2004

Strategic trading against retail investors with disposition effects

Jouahn Nam
Pace University

Jun Wang
Baruch College

Ge Zhang
University of New Orleans

Strategic Trading against Retail Investors with Disposition Effects

Jouahn Nam, Jun Wang and Ge Zhang*

Abstract

In this paper, we study a model incorporating the retail trader's reluctance to sell into losses. We show that in this setup the informed trader always buys the asset when he receives a favorable signal. However, when the informed trader receives an unfavorable signal, he may not always sell the asset if the signal is moderately bad and the retail trader is reluctant to realize losses. Hence the good news travels faster than the bad news and the asset price exhibits steady climbs with sharp and sudden drops.

Keywords: Disposition effect, retail investors, strategic trading.

JEL classification: G10.

---

*Nam is from Lubin School of Business, Pace University, New York, NY, 10038. phone: (212) 346-1818, email: jnam@pace.edu. Wang is from Department of Economics and Finance, Baruch College, One Bernard Baruch Way, Box B10-225 New York, NY 10010 phone: (646) 312-3507, fax: (646) 312-3451, email: jun_wang@baruch.cuny.edu. Zhang is from Department of Economics and Finance, College of Business Administration, University of New Orleans, New Orleans, LA 70148. Tel: (504) 280-6096, email: gzhang@uno.edu.
We would like to thank John Graham and Pete Kyle for many helpful comments. All errors are ours.

Strategic Trading against Retail Investors with Disposition Effects

Abstract

In this paper, we study a model incorporating the retail trader's reluctance to sell into losses. We show that in this setup the informed trader always buys the asset when he receives a favorable signal. However, when the informed trader receives an unfavorable signal, he may not always sell the asset if the signal is moderately bad and the retail trader is reluctant to realize losses. Hence the good news travels faster than the bad news and the asset price exhibits steady climbs with sharp and sudden drops.

Keywords: Disposition effect, retail investors, strategic trading.

JEL classification: G10.

1 Introduction

In the past several years, the Internet has transformed the way many individual investors invest their money. Using the Internet, the individual investors have gained easy access to real time stock quote and market information. The low transaction costs offered by the online brokerage firms enable more investors to trade on their own with minimal cost. The following paragraph is an excerpt from the SEC filing document about the second quarter 2000 of E*Trade Group, one of the largest online brokerage firms catering to individual investors.

> Brokerage transactions for the second quarter of fiscal 2000 totaled 14.2 million, or an average of 226,100 transactions per day. This is an increase of 220% over the average daily brokerage transaction volume of 70,200 in the prior year.

Note that the year over year growth of transaction volume is over 200%. This boom of online stock trading is evidence that retail investors are playing an increasingly important role in the market. Especially in the trading of internet stocks, while many professional traders shy away from some extremely volatile stocks, retail investors play a dominant role in the trading of these stocks.

In most of the microstructure literature, retail investors are usually treated as noise traders and they are assumed to provide market liquidity by submitting orders of random sizes. However, there is evidence suggesting that the trading activities of retail investors are not completely random. Several regularities of their trading activities exist. One of the predominant regularities of the retail investors' trading behavior is the reluctance to sell assets below their purchase price, or "losers". This effect is called disposition effect. The reason for such reluctance is more related to psychology than to economics. As selling into losses is like admitting a prior mistake, people have a natural tendency to avoid such action. Odean (1998) provides evidence that individual investors tend to sell winners too early and hold losers too long. In several laboratory studies, people become more risk averse after prior losses and less risk averse after prior gains (See Thaler and Johnson 1990, Gertner 1993). Barberis, Huang, and Santos (2001) incorporate reluctance to sell into losses in the representative agent's utility function and study the implication for asset dynamics.

In this paper, we provide a model to study the effect of retail investors' reluctance to sell into losses on the trading strategies of informed traders. We show that when the market is dominated by retail investors who are unwilling to realize losses, informed traders may not trade as aggressively with bad signals as they would in a market made up with regular noise traders. When informed traders receive good signals, they simply act on the signals and buy shares. The price increases following their trade but the rise in price does not affect the trading behavior of retail investors. When informed traders receive bad signals, they have to consider two effects from selling shares. Selling shares always drags down the price but not to the full extent of bad signals informed traders receive. When informed traders sell shares in the early period, they capture the profit of selling right away. However, the price decrease makes retail traders reluctant to sell in the later period. This effect reduces the liquidity in the later period and reduces the trading profit of informed traders in the future. When the initial signal is moderately bad, the loss in trading profit from lost liquidity outweighs the early trading gain. Thus informed traders are less aggressive in trading on bad news.

Because informed traders are more likely to refrain from selling after receiving bad information, bad news will travel slowly in these markets. In contrast, good news is not held back by informed traders. When firms are in the early growth stage, information is quite noisy. Then informed traders sell only when the early information is really bad but they buy when the news is marginally good. Hence in these markets, good news travel faster than bad news. In this case we provide one explanation on the assumption made by Hong, Lim, and Stein (2000). As for the price patterns, these markets are likely to have long steady climbs with sharp drops because the informed trader chooses to refrain from selling until the last possible minute. Because the volume during the increase consists of trading volume contributed by informed traders and retail investors, and retail investors are reluctant to sell if the price drops, the volume during the price increase is likely to be higher than the volume during the price drop.

