Short-Term Trading Strategy in the Presence of Daily Price Limits

Guojun Wu
University of Michigan
Shanghai Stock Exchange

(Confidential)
(Preliminary)

October 20, 2003

* We thank Fang Xinhai, Hu Ruyin, Liu Xiaodong, Liu Wei, Shi Donghui, Wang Fenghua, Xia Jialing, Zen Gang and seminar participants at Shanghai Stock Exchange for comments and discussion. We thank Cui Jun for excellent research assistance. Contact Guojun Wu, School of Business, University of Michigan, 701 Tappan Street, Ann Arbor, MI 48109, U.S.A. Phone: (734) 936-3248; Fax: (734) 936-0274; Email: gjwu@umich.edu.

Abstract

In this paper we investigate short-term trading strategies in the presence of daily price limits. Although researchers previously have not found any short-term momentum in the Chinese stock market, we find that there is significant daily and overnight momentum associated with price limit events. Moreover, profitable trading strategies can be devised to take advantage of the momentum.

We are able to identify ten stock trading accounts that specialized in trading off the daily price limits. We obtain data on orders and trades with account owner information. These traders have generated significant profit taking overnight positions in stocks that reached their daily price limits. They purchased stocks at or close to limit prices and sold out shortly after market opening the next trading day. They would place large buy orders at limit prices to keep prices there. Stocks that reached price limits often attract much attention from the financial media and the investing public. These traders usually would withdraw these large orders shortly after they were placed. Their order placing and buying activities are suspicious of manipulation, but it is mostly limited to keeping stock prices at the limit prices. We did not find evidence that these traders possessed special skills in identifying stocks with stronger momentum than an average stock that reached its price limit, or in identifying stocks that were temporarily under-priced.

JEL Classification Code: G14, G15

Keywords: short-term, trading strategy, manipulation, momentum, reversal, daily price limit

1. Introduction

Daily price limit is often imposed by stock exchanges or market regulators as a method of limiting market speculation and volatility. Shi (2002), for example, lists its presence in stock exchanges in Taiwan, Malaysia, Thailand, the Philippines, Japan, South Korea, Austria, Finland, Portugal and other markets. The limit can be as restrictive as ±5% or 7% such as those imposed in Luxemburg or Taiwan. The two Chinese stock exchanges based in Shanghai and Shenzhen impose a ±10% daily price limit on all stocks, except for those so-called "Special Treatment" or "ST" shares where the daily price limit is narrowed to ±5%. A stock is put on the "ST" list if the firm's accounting profit is negative for two consecutive years, or if the per share net asset value of the firm is lower than the face value of the stock. Once the price limit is reached, trading can only take place at prices that do not exceed the limit.

The intended purpose of price limits is to stabilize price and to reduce market volatility. Since emerging capital markets often exhibit higher volatility, it is not surprising that many emerging capital markets in Asia have adopted the practice. The argument for price limits is that it provides price stability by giving investors time to examine and digest information and cool off. Therefore it is a useful method in reducing market speculation and volatility. However, there is no consensus on whether the practice is effective in reducing market volatility. Even if it does, opponents of the measure argue, the cost in terms of price distortion may be too high since it reduces the role of price as an information aggregator. It increases uncertainty on the tradability of shares. Under certain circumstances, it may even increase market speculation and volatility

Researchers have proposed and tested several hypotheses regarding daily price limits. The price stabilization hypothesis argues that the presence of price limits reduces price volatility. Lee and Kim (1995) studied the Korean market and found evidence supporting the hypothesis. Therefore, the presence of price limits does not seem to lead to higher volatility, even if there is added uncertainty on the tradability of shares. The cooling off hypothesis says that price limits provide investors some time to cool off. It reduces over-reactions by investors, hence reducing price volatility. Ma, Rao and Sears (1989) examined U.S. Treasury futures data and found evidence supporting the hypothesis. Li et al (2001) used intraday 5-minute price data from the

Shanghai market and found the cooling off effect. When the stock price is close to the upper price limit, the price is more likely to drop than to rise. When the price is close to the lower price limit, the price is more likely to rise than to drop. The cooling off effect is stronger for the lower price limit than for the upper price limit. Wu et al (2002) find that appropriate price limits not only reduce abnormal fluctuations in the stock market, but also increase market liquidity. However, Shi and Sun (2001) and Liu, Liu and Tian (2001) find that price limits do not seem to reduce volatility or speculation. Yet they negatively affect the price discovery process and the normal trading activities of investors.

The opponents of the daily price limit practice have also proposed and tested several hypotheses. When there is a large change in the fundamental value of a firm, the resulting change in the equilibrium price may be larger than the price limit. Due to the price limit, the equilibrium price cannot be reached in a single trading day. Hence price discovery is delayed. This is the delayed price discovery or the trading interference hypothesis. Kim and Rhee (1997) found the effect in the Japanese market, and Choi and Lee (2001) found the effect in Korea. The second popular hypothesis is the magnet effect. Fama (1989) pointed out that investors may speed up their trades when the price is close to the limit. This aversion to inability to trade will accelerate the convergence to the limit price. This hypothesis was supported by empirical analyses in Cho and Russell (2001) and Choi and Lee (2001) using data from the Taiwan and Korean markets, respectively. However, Li et al (2001) did not find the magnet effect in the Shanghai market.

In this paper we want to address the following questions: Do price limits lead to market predictability and inefficiency? If yes, are the predictability and inefficiency economically significant so that profitable short term trading strategies can be devised? We will conduct our analysis using transactions data which identify trading accounts. In addition, we will focus on a group of investors who seem to take advantage of the presence of price limits. In the following discussion will call this group of traders the Ningbo Traders, since all of them are located in the coastal city of Ningbo. The city has a population of 5.5 million and is about 200 miles to the south of Shanghai. The Market Surveillance Department at the Shanghai Stock Exchange identified ten stock trading accounts that are controlled by the Ningbo traders. Our data analysis supports their identification. These accounts indeed specialize in short-term trading around daily

price limits. Since short selling is not allowed in the Chinese stock market and transactions are settled after the closing of market, the strategy usually involves buying into a stock when its price is close to or at its upper price limit and then sell all these shares early in the following trading day.

We find there is significant daily and overnight price momentum after price reaches its upper limit. Indeed, daily price limits lead to market predictability and inefficiency. The predictability and inefficiency are economically significant so that short-term trading strategies can be devised. The Ningbo Traders can generate significant trading profit. We study their order placing and trading strategy to see if their trades had any impact on prices. We find that they did not seek to impact on prices. Their order placing and buying activities are suspicious of manipulation, but it is mostly limited to keeping stock prices at the limit prices.

Current studies on price limits mostly examine the day during which price limit is reached. We study the strategy that utilizes the price limits for "cross-day" short-term trading profits. Our study has important implications for market efficiency analysis. We will show that it is highly unlikely that the Ningbo Traders are trading on insider information. They seem to base their trading strategies almost entirely on public information. We did not find evidence that the Ningbo Traders possessed special skills in identifying stocks with stronger momentum than an average stock that reached its price limit, or in identifying stocks that were temporarily under-priced. They were skillful in taking advantage of trade-to-trade swings in selling their shares.

Our study is based on individual stocks, yet it has broad implications for the entire market. Herding and high-cross correlation make the strategy even more significant for China since most stocks tend to move up or down together. Our study is related to the literature on momentum, although there are few studies that examine very short-term trading strategies. Jegadeesh and Titman (1993)'s study shows that equity returns exhibit momentum based on past 3-12 months performance. Hirshleifer, Subrahmanyam and Titman (1994) analyze trading behavior and equilibrium information acquisition when some investors receive common private information before others. The model is consistent with trading strategies such as short-term position reversal and following the leader (mimicking earlier trades). Daniel, Hirshleifer and Subrahmanyam

(1998) examine investor psychology and security market under- and over-reactions. The over-reaction issue is also examined by DeBondt and Thaler (1985, 1987), Zarowin (1989), and Richards (1997).

Wu (2002) find that a pure momentum strategy in general does not yield excess profitability and there is strong mean reversion over 3-6 months horizon in the Chinese market. Contrarian investment strategy produces positive excess returns and in general outperforms the pure momentum strategy. There is no study that examines the (very) short-term momentum/reversal effect around price limits.

The paper is organized as follows. Section 2 describes the data used in the study and examines short-term price dynamics, especially around daily price limits. We study both the daily and overnight momentum of stocks. Section 3 focuses on the Ningbo Traders who specialized in trading off the momentum around daily price limit events. We also analyze the profitability of the Ningbo Traders and other traders and explore the sources of the profit. In Section 4 we study the order placing and trading strategies of the Ningbo Traders. We attempt to answer the question if the Ningbo Traders are market manipulators. The final section contains the concluding remarks.

2. Price Dynamics around Daily Price Limits

In China, each investor must apply for a unique "stock trading account number" before he or she can begin trading in stocks or bonds. An investor can employ the service of any brokerage firms, but his trades are identified at the stock exchange by his stock trading account number. Therefore, the stock exchange knows not only which brokerage houses each trade originates from but also who are the ultimate buyer and seller of the trade.

The Shanghai Stock Exchange utilizes a single price auction for its opening. All orders entered between 9:15am and 9:25am are matched with a single price to maximize the total

transaction volume. Unexecuted orders are automatically entered into the limit order book for continuous auction at 9:30am. It continues until market closing at 3:00pm, with a lunch break from 11:30am to 1:00pm. The official closing price of each stock is the volume-weighted average price during the last minute of trading, or the price of last trade if there is no trade during the last minute.

2.1. The Data

We have collected daily price data for all stocks traded on the Shanghai Stock Exchange from January 2, 2001 to July 25, 2003. The information includes date, stock symbol, opening price, closing price, maximum price, minimum price, trading volume, and the number of shares outstanding. There are a total of 749 stocks in the sample. We also collected corresponding information for the major market composite index. For each trading day, we then look for stocks that have reached their daily price limits at any time during the trading day. If a stock reached the limit price on a day, we define this as a "price limit event". We call the day a "price limit day", and the following trading day "the second day". There are a total of 723 stocks and 2,141 price limit events, among them 580 events are on stocks that were in "ST" status on the day price limits were reached.

For the 2,141 price limit events, we then collect the entire record of intra-day trading for the price limit days and the second days. The trade data record includes information for each trade, i.e., date, stock symbol, price, size of the trade, trading time, buyer stock trading account number and seller stock trading account number. Since we know the account numbers of the Ningbo Traders, we can replicate their trading activities during the entire sample period. The Ningbo Traders did not trade all the stocks that reached their price limits. They participated in trading of 410 price limit events, among them 218 are on stocks that were in "ST" status on the day price limits were reached. Figure 1 plots the time series of the number of stocks that reached price limits during the sample period from January 2001 to July 2003. The top panel graphs all stocks that reached price limits, and the bottom panel graphs the number of stocks that the Ningbo Traders traded in. There is no clear correlation between the number of price limit events and the number of events that the Ningbo Traders traded in. For example, between the end of 2001 and

the middle of 2002, there were large numbers of price limit events. Yet there was no associated increase in trading activities by the Ningbo Traders. In 2003, there was a decline in the number of price limit events, yet the Ningbo Traders traded more stocks. Over the sample period, there is a trend of increased activities by the Ningbo Traders. They do not appear to prefer the ST or non-ST stocks.

For the Ningbo Traders we also collected all their order placing records for the price limit days. The record includes information on the time the order was placed, the time the order was executed, and the time any part of the order was withdrawn. We use this information to study the effect of the frequent order placing and withdrawing by the Ningbo Traders. To compare the trading activities of the Ningbo Traders with other traders, we also collected all the trading records for all stock trading accounts that traded through any brokerage houses based in the city of Ningbo.

2.2. Price Momentum and Daily Price Limits

Based on the delayed price discovery hypothesis, there should be price momentum after a price limit has been reached. To study this issue we estimate the following daily momentum model for the 749 stocks in our sample,

$$r_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \varepsilon_t,$$

where r_t is the daily return of the stock, and I_t is an indicator function that equals 1 if the price limit is reached on day t and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume and average turnover ratios. All the averages are taken over the entire sample period. In the Chinese stock market, there are three classes of shares in the RMB¥ denominated A-share market: the non-tradable government-owned state shares, the non-tradable institutions-owned legal person shares, and tradable shares that can be owned by anyone. The division of shares into these three classes is a result of on-going privatization effort by the government in transforming state-owned or collective-owned enterprises into share-holding companies. The eventual goal of reform is to make all shares tradable. But how to get there from

the current system is a topic of heated discussion in the academia, the securities industry, government regulators, the financial media and the investing public.

