

Analysis and Analog Simulation of the Investors' Margin Trading Behavior

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Abstract—This paper took investors' margin trading behavior as the object of study and suggested the hypothesis that the behavioral financial factors would increase market volatility and affected investors' returns in the environment of margin trading system through theoretical analysis. On the basis of the hypothesis, this paper used the data of margin trading of A stock market in China to carry out measurement test, and indicated that investors' margin trading behavior existed significant overconfidence, disposal effect and herd effect. Further, this paper constructed artificial stock market and carried out analog simulation of the investors' margin trading behavior, which shows that the introduction of margin trading system increases the market risk to a certain extent, but it also can be reduced by pre-learning process. Meanwhile, it can be found that the introduction of margin trading increases the returns of fundamental analysis traders, technical analysis traders and noise traders in varying degrees. Compared with other traders, the trend trading strategy adopted by technical analysis traders who make use of excessive market volatility to gain higher income in the margin trading transaction under the incomplete and effective market background.

Keywords—margin trading; behavioral finance; analog simulation

I. INTRODUCTION

By the end of June 2017, there were a total of 970 stocks on the basis of margin trading in the A share market. The margin trading accounted for nearly 10% of the share market and the role of the margin trading in the stock market could not be underestimated. At the same time, the main body of margin trading transactions in China's securities market is based on individual investors. At the end of February of 2017, the total number of account opening accounts for 4 million 280 thousand households, of which the number of individual investors accounts for 99.75%. In order to hedge the risk that may be formed by the leverage and short function of the margin trading transactions, China has set up a high threshold for investor access in the current margin trading system design. Behavioral finance research shows that investors, especially individual investors, tend to exhibit irrational characteristics when trading. These investors, who have relatively strong capital strength and rich investment experience to reach the threshold of the margin trading, are still irrational behaviors in the margin trading transactions? If they have irrational behaviors, how will it affect stock price volatility and investors' returns? The answers to these questions depend on the further analysis of investors' margin trading behavior. Therefore, this paper tries to simulate a stock market through the construction of artificial stock market

on the basis of the analysis of the investor margin trading behavior, thus depicting a real margin trading process and revealing its market impact.

The research on the margin trading transactions is infancy through combing the existing literature, but there is still a certain number of research results on the simulation of investor behavior and stock market for reference.

A. Research on Investor Behavior

In the study of disposal effect, the extant literature has two contrasting views on this relationship. The first view is that individual investors tend to hold the loss stocks and sell the profit stocks, indicating the disposition effect of the individual investor's stock trading behavior. Odean calculates the actual profit ratio and the actual loss ratio based on the 162948 transactions records [1], and the research of Frazzini argues that there is also a disposition effect in institutional investors' transactions [2]. Rau further compares the investment behavior of institutional and individual investors and concludes that institutional investors have more disposal effects than individual investors in the process of investment [3]. The second view is that investors generally prefer to hold profit stocks and sell loss stocks on the basis of the choice of stocks that have book loss but a favorable performance and have a book profit but poor performance in the near future. Kaustia supports this view. The conclusion is contrary to the previous research [4].

In the study of investor overconfidence, scholars generally believe that investors are overconfident. Yang Qing draws on the method of Odeans and chooses the account data of all individual investors in a securities business department. The result indicates that there is a general tendency of overconfidence in our individual investors [5]. Tan analyses investor transactions data between January 1999 and December 2003 and finds that favorable historical investment gains will increase the degree of overconfidence of investors through self-attribution bias, but the impact of investment experience on excessive trading is not significant [6]. Liao selects the daily transactions data of 16990 individual investors from January 2006 to June 2009 and measures overconfidence by the early excess net income of investors, and also finds that investors generally have overconfidence [7].

In the study of herd effect, Liu Bo selects the relevant data of Shanghai and Shenzhen two cities from January 1993 to December 2000 respectively. Through two indexes of *CSSD* and *CSAD* to test the existence of the herd effect in China stock market, the results show that there is a significant herd effect in

the stock market [8]. Li uses Top View investor's position and diurnal data of account change to analyzes the difference of herding behavior between institutional and individual investors. It finds that the herding behavior of institutional investors in China is more obvious than individual investors [9]. Cheng finds that the domestic and foreign institutional investors generally have herding behavior in China A share market, and foreign institutional investors tend to follow the domestic institutional investors [10] through the expansion of the measure model of herd behavior.