This paper is related to many studies that attempt to explain asset dynamics using behavior models, for example, Barberis, Shleifer and Vishny (1998), Danial, Hirshleifer and Subrahmanyam (1998), Hong and Stein (1999), etc. We study how one common behavior bias, reluctance to sell losses, can effect the asset price dynamics.

The paper is organized as follows: Section 2 describes the model and Section 3 shows equilibria in this model. Section 4 provides some discussions. Section 5 concludes the paper.

2 Model setup

Consider a two period economy with one traded asset. This asset generates a dividend at the end of period 2 and the dividend can be one of the two values, D or 0, $(D > 0)$. At the beginning of the first period, the market consensus is that the probability of dividend being D is δ_0. The market consists of one trader and one market maker. In each period, the trader can buy one unit of the asset, sell one unit of the asset, or not trade. The trader is an informed trader with probability μ and a retail trader with probability $1-\mu$.[1] One can also consider this model as one market maker dealing with many traders. In each period, one of the traders is selected randomly to trade. In this case, μ represents the percentage of informed traders and $1-\mu$ is the percentage of noise traders.

[1]Easley, O'Hara and Srinivas (1998) adopts a similar structure to study in which market informed traders trade, equity market or derivative market.

Before submitting an order in each period, the informed trader observes a signal. In period 1, the signal indicates the asset is in one of two states, H or L. In state H, the probability of a positive dividend is δ_H and in state L, the probability of a positive dividend is δ_L. We assume that $\delta_H > \delta_0 > \delta_L$. Ex ante, the probability of state H occurring is β and the probability of state L occurring is $1-\beta$. In period 2, the informed trader observes the dividend value before he submits an order. The informed trader is risk neutral and he attempts to maximize his expected trading profit in both periods. Assuming the discount factor of the informed trader is 1, maximizing the expected trading profit in both periods is equivalent to maximizing the sum of the two-period trading profit. In addition, The state is revealed to the market maker at the end of period 1 and the dividend of the asset is revealed at the end of period 2.[2]

The retail trader trades for liquidity or hedging reasons. In period 1, he issues a buy order with probability λ and a sell order with probability γ, ($\lambda > 0$, $\gamma > 0$, $\lambda + \gamma < 1$). To capture the reluctance of retail investors to sell into losses, we assume that in period 2 the retail trader issues a buy order with the same probability λ but a sell order with probability $\alpha\gamma$. If the period 1 price of the asset does not decrease, $\alpha = 1$, otherwise, $\alpha \leq 1$. This α is a coefficient to model the retail trader's willingness to sell into losses. As the retail trader only observes asset prices, this α depends only on the price history of the asset.

The market maker is risk neutral and competitive.[3] He does not know whether the trader is an informed trader or a retail trader, but he knows the probability μ that a trader is an informed trader. He does not observe the signal the informed traders observes in period 1. Instead, he knows the distribution of the two states. In each period, the market maker sets the price of the asset after he observes the trade order, but before any information is revealed. Because

[2]If the state is not revealed in the market at the end of period 1, the main results of this model still hold although the derivation is more complicated. See discussion in Section 4.

[3]Like most of the works in this area, the role of the market maker here is to set the market price of the asset. One can consider there are many market makers competing against each other for the order flow and this is consistent with the practice at NYSE and NASDAQ.

the market maker is risk-neutral and competitive, he sets the price of the asset equal to the expected value of the asset. This trading setup is similar to Glosten and Milgrom (1985) and is widely used in the microstructure literature. Figure 1 sketches the timeline of this model and Table 1 lists the parameters described above.

3 Equilibria

We concentrate on perfect Bayesian equilibria of this game. First define the following notation: x is the trading choice of the trader and it can take three values, b, buy one unit of asset, s, sell one unit of asset, and, n, not trade. In order to accommodate mixed strategy, we define $\Pi_t = (\pi_t^b, \pi_t^n, \pi_t^s), t \in \{1,2\}$ as the probability weights at time t that the informed trader assigns to the three available trading strategies in the equilibrium. If the informed trader adopts a pure strategy, then he assigns a probability weight of 1 to the strategy he selects and 0 to other strategies. The informed trader needs to select a strategy for all the possible states, therefore his strategy space is then $\{\Pi_1(\delta_H), \Pi_1(\delta_L), \Pi_2(1), \Pi_2(0)\}$, where $\Pi_t(\delta)$ is his time t strategy given his private information about the probability of high dividend state, δ.

For the market maker, let $\omega_1(x_1)$ be his belief of the informed trader's strategy in period 1 given order x_1. Let $\omega_2(x_1, x_2, \delta)$ be his belief of the informed trader's strategy in period 2 given the trader's order of x_1 in period 1 and x_2 in period 2, and the revealed probability of the high dividend state, δ. Let $p_1(x_1)$ be the period 1 price of the asset given trader's order x_1. Let $p_2(x_1, x_2, \delta)$ be the period 2 price of the asset given the trader's order of x_1 in period 1 and x_2 in period 2, and the revealed probability of the high dividend state, δ. Note that since the state is revealed at the end of period 1, the order of the informed trader in period 1 does not affect how the market maker prices the asset in period 2 directly. But it has an indirect effect. The trading order may depress the price in period 1 and hence cause the retail trader to be less willing to sell in period 2. The market maker takes this effect into account when valuing the asset in period 2.