Results in Table 1 show that there is no daily momentum for the stocks in our sample. The estimated β is -0.0012 for the pooled regression for all stocks, and it is statistically insignificant. The estimates are also mostly negative for the sorted portfolios according to market capitalization, tradable capitalization, trading volume or turnover ratios. They are all statistically insignificant. Our result is consistent with earlier work on market momentum by Wu (2002).

Results in Table 1 also show that the estimate for γ is 0.0102 for the pooled regression for all stocks, and it is statistically significant. It indicates that the second day return after a price limit event is 1.02% on average for all stocks. The estimates are also positive and statistically significant for the sorted portfolios according to tradable market capitalization, trading volume or turnover ratios. According to total market capitalization, γ is positive and statistically significant for large stocks only. Overall there is strong evidence that the second day of a positive price limit event is associated with about 1% abnormal return.

In addition to daily momentum analysis we are also interested in overnight momentum in the market. We estimate the following overnight momentum model for the 749 stocks in our sample,

$$\bar{r}_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \varepsilon_t,$$

where $\bar{r}_t$ is the return computed using the opening price of day t and the closing price of day t-1. The only difference between this model and the daily momentum model is the dependent variable, which we use the overnight return instead of the regular daily return. We use this model to find out if the overnight return is affected by the previous day's return and the price limit events.

Table 2 reports parameter estimates for the overnight momentum model. Results in Table 2 show that there is overnight momentum for the stocks in our sample. The estimated β is 0.0098 for the pooled regression for all stocks, and it is statistically significant. The estimates are also all positive for the sorted portfolios according to total market capitalization, tradable capitalization, trading volume or turnover ratios. Moreover, medium and large stocks, and liquid stocks (high

trading volume stocks) exhibit strong and statistically significant overnight momentum

Results in Table 2 also show that the estimate for γ is mostly positive and statistically significant. The estimated γ is 0.0066 for the pooled regression for all stocks, and it is statistically significant. It indicates that the overnight return is 0.66% on average for all stocks. The price limit effect is stronger for stocks with small and medium tradable market capitalizations. Overall there is evidence that the overnight return after a price limit event is about 0.66%.

3. The Trading Activities of the Ningbo Traders

3.1. Trading Activities

The Ningbo Traders participated in trading 410 price limit events. There are an additional 248 events where they did not buy on the price limit day but sold shares on the second day of a price limit event. Since those shares could be bought a few days earlier as an extension of the short-term trading strategy, we will include these events and consider a total of 658 price limit events in our analysis of the Ningbo Traders.

Figure 2 graphs the number of trades and the trading volume on the price limit days and the second days for the accounts owned by the Ningbo Traders. There are a total of 10 accounts. The left axis shows the number of trades for each of the 10 accounts, and the right axis shows the associated trading volume. These accounts are not equally active in trading. Some trade as little as a few thousand times over the sample period. Some trades more than 55,000 times. The trading volume is closely related to the number of trades so there is no obvious preference for trade sizes by any of these 10 accounts.

Figure 3 graphs the distribution for the number of trades and the trading volume for all non-Ningbo stock trading accounts that traded stocks on the price limit days and the second days. The top panel graphs the distribution of the number of trades and the bottom panel graphs the

trading volume in shares. About 1.4 million accounts (20% of all accounts) traded less than 500 times, yet, about 1.5 million accounts traded more than 5,000 times during the sample periods. In terms of trading volume, there are about 1.35 million accounts traded less than 500 shares on the price limit days and the second days during the sample period. For the larger traders, there are about 0.8 million accounts traded more than 10,000 shares during this period.

3.2. The Profit and Loss of the Ningbo Traders

To study the profit and loss of the Ningbo traders, we identify the 658 "price limit events" that the Ningbo traders participated in trading. To analyze the profitability of the trades, we need to know the number of shares purchased on the day price limit was reached and the number of shares sold in the following trading day. The numbers of shares bought and sold may not be the same for some stocks or accounts. Therefore, it is necessary for us to make assumptions about the price cost of extra shares sold or the price value of shares not yet sold. There are 317 out of 658 price limit events that the Ningbo traders sold the same number of shares on the second days as they bought on the price limit days. We can compute the profit for these transactions exactly.

For each of the 10 accounts we compute the cumulative number of shares bought N_B on the price limit day, the cumulative value of shares bought V_B on the price limit day, the cumulative number of shares sold N_S on the second day, and the cumulative value of shares sold V_S on the second day. If the cumulative number of shares bought is higher than the cumulative number of shares sold, we do not know the prices at which the extra shares were sold. If the cumulative number of shares sold is higher than the cumulative number of shares bought, we do not know the prices at which the extra shares were bought. For these situations we first consider as method 1 using the minimum of the cumulative numbers of shares bought and sold.

Method 1:

If the cumulative purchase is higher than the cumulative sale then the gross profit is computed using only the sale amount. If the cumulative purchase is lower than the cumulative sale then the gross profit is computed using only the purchase amount:

$$GrossProfit_1 = V_S - \frac{V_B}{N_B} \times N_S, \qquad if \quad N_B > N_S,$$

and

$$GrossProfit_1 = \frac{V_S}{N_S} \times N_B - V_B, \qquad if \quad N_B < N_S.$$

There is a 0.2% transactions tax for each trade and the exchange charges a 0.015% service fee. In addition, brokerage houses charge commissions up to 0.5% per trade. However, the Ningbo Traders are likely to receive significant discount on the commissions. We will deal with the transactions cost below.

Another approach is to consider using the maximum of the cumulative numbers of shares bought and sold.

Method 2:

If the cumulative purchase is lower than the cumulative sale then the limit price on the price limit day would be used to compute the cost of those extra shares sold. This is a conservative method since the Ningbo Traders were able to take up their position at an average price several pennies below the limit price [See next section for more analysis on the prices paid by the Ningbo Traders]. If the cumulative purchase is higher than the cumulative sale then the opening price of the second day would be used to compute the sale value for those extra shares purchased. Again we are being conservative here. We assume that the Ningbo Traders had to sell at the opening price on the second day without applying their trading skills. As we will see below that the Ningbo Traders seem to possess considerable trading skills in taking advantage of minute-to-minute swings in prices.

$$GrossProfit_2 = V_S + (N_B - N_S) \times p_{\text{limit}} - V_B, \qquad if \quad N_B < N_S,$$

and

$$GrossProfit_2 = V_S + (N_B - N_S) \times p_{\text{open}} - V_B, \qquad if \quad N_B > N_S.$$

Table 3 reports the profit and loss of the Ningbo Traders during our sample period using the above 2 methods.

There are a total of 10 accounts involved in the trading strategy. In Panel A, we report the

profits treating each account as being separately owned. There are a total of 658 observations in the sample and the mean profit is ¥38,435.88 under method 1 and ¥53,410.33 under the second method. The first method might have underestimated the profit. Under the first method, any unmatched buy and sell orders in the two days are ignored. Under certain market conditions, any delayed profit-taking would have been ignored. For example, if an upper price limit event is followed on the second day by another upper price limit event, the Ningbo Traders might not be able to sell on the second day. The profit would be zero under method 1, yet the true profit is very large since the second day price increase is very significant. In addition, if a position was taken up earlier at a lower cost the profit would also be ignored.

The table also reports the profit results separately for ST shares and non-ST shares. There are 349 observations for non-ST shares and 309 observations for ST shares. The mean profit for non-ST shares is ¥60,372.48 and ¥13,659.59 for ST shares under method 1, and is ¥84,161.53 and ¥18,678.39, respectively under method 2. Recall that the price limit for the ST shares is 5% and 10% for non-ST shares. The non-ST shares are often more liquid than the ST shares. On average, the non-ST shares generate 4-5 times as much profit as the ST shares per price limit event for the Ningbo Traders.

In Panel B we report the profits for the sum of the 10 accounts as if they were all owned by the same group. This serves as a robustness check in case the owners of the 10 accounts act together as a whole. There are 502 observations as compared to 658 observations for the accounts separately. The mean profit is ¥50,174.17 under method 1 and ¥70,907.45 under method 2. The mean profit for non-ST shares is ¥84,385.33 and ¥16,503.90 for ST shares under method 1, and is ¥118,021.30 and ¥24,538.53, respectively under method 2. The results are similar to those treating each account separately.

In Panel C we report profit for each of the 10 accounts for only those 317 events where the Ningbo Traders sold exactly the same number of shares on the second days as they bought on the price limit days. The profit in Panel C also excludes the round-trip 0.4% transactions tax and 0.03% stock exchange service fee. Even after taking into account these transactions cost, the per-event per-account profit is ¥31,345.68 for all price limit events. The mean profit is

¥44,991.59 for non-ST shares and ¥10,930.54 for ST shares. Figure 4 plots the distribution of these profits by the Ningbo Traders. Overall the profit for the Ningbo Traders is highly significant over the sample period. We have discussed their trading activities with market surveillance professionals at the Shenzhen Stock Exchange and found that they employed similar trading strategies in trading stocks listed on that market. Since they traded a large number of stocks in different industries and different markets overnight, it is highly unlikely that their trades were based on private information. We conclude that the Ningbo Traders were able to generate significant profit without private information.

4. Are the "Ningbo Traders" Manipulators?

The Ningbo Traders generated large volume in the stocks they traded in. They have the potential to impact the price of stocks and may be able to manipulate the price of the stocks. To understand if the Ningbo Traders earned profit through market manipulation we need to first briefly review the literature on stock market manipulation. The most important theoretical contribution is arguably Allen and Gale (1992). They show that a profitable price manipulation is possible, even though there is no price momentum and no possibility of a corner. The key to this argument is information asymmetry. Traders are uncertain whether a large trader who buys the share does so because he knows it is undervalued, or because he intends to manipulate the price. It is this pooling that allows manipulation to be profitable.[1]

Aggarwal and Wu (2003) extend the model of Allen and Gale (1992) by adding another class of investors to the setup: the information seekers or arbitrageurs. These investors actively seek

[1]There are several papers that examine theoretically and empirically price manipulation in a number of different settings. For example, Kumar and Seppi (1992) investigate the susceptibility of futures markets to price manipulation. Jordan and Jordan (1996) examine Salomon Brothers' market corner of a Treasury note auction in May 1991. Vitale (2000) examines manipulation in the foreign exchange market. Gerard and Nanda (1993) examine the potential for manipulation in seasoned equity offerings. In a dynamic model of asset markets, Jarrow (1992) investigates market manipulation trading strategies by large traders in a securities market. Market manipulation trading strategies are shown to exist if there is "price momentum." Jarrow (1994) studies the impact that derivative security markets have on market manipulation. Merrick, Naik and Yadav (2003) examine a case of manipulation involving a delivery squeeze on a bond futures contract traded in London.

out information about undervalued stocks. In a market without manipulators, these information seekers unambiguously improve market efficiency. The presence of manipulators reduces market efficiency.

There were relatively few empirical studies of stock market manipulation. Mahoney (1999) is perhaps one of the earliest comprehensive studies on the issue. He examined data on stock pools that were formed to manipulate stocks. He found little evidence of manipulation. Even if some pools did attempt to engage in manipulation, the price behavior of a selection of pool stocks suggests that such attempts were unsuccessful. More recently, Khwaja and Mian (2003) analyzed a data set containing daily firm-level trades of every broker trading on the stock exchange in Pakistan over a 32-month period. They find evidence that brokers manipulate price to profit from positive feedback traders. Aggarwal and Wu (2003) also provide evidence from SEC actions in cases of stock manipulation and find that stocks in poorly regulated markets are more likely to be manipulated. Their study suggests that manipulation may be more prevalent in emerging markets than in the U.S.

