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Research Article

The Nonlinear Relationship between Investor Sentiment, Stock Return, and Volatility

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Based on the DSSW model, we analyze the nonlinear impact mechanism of investor sentiment on stock return and volatility by adjusting its hypothesis in Chinese stock market. We examine the relationship between investor sentiment, stock return, and volatility by applying OLS regression and quantile regression. Our empirical results show that the effects of investor sentiment on stock market return are asymmetric. There is "Freedman effect" in Chinese stock market, but only optimistic sentiment has a significant nonlinear impact on stock market returns when the stock market is a balanced market or a bear market. Meanwhile, "create the space effect" does exist in Chinese stock market too. It only exists when the market is in equilibrium, and only pessimistic sentiment has the nonlinear effect on stock market volatility.

1. Introduction

The relationship between investor sentiment and stock market returns is one of the important subjects of the study of behavioral finance. Behavioral finance believes that due to the unpredictable behavior of investors and arbitrage limitation in the real world, arbitrage cannot correct the deviation between stock price and value caused by irrational investors immediately. Therefore, stock price and return are determined by its fundamental risk and the mispricing caused by irrational investor sentiment.

A growing body of research focuses on the relationship between investor sentiment, stock return, and volatility. Most papers expect a negative relation to exist, as high sentiment in one period is argued to drive the prices up beyond their fundamental values, and a subsequent corrective price movement down should be observed. Baker and Stein [1] use trading volume as the proxy variable of investor sentiment and find out that there is a negative correlation between annual trading volume and stock returns. Brown and Cliff [2] have found out that the sentiment of noise traders is negatively related to stock returns in the next one to three years after research. Ben-Rephael et al. [3] drew the conclusion that investor sentiment is negatively related to the stock return in the later stage of the whole stock market. Aissia [4] found that foreign and home sentiment is strong contrarian predictor of stock returns. Another paper found a positive causal relationship between sentiment and future stock return. A positive relationship is in line with a notion that sentiment is persistent,e.g., high sentiment in one period can cause increased buying activity and raise prices in that period and subsequent periods. Verma and Verma [5] divided investor sentiment into rationality and irrationality and explored their impact on volatility of stock returns individually. The results show that both individual and institutional investors have a significant positive impact on stock returns. At the same time, the positive influence of rational sentiment on stock returns is more significant. Tetlock [6] used the Wall Street Journal column as a sentiment indicator for stock market reviews and found media pessimism about the stock market may cause downward pressure on the stock price.

The common point of the above research is to use the linear model to test the effect of investor sentiment on stock returns. In recent years, some papers have studied the nonlinear relationship between investor sentiment, stock market return, and volatility. Beaumont et al. [7] found that investor sentiment has a significant asymmetric effect on stock returns. When investors turn bullish (bearish), the Friedman effect prevails over the create space effect (and vice versa). Stambaugh et al. [8] studied the stock return characteristics of these arbitrage strategies under different sentiment states by building different portfolio strategies. The results show that high sentiment leads to an overvalued stock far more than the undervalued stock price caused by low sentiment. Lutz [9] found that the effects of sentiment are asymmetric: during peak-to-trough periods of investor sentiment (sentiment contractions), high sentiment predicts low future returns for the cross section of speculative stocks and for the market overall, while the relationship between sentiment and future returns is positive but relatively weak during trough-to-peak episodes (sentiment expansions). Shi and Wang [10] analyzed the volatility of market returns in different sentiment periods. They found that the positive relationship between risk and returns exists only in the pessimistic period.

To sum up, investor sentiment is an important factor affecting the volatility of securities prices and returns. However, the existing literature studies mostly use linear model to study the influence of investor sentiment on stock market return. Most of the literature studies consider that there is a negative linear relationship between investor sentiment and stock return, while some literatures suggest that investor sentiment has a positive impact on market return. Although, in recent years, some papers have begun to study the nonlinear effects of investor sentiment on stock market return, they tend to use the ordinary least squares regression analysis method to study the relationship between the two when the market returns are in the mean level. Compared with the ordinary least squares regression, quantile regression method can describe the distribution characteristics of investor sentiment more fully and capture the impact of market return on the tail distribution of sentiment. It is a more robust estimation method. In this paper, we adopt quantile regression method to discuss the nonlinear effects of investor sentiment on stock market return under different market conditions.

2. The Model

De Long et al. [11] proposed the famous DSSW model which pointed out the influence of irrational behavior of noise traders on stock prices. They laid the basic framework of noise trading theory and questioned the rationality of traditional financial theory. In this paper, we will take DSSW model as the theoretical basis and adjust the hypothesis of the model according to the actual situation to better depict the influence mechanism of investor sentiment on stock market returns in Chinese stock market.

2.1. Supposed Conditions. Under the general conditions, we make the following reasonable assumptions.

Firstly, supposed there are only two assets in the market for traders to select. One is risk-free asset with interest rates of r_f. r_f here is a constant that does not change over time, and risk-free asset provides full elasticity at price 1. The other is risk asset. Its price and dividend in the t period are denoted by P_t and d_t, respectively. P_t and d_t are sometimes denatured, and the supply of risky asset is fixed at M.