Because the retail trader is not strategic in his trading decision, we define the equilibrium based on the strategies and beliefs of the informed trader and market maker.

Definition. *A* Perfect Bayesian Equilibrium *is a triple consisting of informed trader strategies,* $\{\Pi_1(\delta_H), \Pi_1(\delta_L), \Pi_2(1), \Pi_2(0)\}$*; market maker pricing strategies,* $\{p_1(x_1),\, p_2(x_1, x_2, \delta)\}$*; and beliefs,* $\{\omega_1(x_1), \omega_2(x_1, x_2, \delta)\}$ *such that*

- *(sequential rationality — informed trader) Any strategy at time 1 (time 2) to which the informed trader assigns a positive probability weight maximizes his payoff from time 1 (time 2) given the trading strategy and belief of the market maker.*
- *(perfect competition — market maker) The pricing strategy of the market maker ensures that he earns zero expected profit given his belief.*
- *(belief consistency) The market maker's belief is consistent with the informed trader's strategy whenever possible.*

3.1 Equilibrium strategies in period 2

We first determine the trading strategy of the informed trader and the pricing strategy of the market maker in period 2. The informed trader observes the dividend of the asset. Suppose the informed trader follows the strategy to issue a buy order when he observes the dividend to be D and to issue a sell order when he observes the dividend to be 0. Belief consistency requires that the market maker expect the trading strategy of the informed trader. When the market maker observes a buy order, he knows that the order comes from either an informed trader who knows that the dividend is D or a retail trader who does not have any new information. If the buy order comes from an informed trader, the dividend of the asset must be D. The probability of such event is the probability of an informed trader μ multiplied by the probability of high dividend, δ, which is revealed at the end of period 1. If the order is from a retail trader, there is no information content of the trade. The value of the asset is determined by the revealed state, δD. The probability of such event is the probability of a retail trader $(1-\mu)$ multiplied by the probability of a retail trader issuing a buy order λ. Hence the market maker sets the period 2 price of the asset given a buy order as

$$p_2(x_1, b, \delta) = \frac{\mu\delta D + (1-\mu)\lambda(\delta D)}{\mu\delta + (1-\mu)\lambda}. \tag{1}$$

If the trade is a sell order, the market maker expects that with unconditional probability $\mu(1-\delta)$ the order comes from an informed trader who observes the dividend is 0. With unconditional probability $(1-\mu)\alpha\gamma$, the order is from a retail trader and no more information is extracted. In this case, the market maker sets the period 2 price of the asset given a sell order as

$$p_2(x_1, s, \delta) = \frac{(1-\mu)\alpha\gamma(\delta D)}{\mu(1-\delta) + (1-\mu)\alpha\gamma}. \tag{2}$$

Note that because of the presence of retail trader, the market maker will never price the asset outside the range of $[0, D]$. Hence it is always optimal for the informed trader to issue a buy order when he observes the dividend to be D and to issue a sell order when he observes the dividend to be 0. Any other strategy is not optimal to the informed trader. Hence the above strategies and beliefs constitute an equilibrium for period 2.

Lemma 1. *In period 2, the informed trader plays the pure strategy of issuing a buy order when he observes the dividend to be D and a sell order when he observes the dividend to be 0. The market maker holds the belief that the informed trader play such a strategy and selects the pricing functions as in Equations (1) and (2).*

3.2 Equilibrium strategies in period 1

Because the discount factor of the informed trader is 1, the informed trader makes his trading decision to maximize his expected profit for both periods, or equivalently, he maximizes the sum of trading profit in both periods. The expected profit of an informed trader given order x_1 and the probability of high dividend state δ is given as follows:

$$W_1(x_1,\delta) = [\delta D - p_1(x_1)]S(x_1) + \delta[D - p_2(x_1,b,\delta)] + (1-\delta)p_2(x_1,s,\delta) \tag{3}$$

where $S(x_1)$ is a sign function of x_1 defined as

$$S(x_1) = \begin{cases} 1 & \text{if} \quad x_1 = b \\ 0 & \text{if} \quad x_1 = n \\ -1 & \text{if} \quad x_1 = s \end{cases} . \tag{4}$$

The first term of the right hand side of Equation (3) is the expected trading profit when the informed trader buys or sells the asset in period 1. The expected value of one share is δD and $p_1(x_1)$ is the transaction price. If the informed trade buys one share, his payoff is $\delta D - p_1(x_1)$. If the informed trade sells one share, his payoff is $p_1(x_1) - \delta D$. The remaining terms of the right hand side is the expected trading profit in period 2. The second term is the period 2 payoff when the dividend is D. In this case, the informed trader issues a buy order and hence receives a payoff of $D - p_2(x_1,b,\delta)$. In period 1, he expects the probability of a high dividend in period 2 is δ. The third term is the period 2 payoff when the dividend revealed to the informed trader is 0. In this case, the optimal strategy of the informed trader is to sell and the probability of this state is $1-\delta$.