4.1. Price Effect of Buy and Sell Trades of the Ningbo Traders

We begin our analysis with the price effects of buy and sell trades of the Ningbo Traders. Were they capable of or effective in moving prices? What prices at which did they pay for the shares as compared to the limit prices or closing prices on the price limit days? What prices at which did they get for the shares they sold as compared to the opening prices or closing prices on the second days? To answer these questions, we compute the following price differentials for each of the 10 Ningbo accounts and each of the price limit events:

(1) $\Delta p_1 = p_{t,B} - p_{t,CLOSE}$, where $p_{t,B}$ is the volume-weighted purchase price paid by the Ningbo Traders, and $p_{t,CLOSE}$ is the closing price on the price limit day; and $\%\Delta p_1 = (p_{t,B} - p_{t,CLOSE}) / p_{t,CLOSE}$ is the relative measure of the price differential;

(2) $\Delta p_2 = p_{t,B} - p_{t,LIMIT}$, where $p_{t,B}$ is the volume-weighted purchase price paid by the Ningbo Traders, and $p_{t,LIMIT}$ is the limit price on the price limit day; and

$\%\Delta p_2 = (p_{t,B} - p_{t,LIMIT}) / p_{t,LIMIT}$ is the relative measure of the price differential;

(3) $\Delta p_3 = p_{t+1,S} - p_{t+1,CLOSE}$, where $p_{t+1,S}$ is the volume-weighted sale price received by the Ningbo Traders, and $p_{t+1,CLOSE}$ is the closing price on the second day; and $\%\Delta p_3 = (p_{t+1,S} - p_{t+1,CLOSE}) / p_{t+1,CLOSE}$ is the relative measure of the price differential;

(4) $\Delta p_4 = p_{t+1,S} - p_{t+1,OPEN}$, where $p_{t+1,S}$ is the volume-weighted sale price received by the Ningbo Traders, and $p_{t+1,OPEN}$ is the opening price on the second day; and $\%\Delta p_4 = (p_{t+1,S} - p_{t+1,OPEN}) / p_{t+1,OPEN}$ is the relative measure of the price differential.

Table 4 reports summary statistics of the price differentials for the Ningbo Traders. The Ningbo Traders paid on average 2.55 penny more than the closing prices on the price limit days (Δp_1). When compared to the limit prices, however, they paid on average 3.39 penny (Δp_2) less than the limit prices, which represent an average of 0.272% discount over the limit prices ($\%\Delta p_2$). When they sold shares on the second days, they received on average 1.81 penny more than the closing prices on the second days (Δp_3). The average sale price is only 0.87 penny more than the opening prices (Δp_4), or a mere 0.091% premium over the opening price ($\%\Delta p_4$). It indicates that the Ningbo Traders quickly unloaded the shares after market opening on the second days. Our analysis shows that their strategy is sub-optimal. On average they could be do better if they sell at close, or distribute their selling evenly over the second days. Certainly this adds to the risk of the strategy so the trader has to balance the added expected return with higher risk.

A successful manipulator must be able to move price up effectively when he purchases shares. When he sells the stock the price should not drop by more than the amount it went up when shares were bought. We study four types of trades: Ningbo Traders' and non-Ningbo traders buy trades on the price limit days, and the Ningbo Traders' and non-Ningbo traders sell trades on the second days. To examine the price effect of trades by the Ningbo Traders and others we design a measure of the effect. Let P_t be the closing price of tth trading day; $P_{i,t}$ be the

i th trade in day t; $V_{i,t}$ be the size of the i th trade of day t; and V_t^j and N_t^j be the trading volume and the number of type j trades in day t. The price effect of the i th trade is defined as: $\frac{P_{i,t} - P_{i-1,t}}{P_{t-1}}$. We define measure 1 and measure 2 of price effect for type j trades on day t to be

$$d_{j,t}^1 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i-1,t}}{P_{t-1}},$$

and

$$d_{j,t}^2 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i-1,t}}{P_{t-1}} \times \frac{V_{i,t}}{V_t^j} \times N_t^j \quad .$$

The first measure of price effect is an equal-weighted measure. The second measure is a volume-weighted measure.

Table 5 reports the price effect of the Ningbo Traders and the non-Ningbo traders. The Ningbo Traders bought on 410 stock-days when the stocks reached their upper daily price limits. The price impact is 0.0315% under measure 1 and -0.0295% under measure 2, a minuscule amount by all means. Recall that the prices at which the Ningbo Traders bought the shares are very close to the limit prices. We conclude that when the Ningbo Traders bought shares they do not seek to influence the prices. Their main objective seems to get in at the limit price and ride the short-term momentum overnight. The non-Ningbo traders' purchase has much bigger impact on prices on the days price limits were reached. The price impact is 3.186% under measure 1 and 10.662% under measure 2. Both means are statistically significantly different from zero. This result shows that the non-Ningbo traders were responsible for the price run-ups on the days price limits were reached.

For the trading days after price limits were reached we study the impact of sell trades. There are 379 stock-days when the Ningbo Traders sold shares on the second days. We were surprised to find out that the price effect is 3.285% under measure 1 and 2.461% under measure 2. How could the sell trades have positive price impact? We propose two explanations for this result. First of all, this could be explained by the fact that there is positive price momentum after price limits were reached. First trades of the second day reflect overnight price momentum. The second explanation is related to the trading skills of the Ningbo Traders. We discussed this issue

with professionals at the Surveillance Department of the Shanghai Stock Exchange. They explained that the Ningbo traders displayed good skills in exploiting trade-by-trade price swings. They were often able to execute trades at a price one penny better than the previous trade. This does not mean they were able to generate profit by trading off the swings. But the trade-by-trade price swings were reflected in the calculated measures. The result shows at the least that the Ningbo Traders' sale trades did not have significant negative price effects. For the non-Ningbo traders, the price effect is -0.738% under measure 1 and 3.474% under measure 2. There is no clear conclusion regarding the second day price effect of the non-Ningbo traders.

We also examine the after-effects of the Ningbo trades. The price after-effect of the i th trade is defined as: $\frac{P_{i,t} - P_{i+1,t}}{P_{t-1}}$. We define measure 1 and measure 2 of price after-effect for type j trades on day t to be

$$a^1_{j,t} = \sum_{i \in A^j_t} \frac{P_{i,t} - P_{i+1,t}}{P_{t-1}},$$

and

$$a^2_{j,t} = \sum_{i \in A^j_t} \frac{P_{i,t} - P_{i+1,t}}{P_{t-1}} \times \frac{V_{i,t}}{V^j_t} \times N^j_t .$$

As above, the first measure of price effect is an equal-weighted measure. The second measure is a volume-weighted measure. Table 6 reports the price after-effect of the Ningbo Traders and the non-Ningbo traders. There is little after-effect for the Ningbo Traders when they bought shares. When they sell shares on the second days, the price impact is 3.29% under measure 1 and 2.38% under measure 2. It shows that the Ningbo Traders display significant skills in taking advantage of price fluctuations between trades. This result is consistent with that we found above with price pre-effects.

4.2. Order Placing and Withdrawing

Figure 5 graphs the distribution in frequency and in percentage of the orders by the Ningbo Traders price limit days. The left axis measures the frequency of orders and the right axis measures the percentage as of the total number of orders. We compare the frequency distribution for the ST stocks (top panel) and for the non-ST stocks (bottom panel). We see that there were

many small orders for the ST stocks. For the non-ST stocks, there were many orders larger than 150,000 shares per order.

Table 7 reports a summary of orders matched and withdrawn by the Ningbo Traders. Separately for buy and sell orders we report the number and the volume of orders matched or withdrawn, and the count and volume percentages. For buy orders, more than twice as many orders were withdrawn as those were matched. In terms of the number of orders, 52.60% were withdrawn and only 25.63% of the orders were filled. There were another 21.77% of orders only partially executed. Hence at least part of the orders expired at the end of the trading day. In terms of volume, 72.52% of the buy orders were withdrawn, and only 10.16% of the orders were executed. There is another 17.32% of the buy orders partially executed. On the sell side, the situation is quite different. More than three times as many orders were executed as those were withdrawn. In terms of volume, 65.66% of the sell orders were executed, and only 34.34% of the sell orders were withdrawn. Therefore order withdrawing is used much more frequently by the Ningbo Traders for buy orders than for sell orders.

There is also significant difference between buy and sell orders for the time elapsed between order time and trade time. Figure 6 graphs the distribution of time elapsed between order and trade by the Ningbo Traders in the price limit days. The top panel shows the result for the buy trades and the bottom panel shows the result for the sell trades. There are many more buy orders that took more than 10 seconds to be completed. At the time of order placing, the Ningbo Traders probably knew that many of these orders would not be filled immediately. The sale trades, on the other hand, were mostly filled within 10 seconds. About 45% of the sale orders were filled instantly. The Ningbo traders seemed to place these sale orders to be executed immediately.

Figure 7 graphs the distribution of percentages of an order withdrawn by the Ningbo Traders in the price limit days. For each order placed by the Ningbo Traders, we compute the ratio of the size of the order withdrawn over the size of the order placed. The top panel shows the result for the buy trades and the bottom panel shows the result for the sale trades. There is an apparent dichotomy between the orders filled and the orders withdrawn. For the buy orders, about 24% of the orders were filled. Yet about 70% of the orders had between 90% and 100% in size of each

order withdrawn. Hence the buy orders were placed either to be executed, or to be mostly withdrawn. For the sale trades, there is also an apparent dichotomy. But over 80% of the sale orders were filled.

There are two explanations for the order placing activities of the Ningbo Traders. The first is that they are trying to use the order placing activities to manipulate the stock prices. This explanation is supported by the fact that they tended to use large orders to lock the prices at the limit prices when they built up their positions. Since they often quickly withdrew the orders within a few seconds, it is apparent that they did not intend to have their orders filled. By frequently placing large orders at the limit prices and then quickly withdrew them, the Ningbo Traders created the impression that there were active trading at the limit prices.

The second explanation is more favorable to the Ningbo Traders. By withdrawing orders quickly the Ningbo Traders avoided being hit by large sell orders from large shareholders or market manipulators. The withdrawing activities made it difficult for those traders to unload large positions to the Ningbo Traders. They serve as tools to manage the risk of being hit by large sell orders. But then the question is why the Ningbo Traders place large orders at all if they did not intend to have those orders filled. It is apparent that they were interested in building up their positions on days when price limits were reached. In other words, they believe it is important for the stocks to reach price limits and stay there until market close. The overnight momentum for stocks that have reached price limits is higher than that for those stocks that have not reached price limits. This is clear from our analysis in the second section of the paper on price dynamics.

So the Ningbo Traders acted to promote price limit attainment, at least for those stocks they traded in. They were not completely passive in taking advantage of the short-term momentum associated with the price limits. But they were not manipulators in an asymmetric information equilibrium sense as discussed in Allen and Gale (1992) and Aggarwal and Wu (2003). The approach is similar to that analyzed by Jarrow (1992) in a dynamic model of asset markets. Jarrow investigates market manipulation trading strategies by large traders in a securities market. Market manipulation trading strategies are shown to exist if there is “price momentum.” The Ningbo Traders exploited the momentum inefficiency that existed in the stock market when

prices reach their daily limits.

It is likely that the Ningbo Traders possess special skills that identify stocks with stronger momentum when price limits were reached. To analyze this issue, we estimated the following modified model of daily momentum

$$r_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \lambda D_{t-1} + \varepsilon_t,$$

where D_t is a dummy variable that equals 1 if the Ningbo Traders traded the stock on a day price limits were reached and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume in ¥ and average turnover ratios. All the averages are taken over the entire sample period.

Table 8 reports the parameter estimates for the model. Note that the estimates that are significant at the 1% level are indicated by bold type. For all stocks, the estimate for the Ningbo dummy is positive but statistically insignificant. For the sorted samples, the parameter is mostly statistically insignificant except for large tradable capitalization and high trading volume stocks.

Table 9 reports the parameter estimates for the modified overnight momentum model

$$\overline{r_t} = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \lambda D_{t-1} + \varepsilon_t,$$

where $\overline{r_t}$ is the overnight return computed using the opening price of day t and the closing price of day t-1. All the parameter estimates for the Ningbo Traders are statistically insignificant. Combining results in Tables 7 and 8, we conclude that the Ningbo Trade did not have special skills in picking price limit stocks. Statistically the daily and overnight momentum exhibited by a stock traded by the Ningbo Traders is about the same as an average stock that reached price limit. The source of profit for the Ningbo Traders is the strong momentum associated with price limit events. This is especially true for the strategy that takes advantage of the overnight momentum.

