$ at period 0.

$$\begin{aligned}
\Pr[\omega^+ \{+,0\}] &= \frac{\Pr[\{+,0\}\,\omega^+]\cdot\Pr[\omega^+]}{\Pr[\{+,0\}\,\omega^+]\cdot\Pr[\omega^+]+\Pr[\{+,0\}\,\omega^0]\cdot\Pr[\omega^0]+\Pr[\{+,0\}\,\omega^-]\cdot\Pr[\omega^-]},\\
&= \frac{1\cdot p}{1\cdot p+\frac{1}{2}\cdot(1-2p)+0},\\
&= 2p,
\end{aligned}$$

and $\Pr[\omega^0\,\{+,0\}] = 1-2p$, $\Pr[\omega^-\,\{+,0\}] = 0$.

Therefore, S_H's expected returns from strategy L_0 is

$$\begin{aligned}
&E[\pi_H\,(L_0)\,\{+,0\}]\\
=\;& \Pr[\omega^+\,\{+,0\}]\cdot\{\widehat{v}-(\lambda qQQ_H+C)\}+\Pr[\omega^0\,\{+,0\}]\cdot\{-(\lambda qQQ_H+C)\}\\
&+\Pr[\omega^-\,\{+,0\}]\,\{-\widehat{v}-(\lambda qQQ_H+C)\}\,,\\
=\;& 2p\widehat{v}-(\lambda qQQ_H+C)\,.
\end{aligned}$$

If $p > \frac{\lambda qQQ_H+C}{2\widehat{v}}$, then $E[\pi_H\,(L_0)|\,\{+,0\}] > 0$; and thus S_H's optimal strategy is L_0;

However, since $p < \frac{C}{2\widehat{v}} < \frac{\lambda qQQ_H+C}{2\widehat{v}}$, S_H should wait (hold 0 position at period $s=0$) and try to attain more information from the price path.

Observing the price P_1 at the beginning of period 1, S_H update their beliefs about the state of the world.

$$\begin{aligned}
&\Pr[\omega^+\,\{+,0\}\,,P_1]\\
=\;& \frac{\Pr[P_1\,\{+,0\}\,,\omega^+]\cdot\Pr[\omega^+\,\{+,0\}]}{\Pr[P_1\,\{+,0\}\,,\omega^+]\cdot\Pr[\omega^+\,\{+,0\}]+\Pr[P_1\,\{+,0\}\,,\omega^0]\cdot\Pr[\omega^0\,\{+,0\}]+\Pr[P_1\,\{+,0\}\,,\omega^-]\cdot\Pr[\omega^-\,\{+,0\}]}\\
=\;& \frac{\Pr[P_1\,\{+,0\}\,,\omega^+]\cdot 2p}{\Pr[P_1\,\{+,0\}\,,\omega^+]\cdot 2p+\Pr[P_1\,\{+,0\}\,,\omega^0]\cdot(1-2p)}
\end{aligned}$$

According to the price path, at period 1, $P_1 = v_0+\frac{1}{T}\widehat{v}+\varepsilon_{\Delta t}$ in state ω^+ and $P_1 = v_0+\varepsilon_{\Delta t}$ in state ω^0, where $\varepsilon_{\Delta t}\sim N(0,\sigma_u^2\cdot\Delta t)$.

Thus, $\Pr[\omega^+\,\{+,0\}\,,P_1]$ can be written as:

$$\begin{aligned}
&\Pr[\omega^+\,\{+,0\}\,,P_1]\\
=\;& \frac{\Pr[\varepsilon_{\Delta t}=P_1-v_0-\frac{1}{T}\widehat{v}\,\{+,0\}\,,\omega^+]\cdot 2p}{\Pr[\varepsilon_{\Delta t}=P_1-v_0-\frac{1}{T}\widehat{v}\,\{+,0\}\,,\omega^+]\cdot 2p+\Pr[\varepsilon_{\Delta t}=P_1-v_0\,\{+,0\}\,,\omega^0]\cdot(1-2p)}\\
=\;& \frac{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p}{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p+\phi\left(\frac{P_1-v_0}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot(1-2p)}
\end{aligned}$$

where $\phi(\cdot)$ is the density function of standard normal distribution and denote

$$\frac{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p}{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p+\phi\left(\frac{P_1-v_0}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot(1-2p)}$$

as φ_{H+}

Therefore, S_H's expected returns from strategy L_1 are

$$\begin{aligned}
& E[\pi_H(L_1)\{+,0\},P_1] \\
= \;& \Pr[\omega^+\{+,0\},P_1]\cdot\left\{\widehat{v}-\frac{1}{T}\widehat{v}-\lambda qQ_H\right\}+\Pr[\omega^0\{+,0\},P_1]\cdot\{-\lambda qQ_H\} \\
= \;& \varphi_{H+}\cdot\left(1-\frac{1}{T}\right)\widehat{v}-(\lambda qQQ_H+C)
\end{aligned}$$