Because the prior probability of the high dividend state is δ_0, the price of the asset at time 0 is equal to its expected value, $\delta_0 D$. This value remains the same if the order is submitted by a noise trader since no information is included in the order. If the order is submitted by an informed trader, the expectation will move with the information. If the signal is good, the expectation is $\delta_H D$ and it is $\delta_L D$ otherwise. Suppose the market maker conjectures that in period 1, the informed trader will buy the asset if he observes a good signal, δ_H, and sell the asset if he encounters a bad signal, δ_L. The bid and ask prices in period 1 are then determined as follows:

$$p_1(b) = \frac{\mu\beta\delta_H D + (1-\mu)\lambda\delta_0 D}{\mu\beta + (1-\mu)\lambda}. \tag{5}$$

$$p_1(s) = \frac{\mu(1-\beta)\delta_L D + (1-\mu)\gamma\delta_0 D}{\mu(1-\beta) + (1-\mu)\gamma}. \tag{6}$$

Note that a buy order always increases the price of the asset and a sell order always decreases the price. Because the order contains the noisy signal of the informed trader, the market maker always adjust the price based on the order flow. However, this adjustment is not to the full extent reflected by the signal received by the informed trader, so the informed trader still finds it profitable to issue the trade order under normal circumstances. As shown by the following results, the informed trader finds it optimal to buy if he observes a good signal, δ_H, and sell otherwise. Thus the market maker's conjecture is consistent and the prices specified in equations (5) and (6) are the market prices in period 1.

The trading strategy of the informed trader in period 1 is the focus of this model. When the informed trader observes a good signal, issuing a buy order is always the optimal strategy. Since the signal is revealed at the end of period 1 and a buy order will only drive the price up, the period 2 payoff to the informed trader is the same if he buys one unit in period 1 as it is if he does not trade. Buying in period 1 has the additional advantage of owning one unit which is priced under the expected value given the good signal. Hence we have the following result:

Lemma 2. *In period 1, when the informed trader observes a good signal, he trades on this signal immediately and issues a buy order. That is, if* $\delta = \delta_H$*,* $\max_{x_1} W_1(x_1, \delta_H) = W_1(b, \delta_H)$.

When the informed trader observes a bad signal, things are more interesting. If the retail trader is not reluctant to sell into losses, the informed trader always issue a sell order in period 1. Just like the case of receiving a good signal, the payoff of the informed trader in period 2 is the same because the signal is revealed at the end of period 1. A sell order in period 1 has the extra payoff of selling one unit above its intrinsic value. Hence the strategy of issuing a sell order after observing a bad signal strictly dominates the other two alternatives.

Lemma 3. *In period 1, when the informed trader observes a bad signal and the retail trader is not reluctant to sell into losses, the informed trader trades on this signal immediately and issues a sell order. That is, if* $\delta = \delta_L$ *and* $\alpha = 1$, $\max_{x_1} W_1(x_1, \delta_L) = W_1(s, \delta_L)$.

Thus, as a base case for comparison, we have established the equilibrium when the retail trader shows no disposition effect.

Proposition 1. *When the retail trader shows no disposition effect, there is one unique equilibrium where the informed trader always issue a buy order when he receives a good signal and a sell order when he receives a bad signal.*

Proof. Consider the following equilibrium: the strategy of the informed trader is specified as $\Pi_1(\delta_H) = (1,0,0)$, $\Pi_1(\delta_L) = (0,0,1)$, $\Pi_2(1) = (1,0,0)$, $\Pi_2(0) = (0,0,1)$; the market maker believes that the informed trader follows this strategy and his pricing strategy is specified by Equations (1), (2), (5), and (6), where $\alpha = 1$. From Lemmas 1, 2, and 3, we know that these strategies and beliefs constitute an equilibrium.

We prove the uniqueness of this equilibrium by contradiction. Suppose there exists another equilibrium where the informed trader follows a different strategy. Suppose the informed trader does not buy after observing a good signal. Because λ is positive, the price set by the market maker will be always less than the value perceived by the informed trader ($\delta_H D$ in period 1 and D in period 2). In this case, a buy order generates positive payoff to the informed trader while a sell order generates negative payoff and no-trade incurs zero payoff. Therefore, the only optimal strategy for the informed trader is to buy after observing a good signal. This conclusion contradicts the initial assumption. On the other hand, suppose the informed trader does not sell after observing a bad signal. Because γ is positive, the price set by the market maker will be always greater than the value perceived by the informed trader ($\delta_L D$ in period

1 and 0 in period 2). In addition, because the retail trader does not have any disposition effect ($\alpha = 1$), the trading in period 1 has no effect on the trading in period 2. In this case, a sell order generates positive payoff to the informed trader and is the optimal pure strategy for the informed trader. This conclusion again contradicts the assumption. Thus we have proved the uniqueness of the equilibrium. □

If the retail trader is reluctant to sell into losses, that is, $\alpha < 1$, a sell order may not be optimal. The sell order depresses the price in period 1. This causes the retail trader to be less willing to issue a sell order in the next period. Hence the information content of the sell order in the next period is greater than it is if the informed trader does not trade. By issuing a selling order in period 1, the informed trader effectively reduces future liquidity for the sell order and he receives less payoff from the sell order in period 2. Under certain circumstances, this loss may be greater than the gain of selling one unit of over-valued asset in period 1. This leads to the following result.