B. Research on Simulation of Stock Market

Arthur believes that stock market has nonlinear characteristics, investors are limited rational and can adapt to the environment, and computer simulation of the operation of the stock market is proposed. The establishment of *SFI-ASM* have pioneered the multi Agent design in the framework of computational finance and provided a unified simulation platform for subsequent research [11]. Yang and Ma include the fuzzy decision learning strategy in the construction of artificial stock market model and use sensitivity analysis and historical data to teste and correct the model [12]. Zou constructs artificial stock market based on the characteristics of Chinese stock market by calculating experimental methods and study the influence of different dividend payments to stock price under the mechanism of two-way auction [13]. Wu constructs a two-way and continuous competitive artificial stock market, in which investors are limited, and their investment decisions will be influenced by stock value, price trend and noise factors [14].

II. THEORETICAL ANALYSIS

Based on the hypothesis of market effectiveness, modern financial theory believes that when information enters the market, the homogeneous and rational investors can make a consistent and correct evaluation of the information in the market and integrate information into the stock price fully and in time through the frictionless arbitrage. In reality, according to Liu and Cui [15], there are certain differences and costs in the market information acquisition, and the arbitrage constraints in the market can only achieve limited arbitrage. At the same time, combined with the view of Chi and Zhuang [16], it shows that the investors in the market are neither completely rational nor completely irrational, but a kind of "realistic" investors with behavioral characteristics, and there will be certain cognitive deviations and psychological deviations. The view of "institutional neutrality" in the effective market is questioned in reality, so the introduction of the margin trading system may have an impact on the stock market and the investors.

Generally speaking, when the favorable news enters the market, due to investors are heterogeneous, the interpretation of the same information will also be different. The basic analysis traders are based on the correct information interpretation to produce the arbitrage transactions demand and buy more stocks in the capital budget. The technical analysts still inclined to maintain existing market judgment and will not actively participate in the stock market transactions including margin trading; noise traders may be randomly involved in financing or margin trading based on misinterpretation of information and irrational trading motivation. Therefore, under the expectation of market heterogeneity formed by the difference of traders, the

size of the margin trading will increase because of the favorable news, and the increase in the scale of financing transactions is more significant. Stocks price has been pushed up along with favorable information. On the one hand, the basic analysis traders and noise traders who have participated in the purchase of financing, will produce a certain degree of self-attribution bias and control illusion, and then produce overconfidence. The emergence of this psychological bias will also increase investment and further enhance the scale of financing transactions. On the other hand, based on the rising trend of market prices, technical analysts tend to follow the trend, and further stimulate the increase in the scale of financing transactions by buying stocks or financing to buy stocks. At the same time, the noise traders sold the margin in the process of adverse price fluctuations and had lost, due to the disposal effect on the loss position, noise traders who participate in short selling will not significantly reduce their margin trading and may even be based on further expansion of the market heterogeneity, as well as the overconfidence of self-attribution deviation, and further increase the market divergence. With the continuous rising of the stock price and a clear upward trend, the price positive feedback in the market has produced more and more overconfidence to stimulate the investors and attract new investors to enter the market. Then the market and the margin trading have a remarkable herd effect, that is, the scale of financing transactions is rising constantly. On the contrary, the margin trading is shrinking. At this stage, according to the expected idea of Louwers [17], as the stock price goes high, the investor's cognitive bias will form the excessive attention to the favorable news and the market falls into a cycle of anticipation and market positive feedback and forms the expected self-realization. When the market price is rising, the bubble composition in the stock price is constantly accumulating and expanding, on the one hand, the basic analysis trader is inclined to settle the profit position of the financing transactions because of the disposal effect; On the other hand, the market will be empty when the value is rationally judged, which will lead to a decline in demand for financing transactions and a rise in demand for margin trading. However, technical analysts tend to continue to follow the trend and expand the scale of financing transactions. Due to the existence of herd effect and stock price overshoot in the market, the stock price bubble will usually expand further before it breaks up. Therefore, the basic analysis trader will bear the loss of short selling loss caused by the excessive rising of the market price in this stage. But technical analysts will gain more from financing transactions during the stock bubbles, which is supported by Chen and Ma [18]. When the incremental funds produced by the herd effect and the leveraged funds generated by the financing transactions push the stock price further away from the intrinsic value of the stock, the market inevitably increases and the market fluctuation increases obviously, which has been confirmed in the study of Xu [19][20]. When these funds are insufficient to continue to support the stock market bubble, the bubble will eventually be difficult to sustain and then burst asset price bubbles. The basic analysis trader's margin trading position will get the profit at this time and stimulate the scale of margin trading, and the technical analyst will reduce the scale of financing transactions because of the loss of financing transactions. In the downward trend of asset price bubble, there will be obvious changes in the