If $E[\pi_H(L_1)\{+,0\},P_1]>0$, i.e. $\varphi_{H+}\cdot\left(1-\frac{1}{T}\right)\widehat{v}>(\lambda qQQ_H+C)$, then S_H's optimal strategy is L_1;

Otherwise, S_H should wait (continue to hold 0 position at period $s=1$) and try to attain more information from the price path.

Such an analysis continues until there comes out the period s^* when $E[\pi_H(L_{s^*})|\{+,0\},\{P_\xi\}_{\xi=0,1,\ldots,s^*-1}]>0$ (strategy L_{s^*}) or it goes to the ending period T (strategy N_{all}).

Here, we need to show *short* is never the optimal strategy when receiving signal $\{+,0\}$. It is easy to show S_H's expected returns from strategy S_s are

$$\begin{aligned}
& E[\pi_H(S_s)\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}] \\
= \;& \Pr[\omega^+\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}]\cdot\left\{-\widehat{v}-\left(-\frac{s}{T}\widehat{v}+\lambda qQQ_H+C\right)\right\} \\
& +\Pr[\omega^0\{+,0\},P_1]\cdot\{-(\lambda qQQ_H+C)\} \\
= \;& -\left(1-\frac{s}{T}\right)\widehat{v}\cdot\Pr[\omega^+\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}]-(\lambda qQQ_H+C)<0
\end{aligned}$$

Thus, receiving signal $\{+,0\}$, S_H never adopts the strategy S_s because $E[\pi_H(S_s)\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}]<0$ $\forall s=0,1,\ldots,T$.

Case II: S_H receive signal $\{-,0\}$ at period 0.

Similarly, $\Pr[\omega^-\{-,0\}]=2p$, $\Pr[\omega^0|\{-,0\}]=1-2p$ and $\Pr[\omega^+|\{-,0\}]=0$. Thus, $E[\pi_H(S_0)\{-,0\}]=2p\widehat{v}-(\lambda qQQ_H+C)$.

If $p>\frac{(\lambda qQQ_H+C)}{2\widehat{v}}$, S_H's optimal strategy is S_0; However, since $p<\frac{C}{2\widehat{v}}<\frac{(\lambda qQQ_H+C)}{2\widehat{v}}$, S_H should wait to observe price P_1.

Since $P_1=v_0-\frac{1}{T}\widehat{v}+\varepsilon_{\Delta t}$ in state ω^- and $P_1=v_0+\varepsilon_{\Delta t}$ in state ω^0, where $\varepsilon_{\Delta t}\sim N(0,\sigma_u^2\cdot\Delta t)$.

$$
\begin{aligned}
&\Pr[\omega^{-}\{-,0\},P_1] \\
= &\frac{\Pr[\varepsilon_{\Delta t}=P_1-v_0+\frac{1}{T}\widehat{v}\{-,0\},\omega^{-}]\cdot 2p}{\Pr[\varepsilon_{\Delta t}=P_1-v_0+\frac{1}{T}\widehat{v}\{-,0\},\omega^{-}]\cdot 2p+\Pr[\varepsilon_{\Delta t}=P_1-v_0\{-,0\},\omega^{0}]\cdot(1-2p)} \\
= &\frac{\phi\left(\frac{P_1-v_0+\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p}{\phi\left(\frac{P_1-v_0+\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p+\phi\left(\frac{P_1-v_0}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot(1-2p)}
\end{aligned}
$$

denote

$$
\frac{\phi\left(\frac{P_1-v_0+\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p}{\phi\left(\frac{P_1-v_0+\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p+\phi\left(\frac{P_1-v_0}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot(1-2p)}
$$

as φ_{H-}.

Thus, S_H's expected returns from strategy S_1 are

$$
\begin{aligned}
&E[\pi_H(S_1)\{-,0\},P_1] \\
= &\varphi_{H-}\left(1-\frac{1}{T}\right)\widehat{v}-(\lambda qQQ_H+C)
\end{aligned}
$$

If P_1 can satisfy $\varphi_{H-}\left(1-\frac{1}{T}\right)\widehat{v}>(\lambda qQQ_H+C)$, then S_H's optimal strategy is S_1. Otherwise, S_H should wait to see the price P_2.