Proposition 2. *When the retail trader is reluctant to sell into losses, there are two types of equilibria depending on parameter values. When,*

$$\frac{(1-\mu)\gamma(\delta_0-\delta_L)D}{\mu(1-\beta)+(1-\mu)\gamma}+\frac{(1-\mu)\alpha\gamma(1-\delta_L)\delta_L D}{\mu(1-\delta_L)+(1-\mu)\alpha\gamma}\geq\frac{(1-\mu)\gamma(1-\delta_L)\delta_L D}{\mu(1-\delta_L)+(1-\mu)\gamma}. \tag{7}$$

there is an equilibrium where the informed trader always issue a buy order when he receives a good signal and a sell order when he receives a bad signal in both periods. When condition (7) is not satisfied, there is no equilibrium where the informed traders always sell after receiving a bad signal in period 1.

Proof. Suppose the informed trader follows the strategy that he buys after observing a good signal and sells after observing a bad signal. The market maker believes that the informed trader follows this strategy and his pricing strategy is specified by Equations (1), (2), (5), and (6), where $\alpha < 1$. From Lemmas 1 and 2, the informed trader's strategy is optimal in period 2 and in period 1 when he observes H. The remaining part to be verified is the informed trader's strategy in period when he observes L. In this case, neither a buy order or no-trade leads to a lower price at time 1. Neither strategy triggers any reluctance to sell in period 2 and the expected payoff from the second period is the same. However, a buy order incurs a loss in period 1 because he observes L and no-trade generates zero payoff in period 1. Thus no-trade dominates a buy order. Now we only need to compare no-trade and a sell order after the informed trader observes L. The payoff after a sell order is $W_1(s, \delta_L)$ and the payoff after no-trade is $W_1(n, \delta_L)$. For informed trader to prefer a sell order, it must be the case that $W_1(s, \delta_L) \geq W_1(n, \delta_L)$. Simplifying this condition leads to (7). Thus we have shown the first part of the proposition. To prove the second part, we use contradiction. Suppose there is an equilibrium that the informed trader always issues a sell order after observing L and condition (7) does not hold. In this case, informed trader plays the pure strategy of a sell order. Based on the definition of the equilibrium, the informed trader receives higher payoff from a sell order than any other alternatives (including no-trade). That is, $W_1(s, \delta_L) > W_1(n, \delta_L)$. This contradicts the assumption that condition (7) does not hold. $\square$

Note that the first term on the left hand side of (7) is the payoff to the informed trader from selling a unit of overpriced asset in period 1. The second term is the expected payoff of period 2 in the low dividend state when the informed trader needs to sell. The right hand side is the informed trader's expected payoff of period 2 in the low dividend state if he does not trade in period 1. The expected payoff in the high dividend state in period 2 is the same no matter the informed trader sells the asset in period 1 or not. Hence it does not affect the informed trader's decision to sell in period 1.

Figure 2 illustrates the combination of α and δ_L where the informed trader does not trade fully on his information in period 1. As can be seen from Figure 2, when δ_L is close to δ_0, i.e., the signal is moderately bad, the informed trader does not trade on this signal because the gain of trading in period 1 is minimal while the loss from lowering the liquidity in the future period is much larger. On the other hand, when α decreases from 1 to 0, that is, the retail trader becomes more reluctant to sell into losses, the range of δ_L in which no trade in period 1 is optimal increases. This result is not surprising as the retail trader's reluctance to sell into losses makes the period 1 sell order more unfavorable. Hence no trade occurs for a wider range of δ_L values.

If the signal is really bad, that is, δ_L is close to 0, selling in period 1 is always the optimal strategy for the informed trader, no matter what α is. Low δ_L has two effects on the selling order. First, the profit of selling over-valued asset is higher when δ_L is low. Second, since δ_L is revealed at the end of period 1, the bid price that market maker sets in period 2 is proportional to δ_L. Hence the gain from not trading in period 1 and not reducing future market liquidity is proportional to δ_L as well. This gain can not offset the large trading profit from selling in period 1 when the signal is really bad. Figure 2 also shows the non-trading range varies for different level of μ. The higher the μ is, the bigger the size of non-trading area. This may seem counter-intuitive since a high μ is an indication of high percentage of informed traders in the market. A close examination of condition (7) reveals the logic. The key is that the market maker has perfect knowledge of μ. Thus, the higher the μ is, the smaller the trading profit to the informed trader of selling a unit in period 1. That is why the size of non-trading area increases with μ. In the limit case of μ very close to 0, the market maker does not adjust price if he sees an incoming sell order. Hence selling in period 1 is always optimal because the expected profit of period 2 is the same while selling in period 1 brings the informed trader an additional profit of $(\delta_0 - \delta_L)D$.

When condition (7) holds, the informed trader has no incentive to issue a sell order when he observes a bad signal and the market maker expects him to sell. However, if the market maker expects the informed trader to select no-trade strategy and treats all sell order from retail trader, he will not change price after a sell order in period 1. Then the informed trader finds sell order attractive. Thus there is no equilibrium where either no-trade or sell is played by the informed trader as a pure strategy. We can find an equilibrium where the informed trader plays a mixed strategy between no-trade and sell order.