4.3. The Performance of Stocks after Price Limits Were Reached

When Ningbo Traders participated in the trading of a stock whose price was very close to or at the daily limit, the liquidity of the stock as measured by turnover improved dramatically. Yet this benefit may be very short-term. We wonder if the Ningbo Traders were able to identify short-term under-pricing of the stocks other than the over night momentum effect. Since they made their profit by buying at a price close to the limit price and then sold those shares at a higher price on the second day, we can compute cumulative returns after price limits were reached.

Figure 8 graphs the average cumulative returns and cumulative excess returns for the stocks that reached price limits in our sample. We compute the mean returns for one day to 20 days after the stocks reached their daily price limits. We then cumulate the mean returns to get the plotted cumulative returns. The cumulative excess returns are computed from excess mean returns which are obtained by subtracting the returns of the composite index from the mean stock returns. The top panel shows the result for the stocks that the Ningbo Traders traded in. It is apparent the both the cumulative return and cumulative excess return decline over the 20 days after price limits were reached. Essentially all the abnormal returns were earned on the day right after the price limits were reached. Price momentum virtually disappeared after that and there is evidence of price reversal.

The bottom panel shows the result for the stocks that the Ningbo Traders did not traded in. It is interesting to note that the cumulative returns and cumulative excess returns stayed high for the first 10 days. They declined to zero in the next two days and then rebounded to 2-3% in the next few days. When we combine the two graphs we do not find any difference in performance between stocks the Ningbo Traders traded and the other price limit stocks. If anything, the second day momentum associated with Ningbo Traders is reversed at the end of the 20 trading day period. We conclude that the Ningbo Traders were not able to identify short-term under-pricing of the stocks in addition to the overnight momentum effect associated with price limits.

Overall we do not think trades by the Ningbo Traders reflect private information. Their trading strategy seems to be based almost entirely on the overnight momentum effects associated with price limit events. Their order placing and buying activities are suspicious of manipulation, but it is mostly limited to keeping stock prices at the limit prices. Stocks that reached price limits often attract much attention from the financial media and the investing public. The Ningbo Traders cannot credibly pose as informed traders, but they are likely good researchers in finding market inefficiencies and designing profitable strategies. Daily price limits are obviously responsible for this inefficiency.

Due to the short history of the Chinese stock market, price limits may be a useful tool in reducing market speculation and volatility. Information released to the market needs to be analyzed by investors who are still learning to invest in the capital market. Removing daily price limits completely in the near future may be counter-productive and unnecessary. We think it may be appropriate to phase out the limits, starting with a set of "blue chip" stocks – large and profitable companies with a good record of information disclosure and corporate governance.

5. Concluding Remarks

In this paper we investigate short-term trading strategies in the presence of daily price limits. Although researchers previously have not found any short-term momentum in the Chinese stock market, we find that there is significant daily and overnight momentum associated with price limit events. Moreover, profitable trading strategies can be devised to take advantage of the momentum.

We are able to identify ten stock trading accounts that specialized in trading off the daily price limits. We obtain data on orders and trades with account owner information. These traders have generated significant profit taking overnight positions in stocks that reached their daily price limits. They purchased stocks at or close to limit prices and sold out shortly after market opening the next trading day. They would place large buy orders at limit prices to keep prices

there. Stocks that reached price limits often attract much attention from the financial media and the investing public. These traders usually would withdraw these large orders shortly after they were placed. Their order placing and buying activities are suspicious of manipulation, but it is mostly limited to keeping stock prices at the limit prices. We did not find evidence that these traders possessed special skills in identifying stocks with stronger momentum than an average stock that reached its price limit, or in identifying stocks that were temporarily under-priced.

References

Aggarwal, Rajesh, and Guojun Wu, 2003, "Stock Market Manipulation – Theory and Evidence", working paper, University of Michigan.

Allen, Franklin, and Douglas Gale, 1992, "Stock-Price Manipulation", Review of Financial Studies, 5, 503-529.

Allen, Franklin, and Gary Gorton, 1992, "Stock Price Manipulation, Market Microstructure and Asymmetric Information", European Economic Review, 36, 624-630.

Cho, D., and J. Russell, 2001, "The Magnet Effect of Price Limits: Evidence from High Frequency Data on the Taiwan Stock Exchange," working paper, Graduate School of Business, University of Chicago.

Choi, W. S., and S. B. Lee, 2001, "Price Limits and Asymmetry of Transitory Price Dynamics: Intraday Evidence from the Korea Stock Exchange," working paper, Department of Business Administration, Hanyang University.

Daniel, K., D. Hirshleifer, and A. Subrahmanyam, 1998, "Investor Psychology and Security Market under- and Overreactions," Journal of Finance, 53, 1839-1885.

DeBondt, W. F. M., and R. Thaler, 1985, "Does the Stock Market Overreact?" Journal of Finance, 40, 793-808.

DeBondt, W. F. M., and R. Thaler, 1987, "Further Evidence on Investor Overreaction and Stock Market Seasonality," Journal of Finance, 42, 557-581.

Fama, E. F., 1989, "Perspectives on October 1987, or What Did We Learn from the Crash?" in R. Kampuis, R. Kormendi, & J. Watson (eds.), Black Monday and the Future of Financial Markets, 71-82, Homewood, IL, Irwin.

Felixson, Karl, and Anders Pelli, 1999, "Day End Returns--Stock Price Manipulation", Journal of Multinational Financial Management, 9, 95-127.

Gerard, Bruno, and Vikram Nanda, 1993, "Trading and Manipulation Around Seasoned Equity Offerings", Journal of Finance, 48, 213-245.

Hirshleifer, D. Subrahmanya and S. Titman, 1994, "Security Analysis and Trading Patterns when Some Investors Receive Information Before Others," Journal of Finance, 49, 1665-1698.

Jarrow, Robert A., 1992, "Market Manipulation, Bubbles, Corners, and Short Squeezes," Journal of Financial and Quantitative Analysis, 27, 311-336.

Jarrow, Robert A., 1994, "Derivative Security Markets, Market Manipulation, and Option Pricing Theory", Journal of Financial and Quantitative Analysis, 29, 241-261.

Jegadeesh, N., and S. Titman, 1993, Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," Journal of Finance, 48, 65-91.

Jordan, Bradford D., and Susan D. Jordan, 1996, "Salomon Brothers and the May 1991 Treasury Auction: Analysis of a Market Corner", Journal of Banking & Finance, 20, 25-40.

Khwaja, Asim Ijaz, and Atif Mian, 2003, "Price Manipulation and "Phantom" Markets -- An In-depth Exploration of a Stock Market," working paper, University of Chicago.

Kim, K. A., and S. G. Rhee, 1997, Price Limit Performance: Evidence from the Tokyo Stock Exchange," Journal of Finance, 52, 885-901.

Kumar, Praveen, and Duane J. Seppi, 1992, "Futures Manipulation with `Cash Settlement'", Journal of Finance, 47, 1485-1502.

Lee, S. B., and K. J. Kim, 1995, "The Effect of Price Limits on Stock Price Volatility: An Empirical Evidence in Korea," Journal of Business Finance and Accounting, 22, 257-267.

Li, Shunlei, Hongwei Tian, Biao Zhang, Wenzhang Zhang, and Wen Yang, 2001, "What will happen when Stock Price Is Close to the Limit? Evidence from the Shanghai Stock Exchange" Shanghai Stock Exchange Research Report.

Liu, X. F., X. G. Liu, and C. Z. Tian, 2001, "An Analysis on the Effects of Price Limits," International Finance Research.

Kyle, A. S., 1985, "Continuous Auctions and Insider Trading," Econometrica, 53(6): 1315-1335.

Ma, C. K., R. P. Rao, and R. S. Sears, 1989, "Volatility, Price Resolution, and the Effectiveness of Price Limits," Journal of Financial Services Research, 3, 165-199.

Mahoney, Paul G., 1999, "The Stock Pools and the Securities Exchange Act," Journal of Financial Economics, 51, 343-369.

Merrick, John J., Narayan Y. Naik, and Pradeep K. Yadav, 2003, "Strategic Trading Behavior and Price Distortion in a Manipulated Market: Anatomy of a Squeeze," Journal of Financial Economics, forthcoming.

Richards, A., 1997, "Winner-Loser Reversals in National Stock Market Indices: Can They Be Explained?" Journal of Finance, 52, 2129-2144.

Shi, Donghui, 2002, "Price Limit and Price Behavior: An Empirical Study on the Shanghai and Shenzhen Stock Market," Shanghai Stock Exchange Research Report.

Shi, D., and P. Y. Sun, 2001, "Do Price Limits Lower Stock Volatility?" Securities Market Herald, 11-17.

Van Bommel, Jos, 2003, "Rumors," Journal of Finance, forthcoming.

Vitale, Paolo, 2000, “Speculative Noise Trading and Manipulation in the Foreign Exchange Market”, Journal of International Money and Finance, 19, 689-712.

Wu, C. F., H. L. Liu, W. F. Wu, and Q. G. Mu, 2002, “Price Limits and Price Volatility,” Shanghai Stock Exchange research paper.

Wu, Y. R., 2002, “Momentum and Reversal in the Chinese Stock Market,” Shanghai Stock Exchange research paper.

Zarowin, P., 1989, “Short-run Market Overreaction: Size and Seasonality Effects,” Journal of Portfolio Management, 15, 26-29.

Figure 1: Number of Price Limit Events

This figure graphs the time series of the number of stocks that reached price limits during the sample period from January 2001 to July 2003. The top panel graphs all stocks that reached price limits, and the bottom panel graphs the number of those stocks that the Ningbo Traders traded in. The sample period is from January 2001 to July 2003.

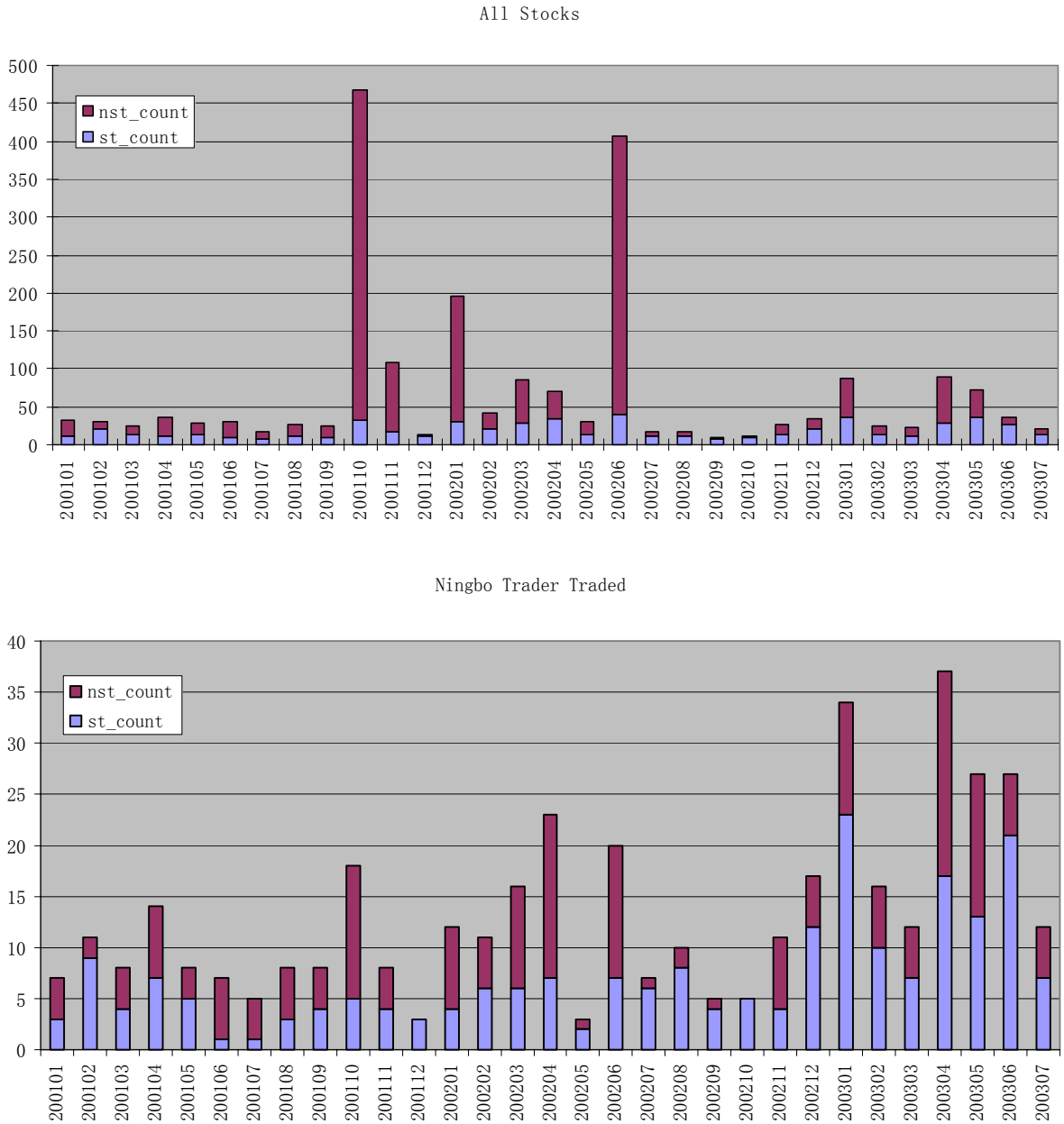


Figure 2: Number of Trades and Trading Volume for the Ningbo Accounts

This figure graphs the number of trades and the trading volume on price limit days and the second days for the accounts owned by the Ningbo Traders. There are a total of 10 accounts. The left axis shows the number of trades for each of the 10 accounts, and the right axis shows the associated trading volume in the number of shares. The sample period is from January 2001 to July 2003.