Such an analysis continues until there comes out the period s' when $E[\pi_H(S_{s'})\{-,0\},\{P_\varsigma\}_{\xi=0,1,\ldots,s'-1}]>0$ (strategy $S_{s'}$) or it goes to the ending period T (strategy N_{all}).

Here, we also need to show *long* is never the optimal strategy when receiving signal $\{-,0\}$.

S_H's expected returns from strategy L_s are

$$
\begin{aligned}
&E[\pi_H(L_s)\{-,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}] \\
= &-\left(1-\frac{s}{T}\right)\widehat{v}\cdot\Pr[\omega^{+}\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}]-(\lambda qQQ_H+C)<0
\end{aligned}
$$

Thus, receiving signal $\{-,0\}$, S_H never adopt the strategy L_s because $E[\pi_H(L_s)\{+,0\},\{P_\tau\}_{\tau=0,1,\ldots,s-1}]<0\ \forall s=0,1,\ldots,T$.

Appendix C: Proof Lemma 3

S_T receive uninformed signal $\{+,0,-\}$ at time $t=0$. $\Pr[\omega^+ \{+,0,-\}] = p$, $\Pr[\omega^0 \big| \{+,0,-\}] = 1-2p$, $\Pr[\omega^- \{+,0,-\}] = p$.

Thus, S_T's expected return from strategy L_0 is $E[\pi_T(L_0)\{+,0,-\}] = -(\lambda qQQ_T + C)$ and S_T's expected return from strategy S_0: $E[\pi_T(L_0)\{+,0,-\}] = -(\lambda qQQ_T + C)$.

Since $E[\pi_T(L_0)\{+,0,-\}] < 0$ and $E[\pi_T(L_0)\{+,0,-\}] < 0$, S_T should wait (hold 0 position at period $s=0$) and try to attain more information from the price path.

Observing the price P_1 at the beginning of period 1, S_T update their beliefs about the state of the world.

Since $P_1 = v_0 + \frac{1}{T}\widehat{v} + \varepsilon_{\Delta t}$ in state ω^+, $P_1 = v_0 - \frac{1}{T}\widehat{v} + \varepsilon_{\Delta t}$ in state ω^- and $P_1 = v_0 + \varepsilon_{\Delta t}$ in state ω^0, where $\varepsilon_{\Delta t} \sim N(0, \sigma_u^2 \cdot \Delta t)$, $\Pr[\omega^+ \{+,0,-\}, P_1]$ and $\Pr[\omega^- \{+,0,-\}, P_1]$ are

$$\begin{aligned} &\Pr[\omega^+ \{+,0,-\}, P_1] \\ = &\frac{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p}{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot (1-2p) + \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p} \\ &\Pr[\omega^- \{+,0,-\}, P_1] \\ = &\frac{\phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p}{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot (1-2p) + \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p} \end{aligned}$$

where $\phi(\cdot)$ is the density function of standard normal distribution.

So, S_T's expected returns from strategy L_1 are

$$\begin{aligned} &E[\pi_T(S_1)\{+,0,-\}, P_1] \\ = &\frac{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p - \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p}{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot (1-2p) + \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p} \\ &\times \left(1 - \frac{1}{T}\right)\widehat{v} - (\lambda qQQ_T + C) \end{aligned}$$

And S_T's expected returns from strategy S_1 are

$$\begin{aligned} &E[\pi_T(S_1)\{+,0,-\}, P_1] \\ = &\frac{\phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p - \phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p}{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot (1-2p) + \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right)\cdot p} \\ &\times \left(1 - \frac{1}{T}\right)\widehat{v} - (\lambda qQQ_T + C) \end{aligned}$$

Denote

$$\varphi_T = \frac{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot p - \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot p}{\phi\left(\frac{P_1 - v_0 - \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot (1 - 2p) + \phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot p} \left(1 - \frac{1}{T}\right) \widehat{v}.$$

If P_1 can satisfy $E[\pi_T(L_1)\{+,0,-\}, P_1] > 0$, i.e. $\varphi_T > \lambda q Q Q_T + C$, then S_T's optimal strategy is L_1; If P_1 can satisfy $E[\pi_T(S_1)\{+,0,-\}, P_1] < 0$, i.e. $\varphi_T < -(\lambda q Q Q_T + C)$, then S_T's optimal strategy is S_1;

Otherwise, S_T should wait (continue to hold 0 position at period $s = 1$) and try to attain more information from the price path.