Proposition 3. *Suppose the retail trader is reluctant to sell into losses. When condition (7) does not hold, there is an equilibrium where the informed trader buy after receiving a good signal in both periods, sell after a bad signal in period 2, and plays a mixed strategy between no-trade and sell after a bad signal in period 1.*

Proof. Consider the following equilibrium: the strategy of the informed trader is specified as $\Pi_1(\delta_H) = (1,0,0)$, $\Pi_1(\delta_L) = (0,1-\pi_1^s,\pi_1^s)$, $\Pi_2(1) = (1,0,0)$, $\Pi_2(0) = (0,0,1)$, where $0 < \pi_1^s < 1$. The market maker believes that the informed trader follows this strategy and his pricing strategy is specified by Equations (1), and (5) for buy orders. For sell order, the market maker sets the bid price in period 1 as

$$p_1(s)' = \frac{\mu\pi_1^s(1-\beta)\delta_L D + (1-\mu)\gamma\delta_0 D}{\mu\pi_1^s(1-\beta) + (1-\mu)\gamma}, \tag{8}$$

and Equation (2) with $\alpha < 1$ after a sell order and $\alpha = 1$ after a no trade. The informed trader's payoff after a sell order is

$$W_1(s,\delta_L)' = [p_1(s)' - \delta_L D]) + \delta_L[D - p_2(s,b,\delta_L)] + (1-\delta_L)p_2(s,s,\delta_L). \tag{9}$$

His payoff after no-trade is

$$W_1(n,\delta_L)' = \delta_L[D - p_2(n,b,\delta_L)] + (1-\delta_L)p_2(n,s,\delta_L). \tag{10}$$

If $\pi_1^s = 1$, $W_1(n,\delta_L)' > W_1(s,\delta_L)'$, and if $\pi_1^s = 0$, $W_1(n,\delta_L)' < W_1(s,\delta_L)'$. Because both $W_1(s,\delta_L)'$ and $W_1(n,\delta_L)'$ are continuous with respect to π_1^s, there always exists a π_1^{s*} such that $W_1(s,\delta_L)' = W_1(n,\delta_L)'$. It is easy to verify that a buy order after observing L is dominated by no-trade and all the other strategies of the informed trader are optimal. Thus we have a mixed-strategy equilibrium where the informed trader, after observing L, issues a sell order with probability π_1^{s*} and does not trade with probability $1-\pi_1^{s*}$. $\square$

4 Discussions

4.1 Robustness of the results

Note that not revealing the signal to the market maker at the end of period 1 does not change the results qualitatively. If the signal in period 1 is not revealed, the market maker needs to update the reference price as well as the probability distribution based on the order in period 1. A buy order increases the period 1 price of the asset and tilts the distribution toward high dividend state. With no liquidity change, the informed trader still finds it profitable to buy when having a good signal. Similarly, a sell order decreases the period 1 price of the asset and tilts the distribution toward low dividend state. If the retail trader is reluctant to sell into losses after the price drops, the liquidity of the next period may dry up and future sell orders are likely to depress the price even further. This effect can be so big that the informed trader may hold the bad news without any trading.

The key result that the informed trader would trade less aggressively with bad news when the retail investors are reluctant to sell losses does not depend on the specific trading model here.

4.2 Empirical predictions

We can derive several empirical implications from this model. First of all, as the buy order is never held back by the informed trader, the asset price rises in period 1 and again in period 2. When the bad signal is received, the informed trader may not always trade on this information as shown above. If the informed trader does not trade in period 1, the price stays the same in period 1, and it is likely to drop in period 2. Hence the price pattern leading to a loss is flat in period 1 and sharp drops in period 2. If the informed trader sells in period 1, the price drops in period 1. Retail traders become reluctant to sell in period 2, and any new sell order from the informed trader brings down the price substantially since liquidity is reduced. The price pattern in this case is a small drop followed by a significant drop. Hence, markets where retail investors dominate are likely to have long steady climb with sharp drops.

Secondly, the volume during price increase consists of trading volume contributed by the informed trader and the retail investor. When the informed trader observes a bad signal, he may refrain from trading immediately and reducing trading volume leading to price drop. In addition, if the informed trader sells after a bad signal, the price drop leads to retail investors' reluctance to sell, again depressing trading volume. Overall, the volume during the price increase is likely to be higher than the volume during the price drop.

Finally, the more retail traders there are in a market, informed traders can better hide their trades in general. However, after an initial price drop, the retail traders become reluctant to sell into losses, there is a significant loss of liquidity in this case. During such times, the sell orders from informed traders quickly depress the market price. Thus more retail traders in a market leads to less liquidity and severe price drops during extreme market downturns.

5 Conclusion

In this paper, we construct a model incorporating the retail trader's reluctance to sell into losses. We show that in this setup the informed trader always buys the asset when he receives favorable signal. However, when the informed trader receives unfavorable signal, he may not sell the asset if the signal is moderately bad and the retail trader is reluctant to realize losses. From this model, we can derive the following empirical implications: 1) The asset price exhibits steady climbs with sharp and sudden drops; 2) The volume during the price increase is higher than the volume during the price drop; 3) More retail traders in a market leads to less liquidity and severe price drops during extreme market downturns.