margin trading under the same logic. This process can be based on information impact to produce margin trading and market fluctuations (Figure 1).

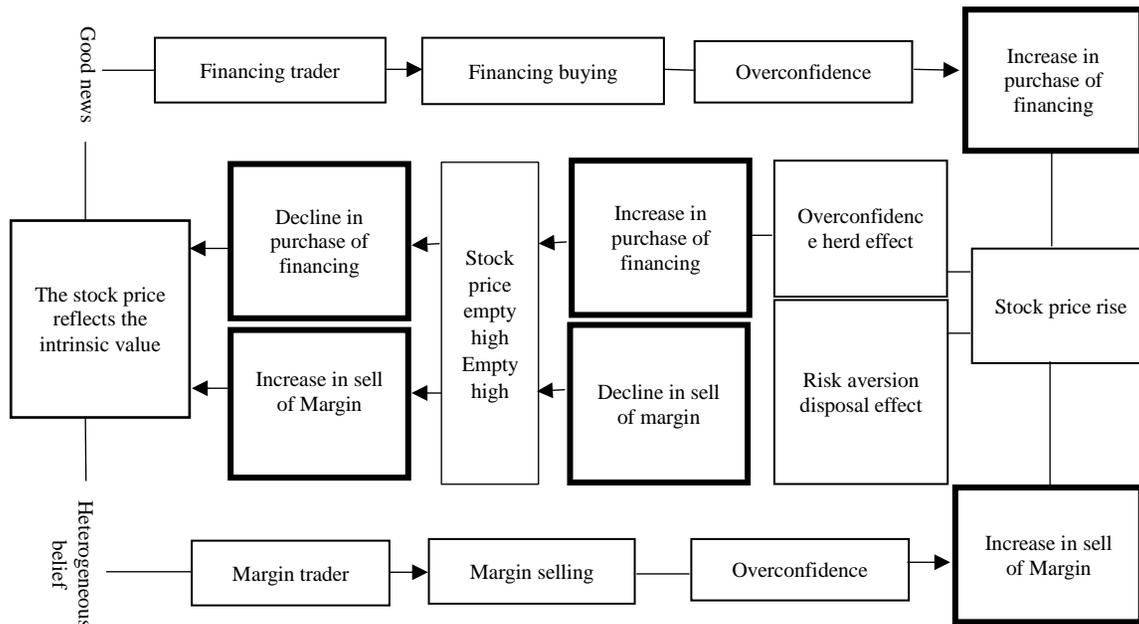


FIGURE I. THEORETICAL ANALYSIS ON INVESTOR'S MARGIN TRADING BEHAVIOR

III. INVESTORS' MARGIN TRADING BEHAVIOR TEST

A. Sample Selection

In September 23, 2014, the margin trading standard was expanded in fourth times, and it was also the last expansion at present. Therefore, the research starting point is selected in September 23, 2014. Considering the comprehensiveness of the study, the research period is required to cover different market conditions. September 30, 2015 is selected as the end point of the study. It includes a clear, basic symmetry of the rising and falling trend of the market to form a complete market operation process. In the study period, the number of margin trading stocks reach 913, accounting for 32.5% of the total number of shares in the A stock market and have strong market representativeness. Further, the stock in margin trading is deleted, the long-term suspension, the ST processing and the delisting stock, and the final 743 stocks are selected as the research samples.