Such an analysis continues until there comes out the period s^* when $E[\pi_T(L_{s^*})\{+,0,-\}, \{P_\xi\}_{\xi=0,1,\ldots,s^*-1}] > 0$ (strategy L_{s^*}) or there comes out the period s' when $E[\pi_T(S_{s'})\{+,0,-\}, \{P_\varsigma\}_{\xi=0,1,\ldots,s'-1}] > 0$ (strategy $S_{s'}$) or it goes to the ending period T (strategy N_{all}).

Appendix D: Proof of Proposition 3

Case I: S_T observe l posts at period 0.

$$\begin{aligned}
\Pr[\omega^+ l] &= \frac{\Pr[l\omega^+]\cdot\Pr[\omega^+]}{\Pr[l\omega^+]\cdot\Pr[\omega^+]+\Pr[l\omega^0]\cdot\Pr[\omega^0]+\Pr[l\omega^-]\cdot\Pr[\omega^-]} \\
&= \frac{1\cdot p}{1\cdot p+\frac{1}{2}\cdot(1-2p)+0} \\
&= 2p
\end{aligned}$$

and $\Pr[\omega^0 \middle| l]=1-2p$, $\Pr[\omega^- | l]=0$.

Also observing the price P_1 at period 1, S_T's beliefs about the state of the world are

$$\begin{aligned}
&\Pr[\omega^+ l, P_1] \\
&= \frac{\Pr[P_1 l,\omega^+]\cdot\Pr[\omega^+ l]}{\Pr[P_1 l,\omega^+]\cdot\Pr[\omega^+ l]+\Pr[P_1 l,\omega^0]\cdot\Pr[\omega^0 l]+\Pr[P_1 l,\omega^-]\cdot\Pr[\omega^- | l]} \\
&= \frac{\Pr[P_1 l,\omega^+]\cdot 2p}{\Pr[P_1 l,\omega^+]\cdot 2p+\Pr[P_1 l,\omega^0]\cdot(1-2p)} \\
&= \frac{\Pr[\varepsilon_{\Delta t}=P_1-v_0-\frac{1}{T}\widehat{v}l,\omega^+]\cdot 2p}{\Pr[\varepsilon_{\Delta t}=P_1-v_0-\frac{1}{T}\widehat{v}l,\omega^+]\cdot 2p+\Pr[\varepsilon_{\Delta t}=P_1-v_0 l,\omega^0]\cdot(1-2p)} \\
&= \frac{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p}{\phi\left(\frac{P_1-v_0-\frac{1}{T}\widehat{v}}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot 2p+\phi\left(\frac{P_1-v_0}{\sigma_u\cdot\sqrt{\Delta t}}\right)\cdot(1-2p)}=\varphi_{H+}
\end{aligned}$$

where $\phi(\cdot)$ is the density function of standard normal distribution.

Therefore, S_T's expected returns from strategy L_1 are

$$\begin{aligned}
&E[\pi_T(L_1)\, l, P_1] \\
&= \Pr[\omega^+ l, P_1]\cdot\left\{\widehat{v}-\frac{1}{T}\widehat{v}-(\lambda q Q_T+C)\right\}+ \\
&\quad \Pr[\omega^0 l, P_1]\cdot\{-\lambda q(Q_T-Q_H-Q_F)-C\} \\
&= \varphi_{H+}\left(1-\frac{1}{T}\right)\widehat{v}-(\lambda q Q_x+C)
\end{aligned}$$

where $Q_x=\varphi_{H+}\cdot\lambda q Q_T+\lambda q(Q_T-Q_H-Q_F)$ which is unknown to S_T, but S_T can make decisions by knowing $Q_x<QQ_T$.

If $E[\pi_H(L_1)|\, l, P_1]>0$, i.e. $\varphi_{H+}\left(1-\frac{1}{T}\right)\widehat{v}>(\lambda qQQ_x+C)$, then S_T's optimal strategy is L_1; Otherwise, S_H should wait (continue to hold 0 position at period $s=1$) and try to attain more information from the price path.

Such an analysis continues until there comes out the period s^* when $E[\pi_T(L_{s^*})|\, l,\{P_\xi\}_{\xi=0,1,\ldots,s^*-1}]>0$ (strategy L_{s^*}) or it goes to the ending period T (strategy N_{all}).