Future research can be extended in several ways. It will be interesting to incorporate learning in the model. In the current setup, the informed has perfect knowledge about the retail investors who are reluctant to sell losses. If the informed trader is trading with some standard noise traders and some retail investors, then the informed is uncertain whether a price decrease will reduce the future liquidity and by how much. Studying the informed trader's learning and strategic trading activities in this context is quite interesting. Previous works such as Foster and Viswanathan (1994), Hong and Rady (2000), Gervais and Odean (1999) may provide directions on how to proceed. It will also be interesting to test the predictions empirically. Given the recent surge of retail investors in the stock market, a study of their trading behavior on the overall market is very important.

6 References

Andersen, T.G., and T. Bollerslev, 1998, DM-Dollar volatility: Intraday activity patterns, macroeconomic announcements, and longer-run dependencies, *Journal of Finance*, 53, 219-265.

Barberis, N., M. Huang, and T. Santos, 2001, Prospect theory and asset prices, *Quarterly Journal of Economics* 116, 1-53.

Barberis, N., A. Shleifer, and R. Vishny, 1998, A Model of investor sentiment, *Journal of Financial Economics* 49, 307-343.

Conrad, J., A. Hameed, and C.M. Niden, 1992, Volume and autocovariances in short-horizon individual security returns, *Journal of Finance* 49, 1305-1329.

Daniel, K.D., D. Hirshleifer, and A. Subrahmanyam, 1998, A theory of overconfidence, self-attrition and security market under- and over-reactions, *Journal of Finance* 52, 1-33.

Easley, D., M. O'hara, and P.S. Srinivas, 1998, Option volume and stock prices: Evidence on where informed traders trade, *Journal of Finance*, 431-465.

Foster, F. D., and S. Viswanathan, 1994, Strategic trading with asymmetrically informed traders and long-lived information, *Journal of Financial and Quantitative Analysis*, 499-519.

Gertner, R., 1993, Game shows and economic behavior: Risk taking on card shark, *Quarterly Journal of Economics*, 507-521.

Gervais, S., and T. Odean, 1999, Learning to be overconfident, working paper, Wharton School.

Glosten, Lawrence R. and Paul Milgrom 1985, Bid, ask, and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71-100.

Hong, H., and J. C. Stein, 1999, A unified theory of underreaction, momentum trading and overreaction in asset markets, *Journal of Finance*, 2143-2184.

Hong, H., T. Lim, and J. C. Stein, 2000, Bad news travels slowly: Size, analyst coverage, and the profitability of momentum strategies. *Journal of Finance*, 265-296.

Hong, H., and S. Rady, 2000, Strategic trading and learning about liquidity, working paper, Stanford University.

Kyle, A., 1985, Continuous auctions and insider trading, *Econometrica*, 53, 1315-1335.

Lo, A. and A.C. MacKinlay, 1990, An econometric analysis of nonsynchronous trading, *Journal of Econometrics* 45, 181-211.

Llorente, G., R. Michaely, G. Saar, and J. Wang, 2000, Dynamic volume-return relation of individual stocks, working paper, MIT.

Odean, T., 1998, Are investors reluctant to realize their losses? *Journal of Finance*, 1775-1798.

Thaler, R. H., and E. Johnson, 1990, Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice, *Management Science*, 643-660.

Table 1. Parameters used in the model.

Parameter	Definition
δ	the probability of the dividend being D
δ_0	the consensus probability of D at time 0
δ_H	the probability of state H that informed traders learns in period 1
δ_L	the probability of state L that informed traders learns in period 1
β	the probability of state H occurring in period 1
μ	the probability that an informed trader is submitting an order
λ	the probability that the retail trader issues a buy order in either period
γ	the probability that the retail trader issues a sell order in period 1
α	the coefficient modeling the retail trader's reluctance to sell losses