B. Investors' Margin Trading Behavior Test

1) Overconfidence test of investors' margin trading behavior

Barber and Odean [21] first propose the use of volume to measure confidence. Compared with volume, Statman [22] further research argues that the turnover rate can fully reflect the frequent trading of investors under overconfidence. In the current related research, most scholars use the turnover rate to measure Investor overconfidence. Accordingly, this paper examines the relationship between the rate of return and turnover rate of margin trading samples which based on the model and introduced by Salma and Ezzeddine [23]

$$V_t = \alpha + \beta \sum_i^T R_{t-i} + \gamma \sum_j^J V_{t-j} + \varepsilon \tag{1}$$

Here: V_t is the turnover rate; R_t is rate of return of margin trading at t time.

Test the stability of the related variables, and the results are shown in Table 1.

TABLE I. UNIT ROOT TEST

Variable	ADF test value	1% critical value	5% critical value	10% critical value	P value	conclusion
V	-3.214020	-3.451421	-2.870712	-2.571728	0.0201	instability
dV	-17.57173	-3.451421	-2.870712	-2.571728	0.0000	stability
R	-14.36775	-3.451283	-2.870651	-2.571695	0.0000	stability

After ADF test, R is stable at 1% significant level, and dV is stable after first order difference. Using the research of

Statmans weekly data of the US stock market, the turnover rate and rate of return daily data of the margin trading are lagged by

5 order regression results are shown in Table 2 as follows:

TABLE II. LEGGED 5 ORDER REGRESSION RESULT

Parameter	α	β_1	β_2	β_3	β_4	β_5	γ_1	γ_2	γ_3	γ_4	γ_5
estimation	-0.01	-1.80	17.86***	-3.12	0.94	0.83	-0.35***	-0.26***	-0.10	-0.09	-0.14**

Note: ***is 1% significant level; ** is 5% significant level; * is 10% significant level.

From Table 2, $dV(-1)$ and $dV(-2)$ have a significant negative impact on dV in the sample period when the high turnover rate in the previous period has a negative impact on the turnover rate of this period, indicating that there is a self-correction mechanism in the process of overtrading. At the same time, the effect of $R(-2)$ on dV is remarkable, which shows that margin trading rate of return has a significant favorable effect on the turnover rate, the higher rate of return, the more frequent investors' margin trading. And the previous margin trading sample returns will enhance the overconfidence of investors in the next margin trading.

2) Herd effect test of investors' margin trading

Compared to the two methods of *LSV* and *CSSD*, Chang proposes a higher accuracy for herd effect measured by standard deviation of cross section income (*CSAD*) method and have been widely used in the academic field [24]. On the basis of that, this study further uses Ma in the *CSAD* model to add two items (formula 2) to test whether herd effect exists [25].

$$CSAD_t = \alpha + \gamma_1 |R_{m,t}| + \gamma_2 R_{m,t}^2 + \varepsilon_t \quad (2)$$

CSAD is the standard deviation of cross section incomes, and R_m is market return. If there is herding effect in margin trading, γ_2 should be significantly negative, and the larger the value, the more significant the herding effect. This paper uses the study samples and calculates the daily scatter plot of *CSAD* and R_m (Figure 2), there is no obvious linear relationship between *CSAD* and R_m , but there may be a herd effect based on the nonlinear relationship.

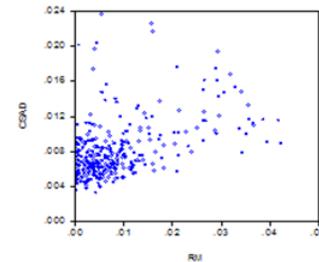


FIGURE II. CSAD AND RM DIAGRAM

Further, the herd effect is tested by Formula 2 to examine the existence of the herd effect of investors in the margin trading. The regression results are shown in Table 3 as follows:

TABLE III. CSAD REGRESSION RESULTS

Parameter	α	r_1	r_2
estimation	0.0073***	0.1469***	-3.0362**

From table 3, the coefficient of r_1 is significantly favorable and the coefficient of r_2 is significantly negative under the significant level of 5%, indicating that there is a significant herd effect of investors in the margin trading.