Here, we need to show *short* is never the optimal strategy when observing l posts. It is easy to show S_T's expected returns from strategy S_s are

$$
\begin{aligned}
& E[\pi_T\left(S_s\right) l, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] \\
= \ & \Pr[\omega^+ l, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] \cdot \left\{-\widehat{v} - \left(-\frac{s}{T}\widehat{v} + \lambda q Q_T + C\right)\right\} + \Pr[\omega^0 l, P_1] \cdot \{-\lambda q Q_T - C\} \\
= \ & -\left(1 - \frac{s}{T}\right)\widehat{v} \cdot \Pr[\omega^+ \{+,0\}, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] - (\lambda q Q_T + C) < 0
\end{aligned}
$$

Thus, observing l posts at period 0, S_T never short because $E[\pi_T\left(S_s\right) l, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] < 0$ $\forall s = 0, 1, \ldots, T$.

Case II: S_T observe s posts at period 0.

Similarly, $\Pr[\omega^- s] = 2p$, $\Pr[\omega^0 s] = 1 - 2p$ and $\Pr[\omega^+ s] = 0$. Since $P_1 = v_0 - \frac{1}{T}\widehat{v} + \varepsilon_{\Delta t}$ in state ω^- and $P_1 = v_0 + \varepsilon_{\Delta t}$ in state ω^0, where $\varepsilon_{\Delta t} \sim N(0, \sigma_u^2 \cdot \Delta t)$.

$$
\begin{aligned}
& \Pr[\omega^- s, P_1] \\
= \ & \frac{\Pr[\varepsilon_{\Delta t} = P_1 - v_0 + \frac{1}{T}\widehat{v} s, \omega^-] \cdot 2p}{\Pr[\varepsilon_{\Delta t} = P_1 - v_0 + \frac{1}{T}\widehat{v} s, \omega^-] \cdot 2p + \Pr[\varepsilon_{\Delta t} = P_1 - v_0 s, \omega^0] \cdot (1 - 2p)} \\
= \ & \frac{\phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot 2p}{\phi\left(\frac{P_1 - v_0 + \frac{1}{T}\widehat{v}}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot 2p + \phi\left(\frac{P_1 - v_0}{\sigma_u \cdot \sqrt{\Delta t}}\right) \cdot (1 - 2p)} = \varphi_{H-}
\end{aligned}
$$

Thus, S_T's expected returns from strategy S_1 are

$$
E[\pi_H\left(S_1\right) s, P_1] = \varphi_{H-}\left(1 - \frac{1}{T}\right)\widehat{v} - \{\lambda q Q_y + C\}
$$

where $Q_y = \varphi_{H-} \cdot \lambda q Q_T + \lambda q \left(Q_T - Q_H - Q_F\right)$ which is unknown to S_T, but S_T can make decisions by knowing $Q_y < Q Q_T$.

If P_1 can satisfy $\varphi_{H-}\left(1 - \frac{1}{T}\right)\widehat{v} > (\lambda q Q_y + C)$, then S_H's optimal strategy is S_1; Otherwise, S_H should wait to see the price P_2.

Such an analysis continues until there comes out the period s' when $E[\pi_T\left(S_{s'}\right)\{-,0\}, \{P_\varsigma\}_{\xi=0,1,\ldots,s'-1}] > 0$ (strategy $S_{s'}$) or it goes to the ending period T (strategy N_{all}).

Here, we also need to show *long* is never the optimal strategy when observing s posts. S_T's expected returns from strategy L_s are

$$
\begin{aligned}
& E[\pi_T\left(L_s\right) s, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] \\
= \ & -\left(1 - \frac{s}{T}\right)\widehat{v} \cdot \Pr[\omega^+ s, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] - (\lambda q Q_T + C) < 0
\end{aligned}
$$

Thus, observing s posts, S_T never short because $E[\pi_T\left(L_s\right) s, \{P_\tau\}_{\tau=0,1,\ldots,s-1}] < 0 \ \forall s = 0, 1, \ldots, T$.

Table 1			
Trader i	Signal θ_i at $t = 0$		
	state ω^+ $\widetilde{v}=v_0+\widehat{v}$	state ω^- $\widetilde{v}=v_0-\widehat{v}$	state ω^0 $\widetilde{v}=v_0$
S_F	$\{+\}$	$\{-\}$	$\{0\}$
S_H	$\{0,+\}$	$\{0,-\}$	$\left\{ \begin{array}{c} \{0,+\} \text{ with prob } \frac{1}{2} \\ \{0,-\} \text{ with prob } \frac{1}{2} \end{array} \right\}$
S_T	$\{+,0,-\}$	$\{+,0,-\}$	$\{+,0,-\}$

Table 2
Summary of Posts and Posters

Number of posts	55,393
Fundamental	1,531
Non-fundamental	12,915
Trades	1,751
Irrelevant	39,196
Positive Posts	5,337
Negative Posts	3,577
Posts appreciating others	428
Number of Posters	1,027

NOTES: This is from Activetrader April 2002. Trade estimates are from Mizrach and Weerts (2006).