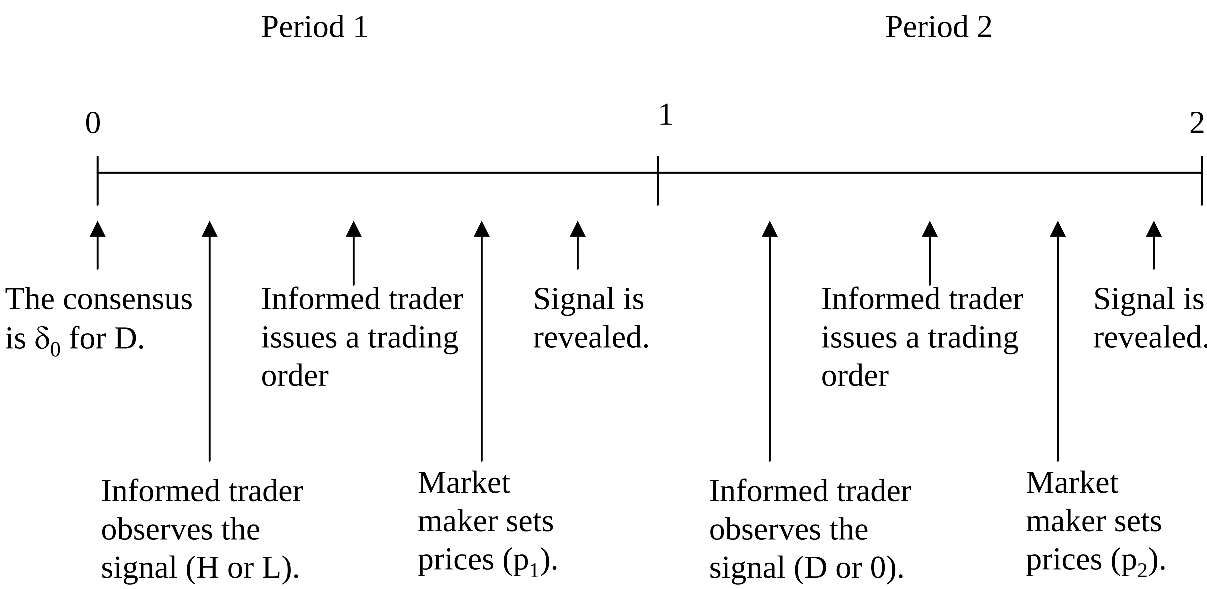

Figure 1, Time line of the model.

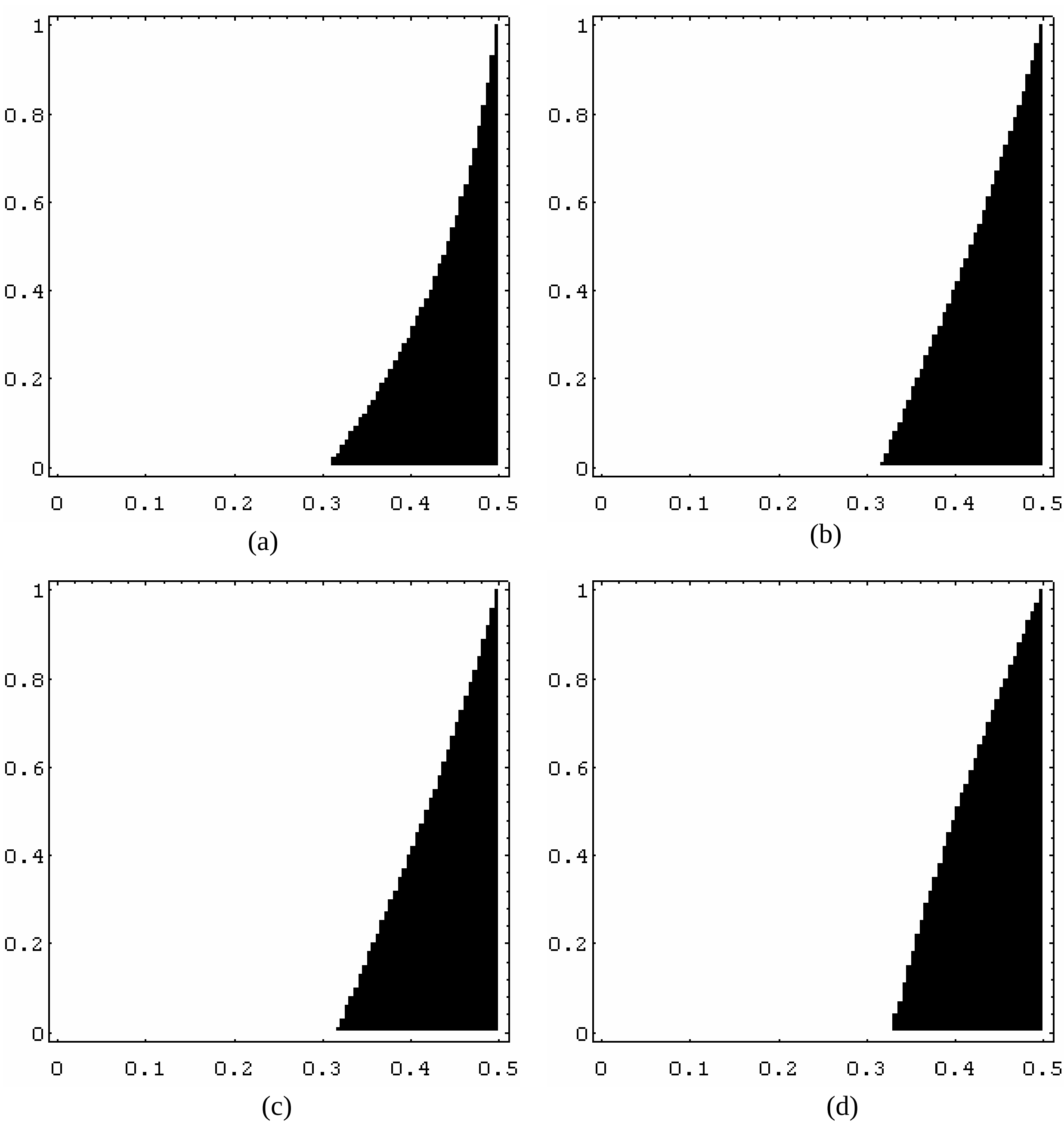

Figure 2. The range of α and δ_L that non-trade is the optimal strategy in period 1. The horizontal axis is δ_L and the vertical axis is α. Other parameters used in this figure are: β=0.5, λ=0.3, γ=0.3, δ_0=0.5, δ_H=0.7, and (a) μ=0.2, (b) μ=0.4, (c) μ=0.6, (d) μ=0.8.