C. Test of Disposing Effect of Investor's Margin Trading Behavior

This paper uses the method of Zhai and Ren [26] to test the disposition effect of investor's margin trading behavior. First, the method is divided into two groups of sub samples based on the favorable and negative values of the R_{n-1} (the previous day of the transactions). Then, the V/R_{n-1} values of the subsamples are calculated, and then test whether the independent variable R_{n-1} has statistically significant effect on dependent variables V (Change ratio of the next transactions day) in subsamples. According to the sample, subsamples with $R_{n-1} > 0$ (sample size

124) and subsamples of $R_{n-1} < 0$ (sample size 125) are shown in Table 4 as follows:

Regression analysis of subsamples is used to test whether the effect of R_{n-1} on V (parameter r_1) is statistically significant. The regression results are shown in Table 5 as follows:

From the above regression results, no matter $R_{n-1} > 0$ or $R_{n-1} < 0$, the effect of R_{n-1} on the statistical significance of margin trading samples is favorable and significant, and when the stock price of margin trading samples is favorable, the margin trading volume of the next trading day is more obvious. This conclusion is consistent with the inference of disposition effect, which indicates that investors tend to hold losses and sell profits in margin trading.

TABLE IV. SUBSAMPLE LIST

$R_{n-1} > 0$ Subsample				$R_{n-1} < 0$ Subsample			
<i>Data</i>	r_{n-1}	v	v/r_{n-1}	<i>Data</i>	r_{n-1}	v	v/r_{n-1}
2015/1/26	0.000641	0.791334	1233.572	2015/7/7	-0.51004	0.951436	-1.86543
2014/11/10	0.002916	1.122538	384.901	2015/6/24	-0.48956	1.199621	-2.45041
2015/6/10	0.008819	0.773846	87.7487	2015/7/10	-0.45776	1.061815	-2.31959
.....						
2015/8/26	0.998089	1.167859	1.170095	2015/7/15	-0.00931	0.760697	-81.7427
2015/1/19	1.141279	0.982767	0.86111	2015/9/23	-0.00684	0.825214	-120.724
2015/9/14	1.548173	1.733186	1.119504	2015/1/9	-0.00477	1.165292	-244.087

TABLE V. SUBSAMPLE REGRESSION RESULTS

	α	r_1	$V / R_{n-1} $
$R_{n-1} > 0$	1.0933***	0.3382***	24.95575
$R_{n-1} < 0$	0.9893***	0.1463*	21.12515

IV. SIMULATION SIMULATION OF INVESTORS' MARGIN TRADING BEHAVIOR

Drawing on the research ideas of Dai [27], this paper constructs an artificial stock market consisting of three parts, namely the market, the trading match mechanism and the traders. In order to analyze the behavior patterns of different types of investors in the margin trading, the investors are divided into basic analysis traders, technical analysis traders and noise traders in three categories, and each type of investors is the same (samples 10), and suppose that investors have *CARA* utility function that investors can constantly learn and adjust their investment strategies according to market changes.

A. Simulation and Simulation Design

1) Market design

The setting of dividend flow follows the formula 3 process which is generated by external stochastic processes. And the basic analysts react to dividends.

$$d_t = \bar{d} + \rho (d_{t-1} - \bar{d}) + \varepsilon_t \quad (3)$$

Where, d_t is dividend of the stock in the t period, \bar{d} is a long term dividend, ρ is correlation coefficient between the current dividend and the previous dividend, ε_t is random variable that follows the normal distribution $N(0, \sigma^2)$.

According to the current system, the margin ratio must be greater than or equal to 50% in the market design, and if less than 50% can't open; the guarantee ratio is greater than or equal to 130%, when the proportion is less than that proportion, the position of the trader's position will be forced selling.

2) Design of transactions matching mechanism

According to the current trading board system, the rise and fall range is set to 10%; the model also sets the liquidation system according to the current margin trading system, adopts the no margin trading to carry out $T+1$ liquidation, while the

margin trading adopts $T+0$ liquidation.