Table 3
Summary of Trades and Traders

Number of trades	1,133
Long	823
Short	310
Round Trips	238
Non Round Trips	895
Holding Time (minutes)	161.28
Non Round Trips	188.45
Round Trips	59.10
Traders	145
Issues Traded	256
Nasdaq	203
NYSE	53
Profits	
Overall	$73,532.00
Profit Per Trade	$44.88
% Profitable	51.03%

NOTES: Source Mizrach and Weerts (2006).

Table 4.1
Test of Hypothesis 1

Hypothesis	Sample	F/All	NF/All	T/All	Irr/All	All	R^2
H1a	1	0.011 (1.97)					10%
H1b	1		-0.089 (-2.37)				11%
H1c	1			-0.009 (-0.56)			1%
H1d	1				0.088 (1.91)		8%
H1e	1					-31.4 (-0.27)	0

NOTES: Sample 1: eliminates all traders with not more than 1 trade or with not more than 10 posts or with 0 fundamental/non-fundamental/irrelevant post and also trim one trader with extreme low profit.

Table 4.2
Test of Hypothesis 2

Hypothesis	Sample	5m Following Rate	5m:f π - non f π	R^2
H2a	2	-0.232 (-2.63)		27%
H2b	2		-1.63 (-5.43)	61%

NOTES: Sample 2 eliminates the traders who never follow others and four traders with extreme high/low profits in Sample 1.

Table 4.3
Test of Hypothesis 3

Hypothesis	Sample	5m bF Ratio	5m:bf π - non bf π	R^2
H3a	3	0.618 (10.44)		72%
H3b	3		0.273 (2.32)	11%

NOTES: Sample 3 eliminates four traders with extreme high/low profits in Sample A.