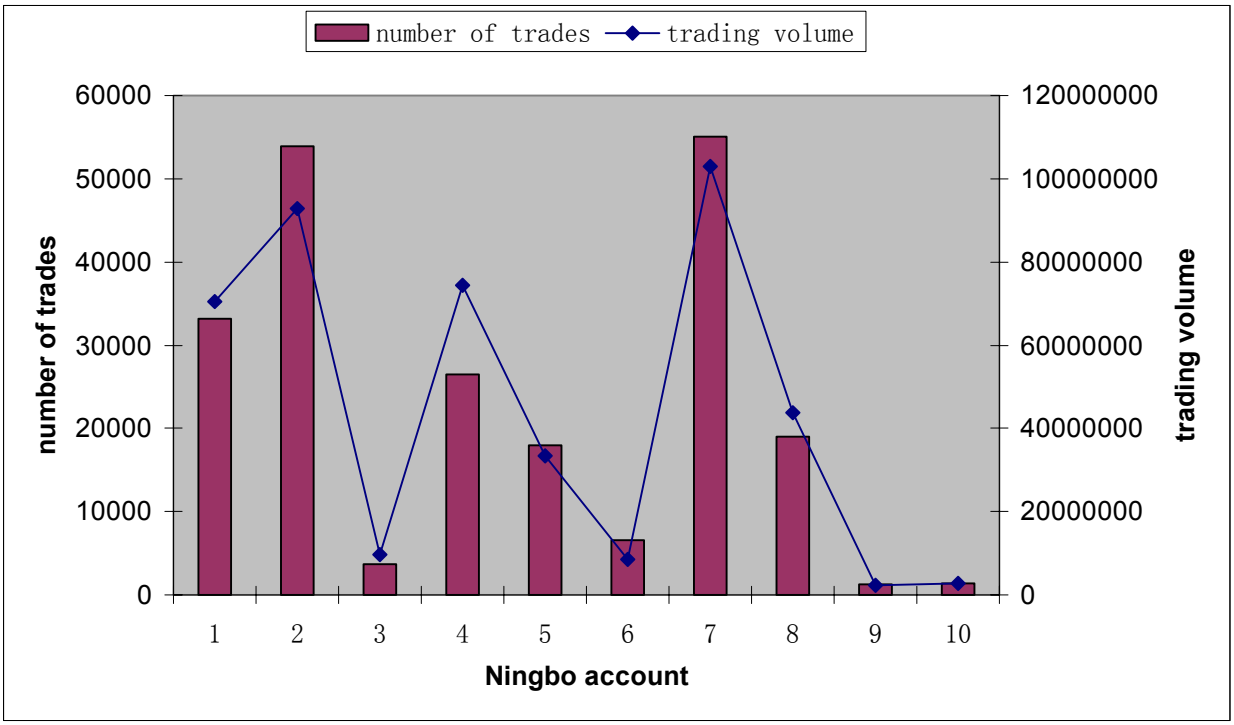


Figure 3: Number of Trades and Trading Volume for Non-Ningbo Accounts

This figure graphs the distribution for the number of trades and the trading volume for all non-Ningbo stock trading accounts that traded stocks on the price limit days and the second days. The top panel graphs the distribution for the number of trades and the bottom panel graphs the trading volume in shares. The sample period is from January 2001 to July 2003.

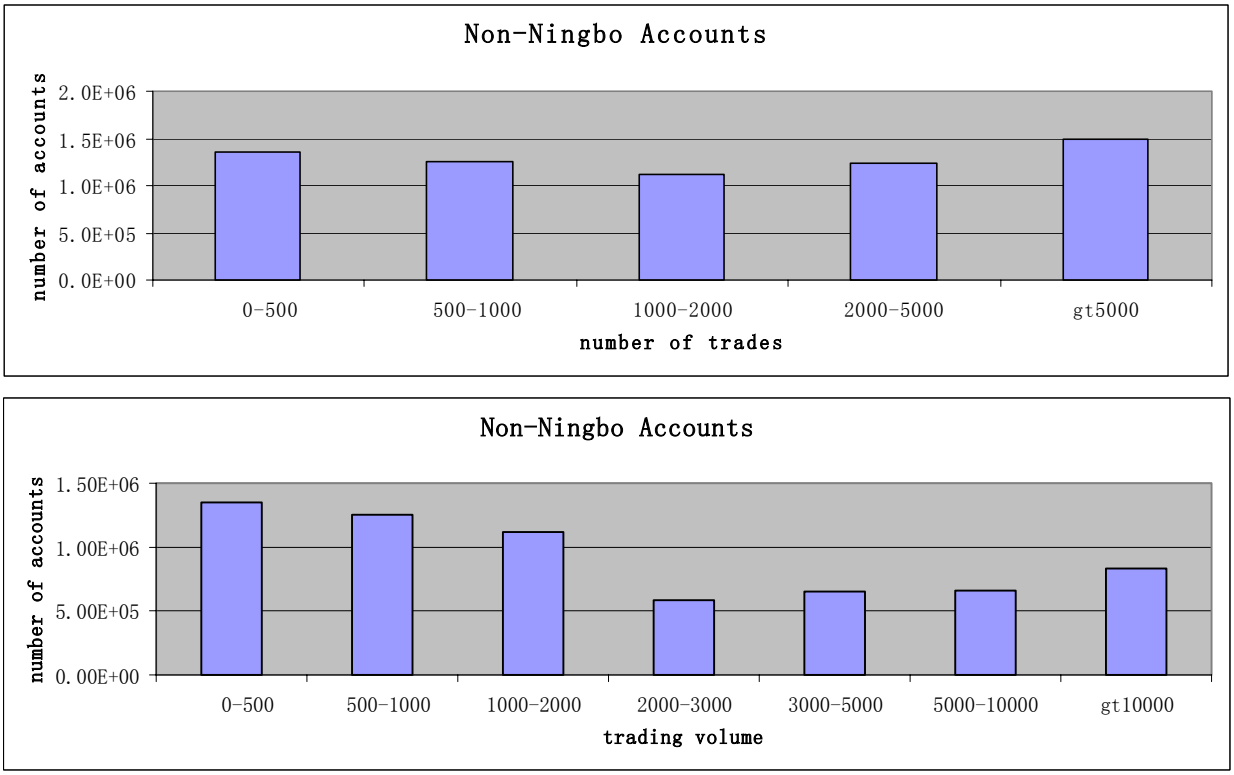


Figure 4: Distribution of Profit by the Ningbo Traders

This figure graphs profit and loss of the Ningbo traders for each of the 10 accounts for only those 317 events where the Ningbo Traders sold exactly the same number of shares on the second days as they bought on the price limit days. The profit also excludes the round-trip 0.4% transactions tax and 0.03% stock exchange service fee. All in RMB Yuan (¥). The sample period is from January 2001 to July 2003.

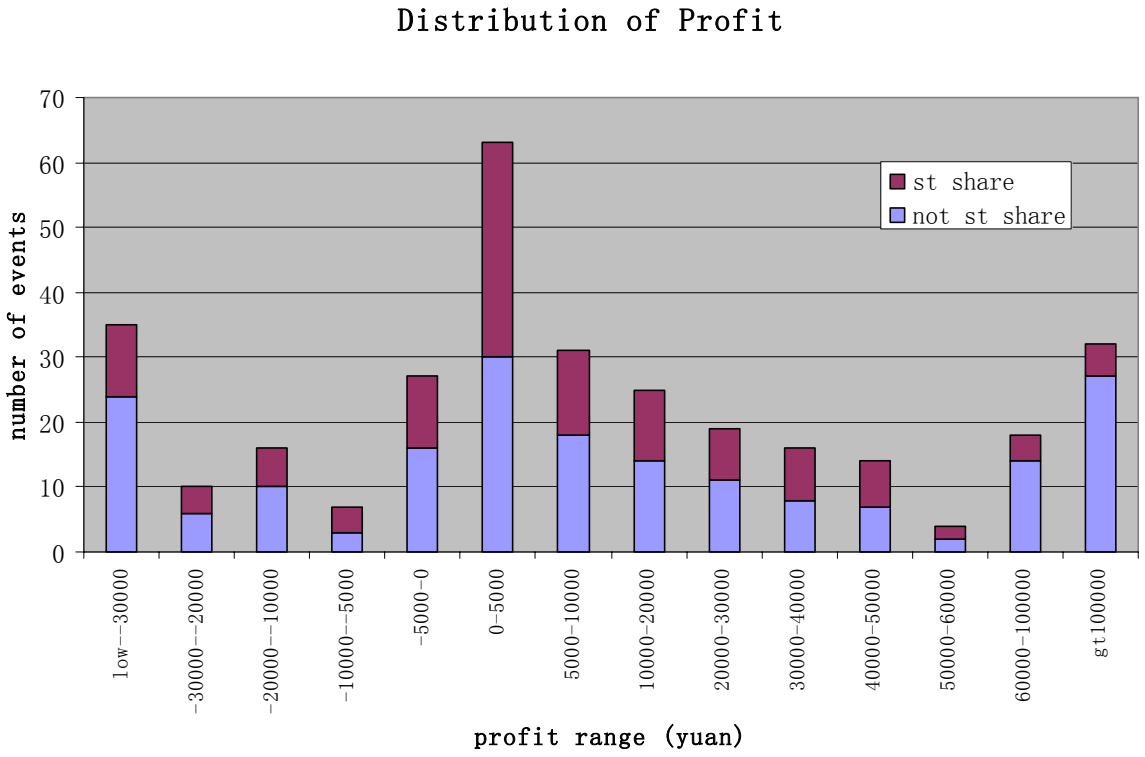


Figure 5: Distribution of Orders by the Ningbo Traders

This figure graphs the distribution in frequency and in percent of the orders by the Ningbo Traders in the day price limits were reached. The left axis measures the frequency of orders and the right axis measures the percent as of the total number of orders. The top panel shows the distribution for the ST stocks and the bottom panel shows the distribution for the non-ST stocks. The sample period is from January 2001 to July 2003.