3) Design of traders

Suppose that technical analysis traders use the average strategy for learning and adjustment. Noise traders have no specific investment strategies, and their quotations follow the normal distribution within the range of the rise and fall, and the basic analysis traders based on genetic algorithm to study and adjust the dividend strategy through studying dividend flow. The investment income of traders participating in financing transactions and margin trading in the t period is shown in formula 4 and formula 5 respectively.

$$e = \frac{E_{i,t} (p_{t+1} + d_{t+1})}{P_t} - 1 \quad (4)$$

$$e = 1 - \frac{E_{i,t} (p_{t+1} + d_{t+1})}{P_t} \quad (5)$$

Here, E_{it} is the expectation of investors in the t period to $t+1$ stock price and dividend, and P_t is the current stock price.

Suppose that the three types of traders have a risk aversion attitude and *CARA* utility function, that is $u_c = -e^{-\lambda c}$, $\lambda > 0$ indicates absolute risk aversion coefficient. $Agent_i$ expects the running state of the stock market in the t period to $t+1$:

$$E_{i,t} (p_{t+1} + d_{t+1}) = a * (p_t + d_t) + b \quad (6)$$

a, b is parameter. When the normal distribution is expected, the *CARA* utility function is used to calculate the amount of stock held by i trader:

$$x_{i,t} = \frac{E_{i,t}(p_{t-1} + d_{t-1}) - p_t(1+t)}{\lambda\sigma_{i,tp+d}^2} \quad (7)$$

$\sigma_{i,tp+d}^2$ is expected variance.

The first order derivation of formula 7 is used to calculate of marginal demand such as formula 8:

$$\frac{\partial x_{i,t}}{\partial p} = \frac{a-r-1}{\lambda\sigma_{i,tp+d}^2} \quad (8)$$

When the marginal demand of formula 8 is favorable, it means that the trader declared the purchase, while on the contrary, it means that the trader declared the sell. When the margin trading is not introduced in the market, the amount of buying and selling of the stock is limited by the amount of cash held by the traders and the number of securities. When the market is introduced into the market, the amount of buying and selling of the stock is limited by the margin ratio and the guarantee ratio. The trader determines that the price of the report is based on the expectation of the stock price and dividend, determined by the parameter a and b , using the CARA utility function to determine the expected holdings and the entrustment declaration of the stock, and the price of the report is determined by the parameters a , b and e , and λ is assumed to be constant.

B. Simulation Results and Analysis

1) Histogram statistics

R software is used to simulate the no margin trading, margin trading, pre-learning without margin trading and pre-learning has margin trading through the above design, and the simulation value of the volatility index is calculated by the index model.

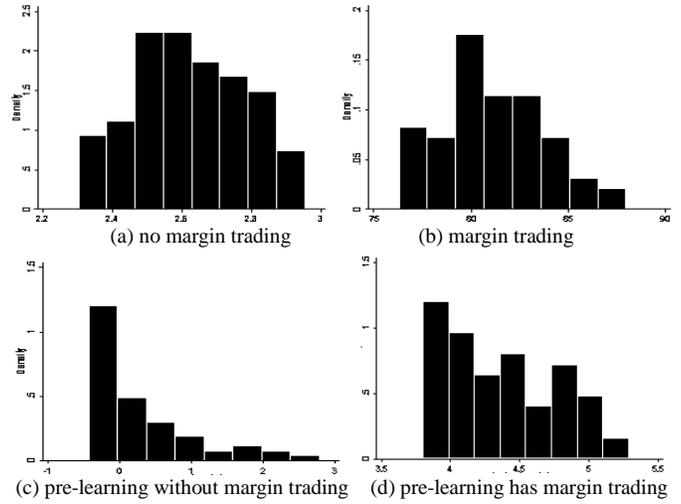


FIGURE III. HISTOGRAM

From figure 3, the four kinds of transactions have the right deviation. The normal distribution and the uniform distribution are widely used. The lognormal distribution, the Gamma distribution, the Weibull distribution and the Cauchy distribution are the most common right partial distributions. Four kinds of transactions are used to test the similarity of each distribution, and the final distribution is determined according to $K-S$ test.