Figure 1
Fundamental Traders Timeline

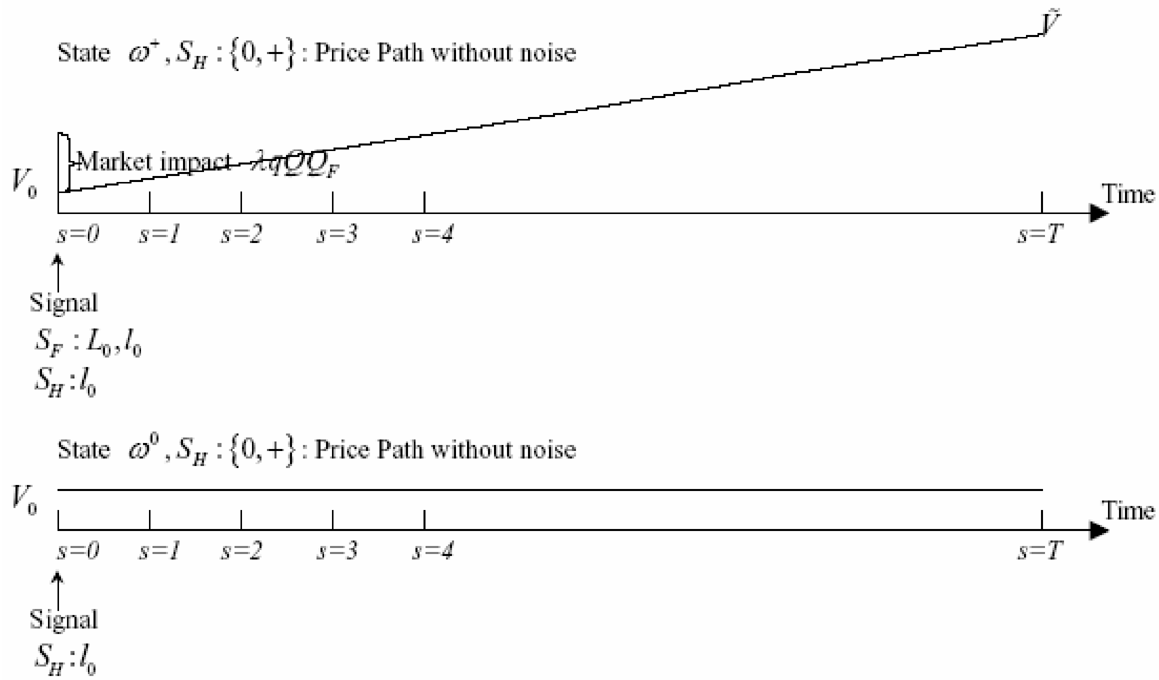

Figure 2
Hybrid Traders Timeline: Period 0

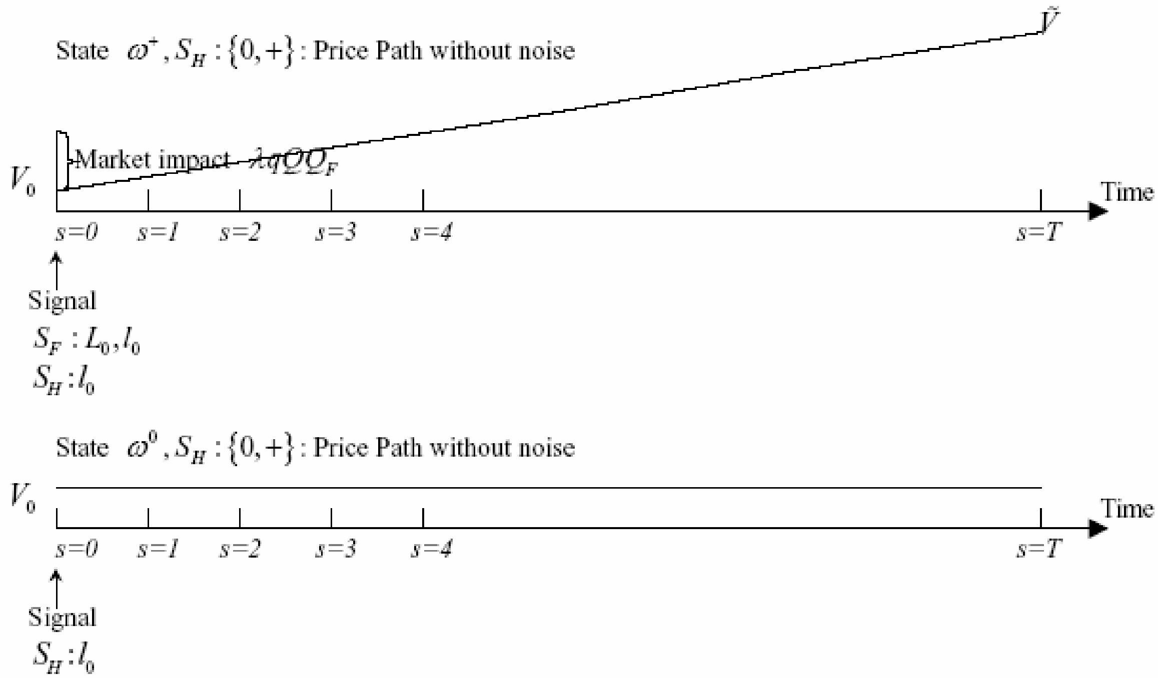

Figure 3
Hybrid Traders Timeline: Period 1