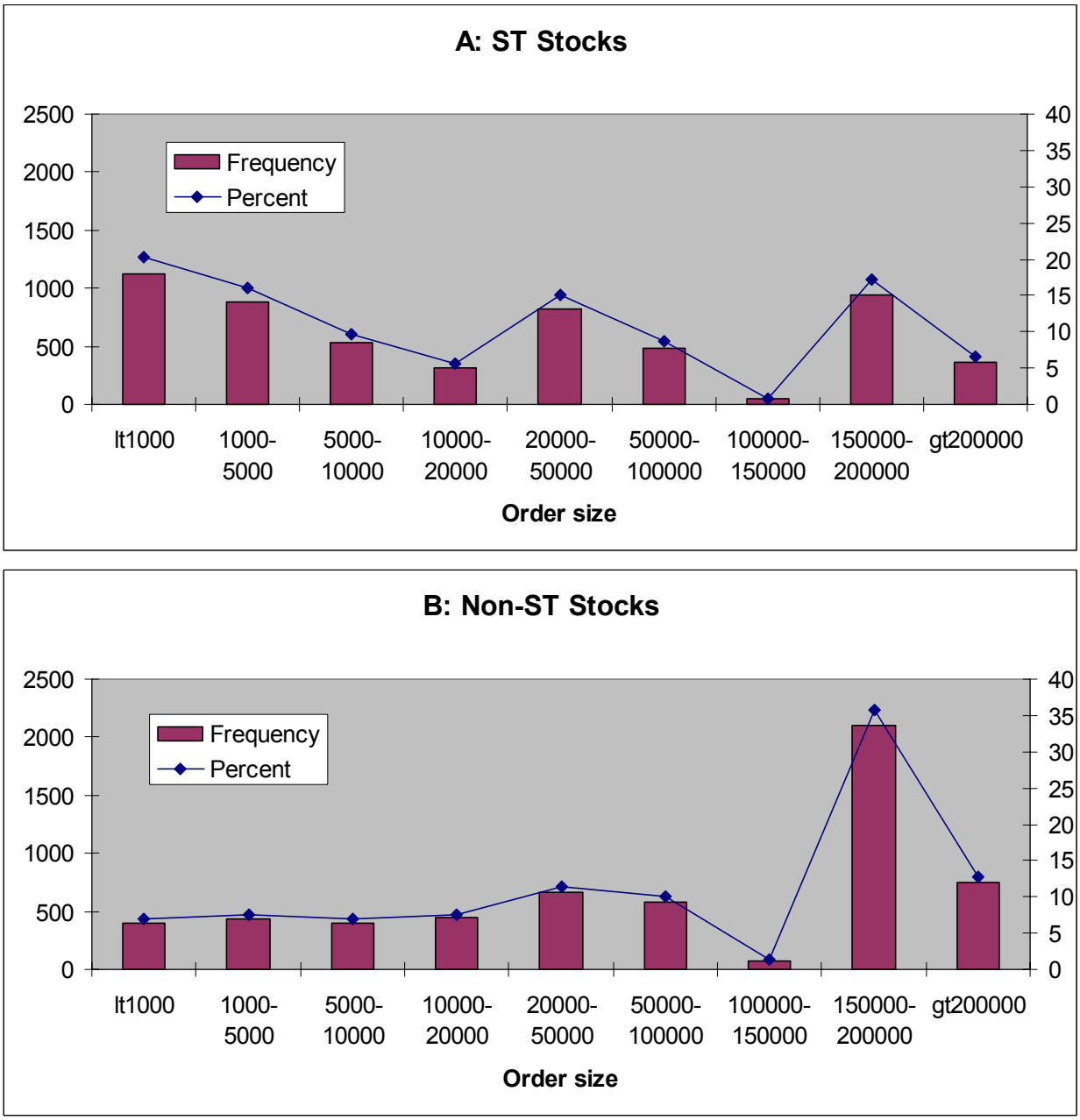


Figure 6: Time Elapsed between Order and Trade for the Ningbo Traders

This figure graphs the distribution of time elapsed between order and trade by the Ningbo Traders in the price limit days. The top panel shows the result for the buy trades and the bottom panel shows the result for the sell trades. The sample period is from January 2001 to July 2003.

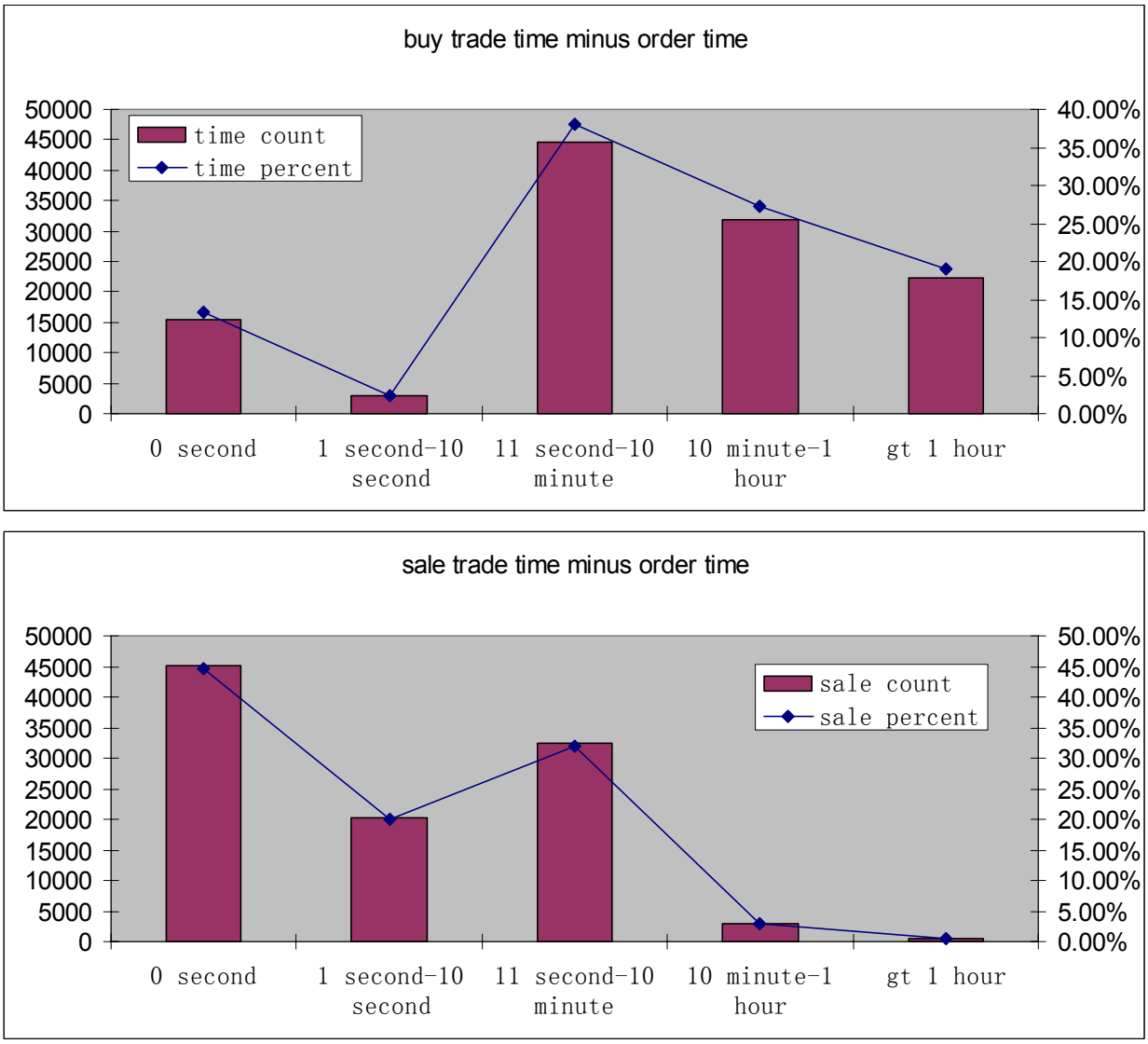


Figure 7: Percentages of an Order Withdrawn by the Ningbo Traders

This figure graphs the distribution of percentages of an order withdrawn by the Ningbo Traders in the price limit days. The top panel shows the result for the buy trades and the bottom panel shows the result for the sell trades. The sample period is from January 2001 to July 2003.

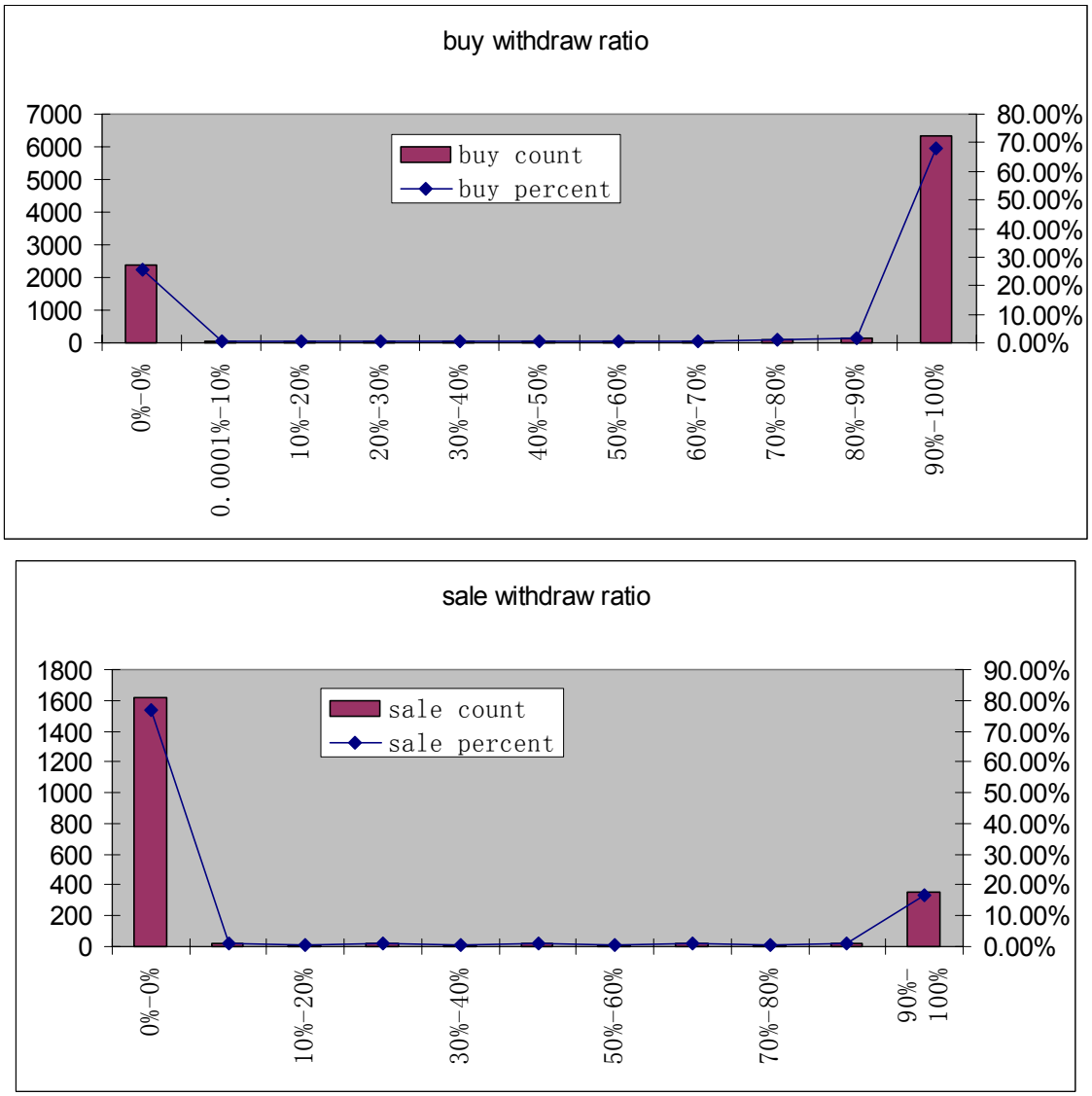
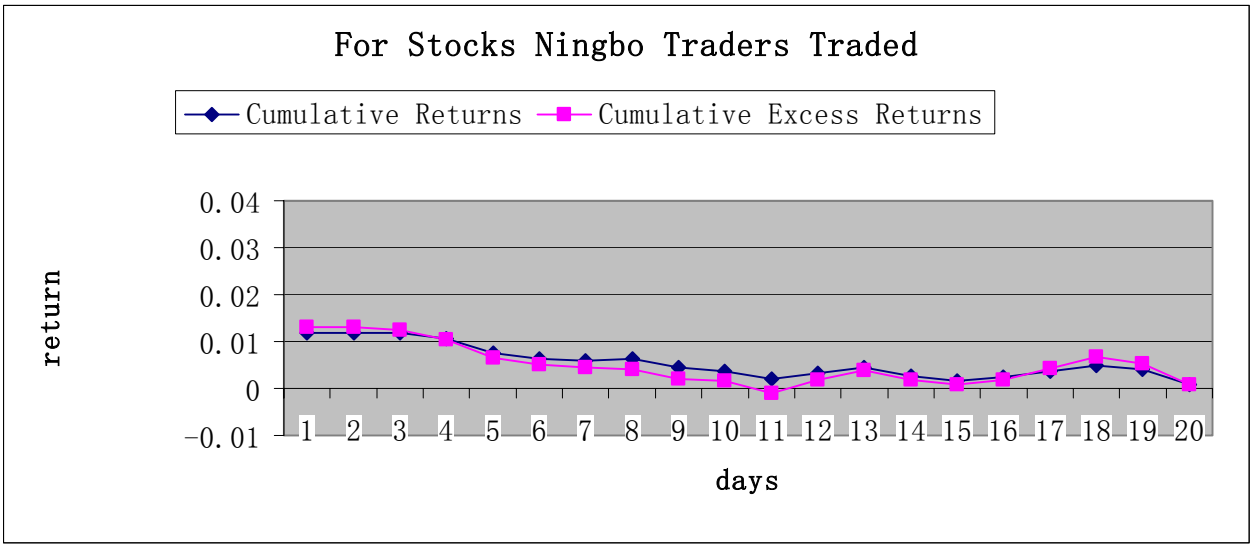