2) Determining the distribution of all kinds of transactions

First, the density function curves of Normal, Uniform, Lognormal, Gamma, Weibull and Cauchy are superimposed on the histogram of all kinds of transactions (omit). Then the maximum likelihood estimation method is adopted to estimate the possible distribution parameters. The estimated results are shown in Table 6.

TABLE VI. ESTIMATION RESULTS OF VARIOUS TRANSACTIONS PARAMETERS

No margin trading		margin trading	
Distribution of fitting	Parameters of distribution	Distribution of fitting	Parameters of distribution
Normal	$\mu=445.52 \quad \delta=170.70$	Normal	$\mu=81.16 \quad \delta=2.68$
Uniform	$a=200.90 \quad b=898.90$	Uniform	$a=88.00 \quad b=76.30$
Gamma	$\alpha=7.32 \quad \beta=0.02$	Gamma	$\alpha=900.55 \quad \beta=11.09$
Lognormal	$\mu=6.03 \quad \delta=0.37$	Lognormal	$\mu=4.39 \quad \delta=0.03$
Weibull	$\alpha=2.76 \quad \beta=500.52$	Weibull	$\alpha=30.22 \quad \beta=82.48$
Cauchy	$\mu=388.08 \quad \delta=92.96$	Cauchy	$\mu=80.89 \quad \delta=1.69$
pre-learning without margin trading		pre-learning has margin trading	
Distribution of fitting	Parameters of distribution	Distribution of fitting	Parameters of distribution
Normal	$\mu=0.27 \quad \delta=0.71$	Normal	$\mu=72177.36 \quad \delta=53811.87$
Uniform	$a=2.79 \quad b=-0.43$	Uniform	$a=198937.60 \quad b=6330.00$
Gamma	N/A	Gamma	$\alpha=1.34 \quad \beta=79140.00$
Lognormal	$\mu=4.39 \quad \delta=0.03$	Lognormal	$\mu=10.84 \quad \delta=0.91$
Weibull	N/A	Weibull	$\alpha=1.34 \quad \beta=79140.00$
Cauchy	$\mu=80.89 \quad \delta=1.69$	Cauchy	$\mu=56814.18 \quad \delta=38098.59$

The *K-S* test is performed on the above distribution at 5% significance level, and the results are shown in Table 7.

3) Standard deviation contrast

In view of the above four distributions, the standard deviation of stock prices is calculated at the significant level of 1% (Table 7) as follows:

TABLE VII. STANDARD DEVIATION OF STOCK PRICE

	No margin trading	margin trading	pre-learning without margin trading	pre-learning has margin trading
Standard deviation mean	25.035	76.704	46.58	22.12

From table 7, the volatility of the stock price in the margin trading is obviously greater than that of the no margin trading in the case of no pre-learning, which shows that the introduction of the margin trading will increase the volatility of the stock price to a certain extent, and the reason possible behind it is the overconfidence in the process of the investors' behavior, the existence of disposition effect and herding effect that will increase the impact on stock price when combined with the leverage function of the margin trading. After eliminating the bias caused by the learning process, under the condition of pre-learning, the fluctuation of stock price caused by the margin trading is less than no margin trading, which shows that the traders can reduce the irrational behavior in their own investment through the pre-learning process and make the two-way trading function of the margin trading become a market stabilizer to some extent, which also shows that the margin trading itself is neutral as a system variable, and its impact on the stock market depends on the rationality of investor behaviors.

V. CONCLUSION

Investors have significant overconfidence, disposal effect and herd effect in the process of the margin trading through the theoretical analysis and quantitative study of China A stock market, which shows that the margin trading with the characteristics of short trading and leveraged transactions may become the cause of excessive volatility in the stock market. In further simulation studies, the introduction of the margin trading tends to increase market risk and can hedge and reduce the market volatility by pre-learning. At the same time, the income level of the three types of traders, including the basic analysis traders, technical analysts and noise traders, have been promoted to some extent after the introduction of the margin trading, in which the income level of the technical analyst is the most significant and the noise trader is always the lowest and lowest negative for all traders.

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