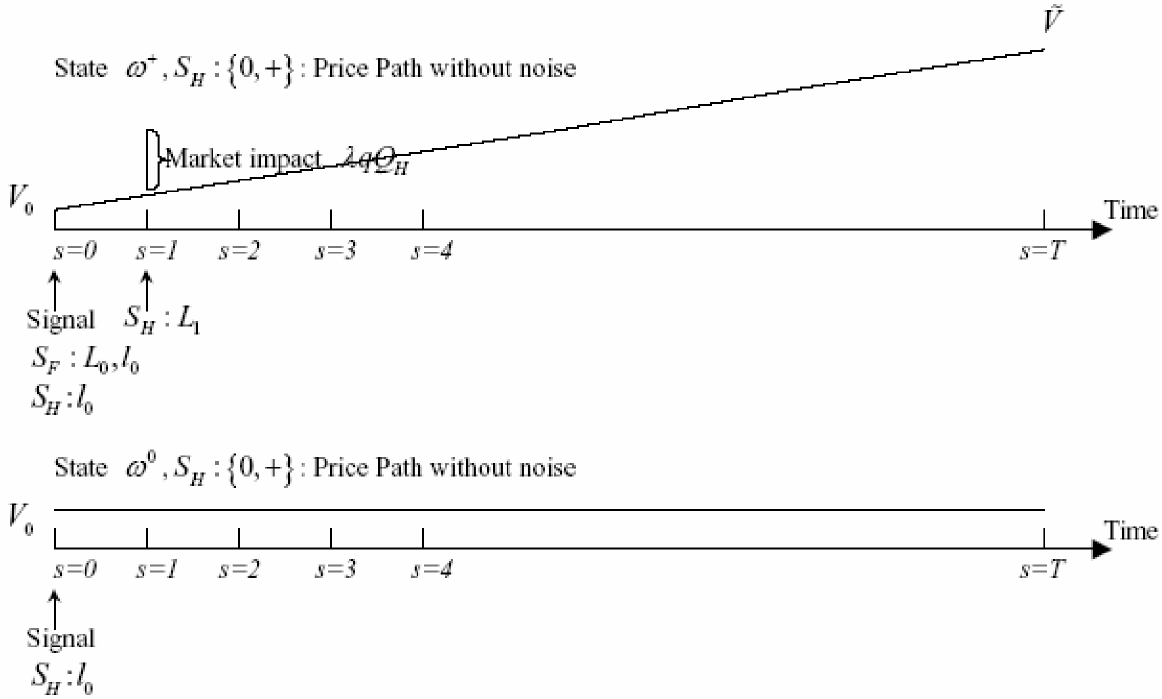

Figure 4
Technical Traders Timeline: Period τ

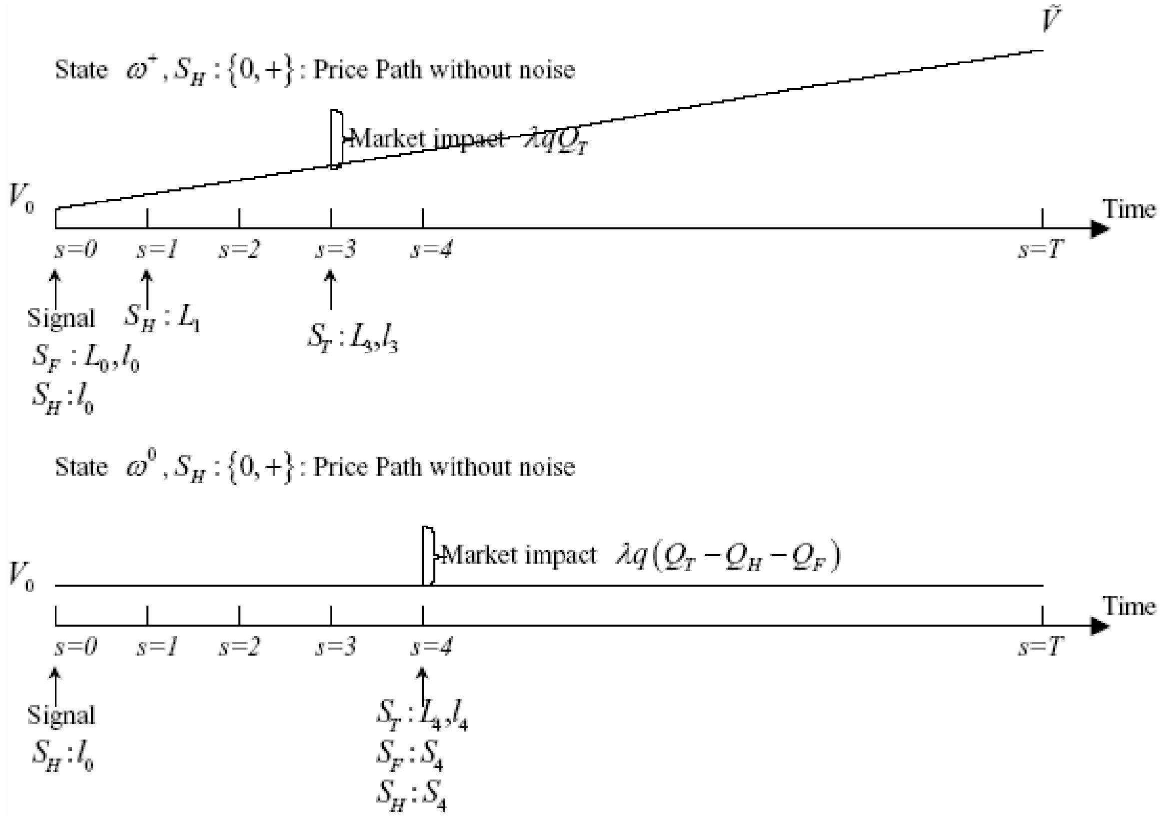

Figure 5
Trading Against the Technical Traders: Period τ