Figure 8: Performance of Stocks after Reaching Price Limits

This figure graphs the average cumulative returns and cumulative excess returns for the stocks that reached price limits in our sample. We compute the mean returns for one day to 20 days after the stocks reached their daily price limits. We then cumulate the mean returns to get the plotted cumulative returns. The cumulative excess returns are computed from excess mean returns which are obtained by subtracting the returns of the composite index from the mean stock returns. The top panel shows the result for the stocks that the Ningbo Traders traded in, and the bottom panel shows the result for the stocks that the Ningbo Traders did not traded in. The sample period is from January 2001 to July 2003.



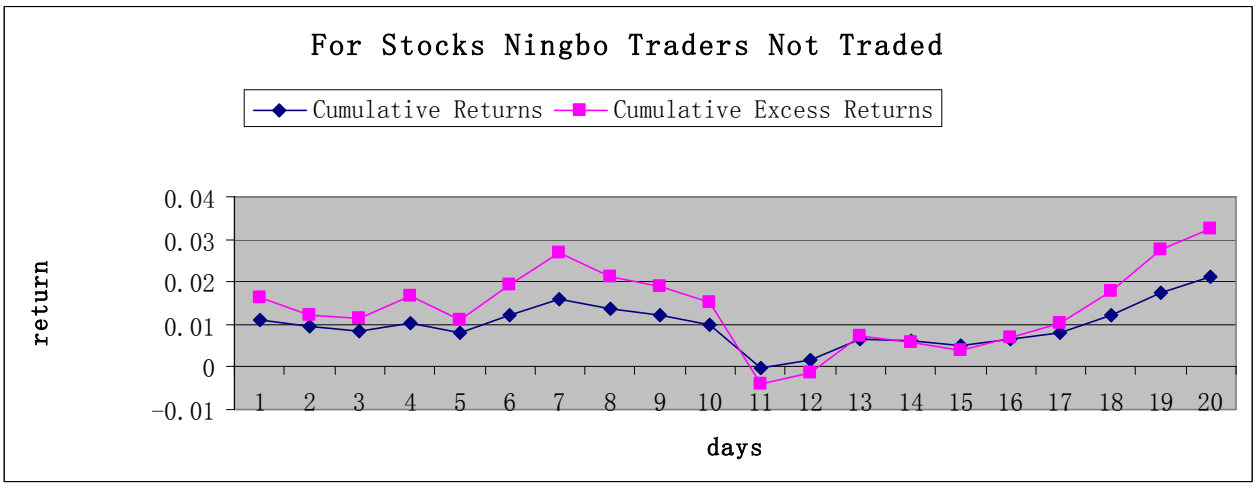


Table 1: Parameter Estimates for the Daily Momentum Model

This table reports parameter estimates for the following daily momentum model

$$r_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \varepsilon_t,$$

where r_t is the daily return of the stock, and I_t is an indicator function that equals 1 if the price limit is reached on day t and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume in ¥ and average turnover ratios. All the averages are taken over the entire sample period. Standard errors are reported in parentheses. The parameter estimates that are significant at the 1% level are indicated by bold type. The sample period is from January 2001 to July 2003.

	α	β	γ		α	β	γ
all stocks:							
	0.0000	-0.0012	**0.0102**				
	(0.0001)	(0.0016)	(0.0011)				
capitalization:				tradable capitalization:			
small	-0.0015	0.0176	-0.0043	small	0.0004	-0.0014	**0.0075**
	(0.0010)	(0.0424)	(0.0096)		(0.0003)	(0.0030)	(0.0029)
medium	-0.0002	0.0022	0.0055	medium	**-0.0002**	0.0024	**0.0121**
	(0.0006)	(0.0064)	(0.0058)		(0.0001)	(0.0029)	(0.0014)
large	0.0000	-0.0021	**0.0108**	large	**-0.0002**	-0.0044	**0.0111**
	(0.0001)	(0.0017)	(0.0012)		(0.0001)	(0.0029)	(0.0009)
trading volume:				turnover:			
low	-0.0001	-0.0020	**0.0113**	low	-0.0002	-0.0024	**0.0121**
	(0.0002)	(0.0027)	(0.0024)		(0.0002)	(0.0027)	(0.0026)
medium	0.0000	0.0012	**0.0093**	medium	-0.0001	0.0026	**0.0100**
	(0.0001)	(0.0028)	(0.0019)		(0.0001)	(0.0029)	(0.0013)
high	0.0001	-0.0045	**0.0097**	high	0.0003	-0.0011	**0.0079**
	(0.0001)	(0.0031)	(0.0013)		(0.0002)	(0.0032)	(0.0021)

Table 2: Parameter Estimates for the Overnight Momentum Model

This table reports parameter estimates for the following daily momentum model

$$\bar{r}_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \varepsilon_t,$$

where $\bar{r}_t$ is the return computed using the opening price of day t and the closing price of day t-1, r_t is the daily return of the stock, and I_t is an indicator function that equals 1 if the price limit is reached on day t and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume in ¥ and average turnover ratios. All the averages are taken over the entire sample period. Standard errors are reported in parentheses. The parameter estimates that are significant at the 1% level are indicated by bold type. The sample period is from January 2001 to July 2003.

	α	β	γ		α	β	γ
all stocks:							
	-0.0129	**0.0098**	**0.0066**				
	(0.0002)	(0.0037)	(0.0026)				
capitalization:				tradable capitalization:			
small	**-0.0148**	0.0229	0.0340	small	**-0.0146**	0.0039	**0.0104**
	(0.0047)	(0.2014)	(0.0454)		(0.0005)	(0.0051)	(0.0050)
medium	**-0.0178**	0.0033	0.0180	medium	**-0.0117**	**0.0224**	**0.0122**
	(0.0010)	(0.0114)	(0.0103)		(0.0003)	(0.0090)	(0.0043)
large	**-0.0124**	**0.0100**	**0.0073**	large	**-0.0122**	**0.0400**	-0.0026
	(0.0002)	(0.0040)	(0.0027)		(0.0003)	(0.0136)	(0.0045)
trading volume:				turnover:			
low	**-0.0109**	0.0055	0.0073	low	**-0.0102**	0.0043	0.0056
	(0.0003)	(0.0049)	(0.0044)		(0.0003)	(0.0049)	(0.0048)
medium	**-0.0134**	0.0051	**0.0205**	medium	**-0.0130**	**0.0178**	**0.0102**
	(0.0004)	(0.0068)	(0.0045)		(0.0003)	(0.0091)	(0.0040)
high	**-0.0143**	**0.0373**	-0.0072	high	**-0.0159**	0.0130	0.0081
	(0.0004)	(0.0113)	(0.0048)		(0.0004)	(0.0075)	(0.0050)

Table 3: Profit and Loss of the Ningbo Traders

This table reports summary statistics of profit and loss of the Ningbo traders. There are a total of 10 accounts involved in the trading strategy. In Panel A, we report the profits treating each account as being separate. In Panel B we report the profits for the sum of the 10 accounts as if they were all owned by the same group. In Panel C we report profit for each of the 10 accounts for only those 317 events where the Ningbo Traders sold exactly the same number of shares on the second days as they bought on the price limit days. The profit in Panel C also excludes the round-trip 0.4% transactions tax and 0.03% stock exchange service fee. All in RMB Yuan (¥). The sample period is from January 2001 to July 2003.

Panel A: For each of the 10 accounts

All shares	N	Mean	StdDev	Minimum	Maximum	Median	Lower quartile	Upper quartile
Profit1	658	38435.88	155554.9	-630646	1704093	965.52	0	31463.18
Profit2	658	53410.33	245756.3	-1040000	2980490	3893.5	0	44798
ST share								
Profit1	309	13659.59	48875.06	-110581	487600	120	0	21021.49
Profit2	309	18678.39	93270.19	-777115	975199	2513.79	0	28819.38
Non-ST share								
Profit1	349	60372.48	206254.8	-630646	1704093	2493.64	0	51227.74
Profit2	349	84161.53	322962.6	-1040000	2980490	6263.98	0	69323.06

Panel B: For the sum of the 10 accounts

All shares	N	Mean	StdDev	Minimum	Maximum	Median	Lower quartile	Upper quartile
Profit1	502	50174.17	208905.3	-630646	2155301	818.2802	0	40246.72
Profit2	502	70907.45	328975.5	-1040000	3644274	4903	0	55286
ST share								
profit1	253	16503.90	59066.88	-211227	487600	0	0	23844
profit2	253	24538.53	110720.7	-777115	975199	2760.06	0	38560.38
Non-ST share								
profit1	249	84385.33	286855.2	-630646	2155301	3609.1	0	74671.12
profit2	249	118021.30	449169	-1040000	3644274	8520	0	90911.78

Panel C: For each of the 10 accounts: matched buy and sell with transactions cost

All shares	N	Mean	StdDev	Minimum	Maximum	Median	Lower quartile	Upper quartile
Profit	317	31345.68	1387574	-366205	138194.7	5264.43	-2135.41	31738.59
ST share								
Profit	127	10930.54	45152.86	-116045	228032.3	2982.12	-373.307	21261.97
Non-ST share								
profit	190	44991.59	173505.7	-366205	1387574	6543.5	-3635.72	41009.88

Table 4: Summary of Price Differentials for the Ningbo Traders

This table reports summary statistics of the price differentials for the Ningbo Traders on the price limit days and the second days. For each of the 10 Ningbo accounts and each of the price limit events, we compute the following price differentials:

(1) $\Delta p_1 = p_{t,B} - p_{t,CLOSE}$, where $p_{t,B}$ is the volume-weighted purchase price paid by the Ningbo Traders, and $p_{t,CLOSE}$ is the closing price on the price limit day; and $\%\Delta p_1 = (p_{t,B} - p_{t,CLOSE}) / p_{t,CLOSE}$ is the relative measure of the price differential;

(2) $\Delta p_2 = p_{t,B} - p_{t,LIMIT}$, where $p_{t,B}$ is the volume-weighted purchase price paid by the Ningbo Traders, and $p_{t,LIMIT}$ is the limit price on the price limit day; and $\%\Delta p_2 = (p_{t,B} - p_{t,LIMIT}) / p_{t,LIMIT}$ is the relative measure of the price differential;

(3) $\Delta p_3 = p_{t+1,S} - p_{t+1,CLOSE}$, where $p_{t+1,S}$ is the volume-weighted sale price received by the Ningbo Traders, and $p_{t+1,CLOSE}$ is the closing price on the second day; and $\%\Delta p_3 = (p_{t+1,S} - p_{t+1,CLOSE}) / p_{t+1,CLOSE}$ is the relative measure of the price differential;

(4) $\Delta p_4 = p_{t+1,S} - p_{t+1,OPEN}$, where $p_{t+1,S}$ is the volume-weighted sale price received by the Ningbo Traders, and $p_{t+1,OPEN}$ is the opening price on the second day; and $\%\Delta p_4 = (p_{t+1,S} - p_{t+1,OPEN}) / p_{t+1,OPEN}$ is the relative measure of the price differential;

The sample period is from January 2001 to July 2003.

	Mean	Std	Minimum	Maximum
$\Delta p_1 = p_{t,B} - p_{t,CLOSE}$	0.025485	0.180377	-2.13758	1
$\%\Delta p_1 = (p_{t,B} - p_{t,CLOSE}) / p_{t,CLOSE}$	0.002853	0.015971	-0.12885	0.075758
$\Delta p_2 = p_{t,B} - p_{t,LIMIT}$	-0.03392	0.1775	-2.13758	7.11E-15
$\%\Delta p_2 = (p_{t,B} - p_{t,LIMIT}) / p_{t,LIMIT}$	-0.00272	0.012148	-0.12885	8.10E-16
$\Delta p_3 = p_{t+1,S} - p_{t+1,CLOSE}$	0.018087	0.314631	-1.26	1.72
$\%\Delta p_3 = (p_{t+1,S} - p_{t+1,CLOSE}) / p_{t+1,CLOSE}$	0.002294	0.024652	-0.10151	0.094017
$\Delta p_4 = p_{t+1,S} - p_{t+1,OPEN}$	0.008722	0.218539	-0.96685	1.173888
$\%\Delta p_4 = (p_{t+1,S} - p_{t+1,OPEN}) / p_{t+1,OPEN}$	0.000907	0.018315	-0.07392	0.083204

Table 5: Price Effects of Trades

This table reports summary statistics of the price effects measure for the Ningbo Traders and non-Ningbo Traders. We study four types of trades: Ningbo Traders' and non-Ningbo traders' buy trades on the first day, and the Ningbo Traders' and non-Ningbo traders' sell trades on the second day. Let P_t be the closing price of the t th trading day; $P_{i,t}$ be the i th trade in day t; $V_{i,t}$ be the size of the i th trade of day t; and V_t^j and N_t^j be the trading volume and the number of type *j* trades in day t. The price impact of the i th trade is defined as: $\frac{P_{i,t} - P_{i-1,t}}{P_{t-1}}$. We define measure 1 and measure 2 of price impact for type *j* trades on day *t* to be

$$d_{j,t}^1 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i-1,t}}{P_{t-1}},$$

$$d_{j,t}^2 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i-1,t}}{P_{t-1}} \times \frac{V_{i,t}}{V_t^j} \times N_t^j,$$

The first measure of price effect is an equal-weighted measure. The second measure is a volume-weighted measure. The sample period is from January 2001 to July 2003.

Variable	Mean	StdDev	N	Maximum	Minimum
		Price limit day buy trades			
d^1 Ningbo Traders	0.000314991	0.0151213	410	0.1648148	-0.1053284
d^2 Ningbo Traders	-0.000294669	0.0189511	410	0.2053296	-0.1622677
d^1 non-Ningbo Traders	0.0318591	0.0460221	2141	0.1925193	-0.1548288
d^2 non-Ningbo Traders	0.1066157	0.5353522	2141	15.4524938	-4.5753041
		Second day sell trades			
d^1 Ningbo Traders	0.0328528	0.0684536	379	0.3861386	-0.4252427
d^2 Ningbo Traders	0.0246145	0.0767837	379	0.4388882	-0.6143076
d^1 non-Ningbo Traders	-0.0073791	0.0416826	2141	0.3864078	-0.3926174
d^2 non-Ningbo Traders	0.0347361	0.5528572	2141	16.9675412	-3.5365897

Table 6: Price After-Effects of Trades

This table reports summary statistics of the price after-effects measure for the Ningbo Traders and non-Ningbo Traders. We study four types of trades: Ningbo Traders' and non-Ningbo traders' buy trades on the first day, and the Ningbo Traders' and non-Ningbo traders' sell trades on the second day. Let P_t be the closing price of the t th trading day; $P_{i,t}$ be the i th trade in day t; $V_{i,t}$ be the size of the i th trade of day t; and V_t^j and N_t^j be the trading volume and the number of type *j* trades in day t. The price after-effect of the i th trade is defined as: $\frac{P_{i,t} - P_{i+1,t}}{P_{t-1}}$. We define measure 1 and measure 2 of price impact for type *j* trades on day *t* to be

$$a_{j,t}^1 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i+1,t}}{P_{t-1}},$$

$$a_{j,t}^2 = \sum_{i \in A_t^j} \frac{P_{i,t} - P_{i+1,t}}{P_{t-1}} \times \frac{V_{i,t}}{V_t^j} \times N_t^j,$$

The first measure of price effect is an equal-weighted measure. The second measure is a volume-weighted measure. The sample period is from January 2001 to July 2003.

Variable	Mean	StdDev	N	Maximum	Minimum
		Price limit day buy trades			
a^1 Ningbo Traders	-0.0042344	0.0204827	392	0.0577105	-0.210582
a^2 Ningbo Traders	-0.0042785	0.0252209	392	0.0845552	-0.2640224
a^1 non-Ningbo Traders	-0.0312351	0.0461691	2462	0.1773221	-0.1886943
a^2 non-Ningbo Traders	0.0526402	0.7362545	2462	20.9612714	-6.6618005
		Second day sell trades			
a^1 Ningbo Traders	0.0329352	0.047575	223	0.3724832	-0.0312869
a^2 Ningbo Traders	0.0238081	0.0528271	223	0.3781774	-0.1158111
a^1 non-Ningbo Traders	-0.000661396	0.0356611	2462	0.1491228	-0.3221477
a^2 non-Ningbo Traders	0.0167708	0.7432602	2462	22.9831814	-4.8806453

Table 7: Summary of Orders Matched and Withdrawn by the Ningbo Traders

This table reports a summary of orders matched and withdrawn by the Ningbo Traders on price limit days. Separately for buy and sell orders we report the number and the volume of orders matched or withdrawn, and the count and the volume percentages. "Trade completed" indicates that the entire order has been filled. "Withdrawn" indicates part or all of the order has been withdrawn. "Other" indicates at least part of the order was not filled and the order was not withdrawn. Hence, at least part of the order expired at the end of the trading day. The sample period is from January 2001 to July 2003.

Trade flag	count	Order-volume	Count-percentage	Volume-percentage
		Buy orders		
Traded completed	2374	165790100	25.63%	10.16%
Other	2017	282754900	21.77%	17.32%
Withdrawn	4872	1183649300	52.60%	72.52%
		Sell orders		
Trade completed	1616	44846684	76.81%	65.66%
Withdrawn	488	23459279	23.19%	34.34%

Table 8: Parameter Estimates for the Modified Daily Momentum Model

This table reports parameter estimates for the following daily momentum model

$$r_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \lambda D_{t-1} + \varepsilon_t,$$

where r_t is the daily return of the stock, and I_t is an indicator function that equals 1 if the price limit is reached on day t and zero otherwise. D_t is a dummy variable that equals 1 if the Ningbo Traders traded the stock on a day price limits were reached and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume in ¥ and average turnover ratios. All the averages are taken over the entire sample period. Standard errors are reported in parentheses. The parameter estimates that are significant at the 1% level are indicated by bold type. The sample period is from January 2001 to July 2003.

	α	β	γ	λ		α	β	γ	λ
all stocks:									
	0.0000	−0.0011	**0.0099**	0.0020					
	(0.0001)	(0.0016)	(0.0012)	(0.0031)					
capitalization:					tradable capitalization:				
small	−0.0015	0.0169	−0.0030	−0.0022	small	0.0004	−0.0014	**0.0074**	0.0005
	(0.0010)	(0.0428)	(0.0146)	(0.0186)		(0.0003)	(0.0030)	(0.0032)	(0.0073)
medium	−0.0002	0.0022	0.0058	−0.0015	medium	**−0.0002**	0.0026	**0.0117**	0.0036
	(0.0006)	(0.0064)	(0.0065)	(0.0141)		(0.0001)	(0.0029)	(0.0015)	(0.0042)
large	0.0000	−0.0019	**0.0103**	0.0031	large	**−0.0002**	−0.0041	**0.0103**	**0.0060**
	(0.0001)	(0.0017)	(0.0012)	(0.0033)		(0.0001)	(0.0029)	(0.0010)	(0.0027)
trading volume:					turnover: turnover:				
low	−0.0001	−0.0021	**0.0119**	−0.0046	low		−0.0025	**0.0133**	−0.0152
	(0.0002)	(0.0027)	(0.0026)	(0.0075)		(0.0002)	(0.0027)	(0.0027)	(0.0094)
medium	0.0000	0.0011	**0.0096**	−0.0022	medium	−0.0001	0.0028	**0.0096**	0.0037
	(0.0001)	(0.0028)	(0.0020)	(0.0051)		(0.0001)	(0.0029)	(0.0013)	(0.0037)
high	0.0001	−0.0035	**0.0073**	**0.0123**	high	0.0003	−0.0005	**0.0059**	0.0087
	(0.0001)	(0.0031)	(0.0015)	(0.0033)		(0.0002)	(0.0032)	(0.0024)	(0.0049)

Table 9: Parameter Estimates for the Modified Overnight Momentum Model

This table reports parameter estimates for the following daily momentum model

$$\overline{r}_t = \alpha + \beta r_{t-1} + \gamma I_{t-1} + \lambda D_{t-1} + \varepsilon_t,$$

where $\overline{r}_t$ is the return computed using the opening price of day t and the closing price of day t-1, r_t is the daily return of the stock, and I_t is an indicator function that equals 1 if the price limit is reached on day t and zero otherwise. D_t is a dummy variable that equals 1 if the Ningbo Traders traded the stock on a day price limits were reached and zero otherwise. We first estimate the model for all the 749 stocks in our sample with a pooled regression. We then sort stocks into three groups according to their average total market capitalization, average total market capitalization for the tradable shares, average trading volume in ¥ and average turnover ratios. All the averages are taken over the entire sample period. Standard errors are reported in parentheses. The parameter estimates that are significant at the 1% level are indicated by bold type. The sample period is from January 2001 to July 2003.

	α	β	γ	λ		α	β	γ	λ
all stocks:									
	-0.0129	**0.0101**	0.0049	0.0110					
	(0.0002)	(0.0038)	(0.0028)	(0.0070)					
capitalization:					tradable capitalization:				
small	**-0.0148**	0.0167	0.0452	-0.0189	small	**-0.0146**	0.0041	0.0096	0.0046
	(0.0047)	(0.2036)	(0.0694)	(0.0886)		(0.0005)	(0.0051)	(0.0055)	(0.0125)
medium	**-0.0178**	0.0038	0.0142	0.0188	medium	**-0.0117**	**0.0228**	**0.0112**	0.0093
	(0.0010)	(0.0114)	(0.0115)	(0.0251)		(0.0003)	(0.0090)	(0.0045)	(0.0132)
large	**-0.0124**	**0.0102**	**0.0065**	0.0057	large	**-0.0122**	**0.0406**	-0.0047	0.0157
	(0.0002)	(0.0040)	(0.0029)	(0.0077)		(0.0003)	(0.0136)	(0.0048)	(0.0126)
trading volume:					turnover:				
low	**-0.0109**	0.0059	0.0049	0.0209	low	**-0.0102**	0.0044	0.0046	0.0120
	(0.0003)	(0.0049)	(0.0047)	(0.0136)		(0.0003)	(0.0049)	(0.0050)	(0.0173)
medium	**-0.0134**	0.0054	**0.0194**	0.0070	medium	**-0.0130**	**0.0190**	0.0074	0.0218
	(0.0004)	(0.0069)	(0.0049)	(0.0122)		(0.0003)	(0.0091)	(0.0043)	(0.0117)
high	**-0.0143**	**0.0374**	-0.0076	0.0020	high	**-0.0159**	0.0129	0.0084	-0.0009
	(0.0004)	(0.0114)	(0.0053)	(0.0119)		(0.0004)	(0.0075)	(0.0057)	(0.0116)