Secondly, De, Long, and others assume that there are rational traders and noise traders in the market. These two kinds of traders deal with stocks under different information sets and different psychological expectations. But taking into account the actual situation of stock deal, we think both rational traders and noise traders will be disturbed by the sentiment in the process of actual investment decision, especially in the Chinese market. Therefore, this paper assumes that all traders are affected by sentiment. And the number of noise traders existing in two periods independently in the market is N.

Thirdly, assume that the initial decision is to select an asset portfolio that maximizes its expected utility. In the end, clear all of the risk assets held by the price P_{t+1}. In the process, due to the influence of sentiment, there is a deviation from the subjective expectation of risky asset. Assuming investors have an initial sentiment of 0, S_t stands for the overall market sentiment in the t period. ρ_t represents the deviation between the expected error price and the expected price P_{t+1} of the rational state in the t period. It obeys the normal random distribution which is independent and identically distributed. That is,

$$\rho_t \sim N\left(\rho^*, \sigma_\rho^2\right). \tag{1}$$

Among them, ρ^* and σ_ρ^2 are two functions related to the general sentiment S_t of the current market. Assuming $\rho^* = f(S_t) \cdot \overline{\rho}, \overline{\rho} > 0$ is the deviation caused by unit sentiment. $f(S_t)$ meets the following: if $S_t > 0$, $f(S_t) > 0$; else if $S_t < 0$, $f(S_t) < 0$. That means, when the market sentiment is high, the expected price deviation is positive. On the contrary, it is negative. Besides, assuming $\sigma_\rho^2 = g(S_t) \cdot \sigma_{\overline{\rho}}^2$, $\sigma_{\overline{\rho}}^2$ is deviation volatility caused by unit sentiment. $g(S_t)$ meets if $S_t < 0$, $g(S_t) < 1$; if $S_t < 0$, $g(S_t) > 1$. That means, when the overall sentiment of the market is high, deviation volatility of the expected price will reduce. On the contrary, it will expand.

Lastly, assume that the investor utility at the end of the transaction is represented by an invariant constant absolute risk aversion function:

$$U = -e^{-(2\gamma)w}. \tag{2}$$

Among them, $\gamma > 0$ represents the absolute risk aversion coefficient of investors (or constant absolute risk aversion coefficient). w stands for the total wealth of investors at the end of the transaction. The function is strictly increasing, which indicates that investors always have a great desire for wealth.

2.2. Model Derivation. Based on the theory of De Long, assuming that the wealth gains satisfy the normal distribution, shareholders are required to maximize the expected value of the asset, which is equal to maximizing the following conditions:

$$\max\left(\overline{w}_{t+1}^{S} - \gamma\sigma_{w_{t+1}^{S}}^{2}\right). \tag{3}$$

Among them, w_{t+1}^S represent wealth expectations in $t+1$ period, and $\sigma_{w_{t+1}}^2$ represent the variance of wealth expectation. In order to determine the investor's demand for risky asset x_t^S, the following conditions are need to be maximized:

$$\max\left[x_t^S\left(E\left(P_{t+1}\right)+\rho_t+d_t\right)+\left(w_t^S-x_t^S P_t\right)\left(1+r_f\right)\right] - \gamma\left(x_t^S\right)^2\sigma_{P_{t+1}}^2. \tag{4}$$

Taking the derivative of x_t^s, it can be obtained that

$$E\left(P_{t+1}\right)+\rho_t+d_t-P_t\left(1+r_f\right)-2\gamma x_t^S\sigma_{P_{t+1}}^2=0. \tag{5}$$

Thus, the investor's demand for risky asset can be expressed as

$$x_t^S=\frac{E\left(P_{t+1}\right)+\rho_t+d_t-P_t\left(1+r_f\right)}{2\gamma\sigma_{P_{t+1}}^2}. \tag{6}$$

Under the assumption of market equilibrium, the total demand for all investors should at the end of the transaction make the risk asset in the market all clear. Combined with the assumptions of the number of investors and the supply of risk asset, it can be obtained that

$$\sum_{i=1}^{N} x_{it}^S = M. \tag{7}$$

Among them, x_{it}^S represent the demand for risky asset by the I trader in phase. Formula (6) is substituted by formula (7), the stock price in the market equilibrium in the t period can be obtained.

$$\leftrightarrow P_t=\frac{1}{1+r_f}\left[E\left(P_{t+1}\right)+\rho_t+d_t-\frac{2M\gamma\sigma_{P_{t+1}}^2}{N}\right]. \tag{8}$$

When the financial market is in steady equilibrium, an unconditional distribution of stock price P_{t+1} is equal to the distribution of P_t in the $t+1$ period. And an unconditional distribution of investor sentiment S_{t+1} is equal to the distribution of P_t. By using recursive method to eliminate $E\left(P_{t+1}\right)$ in formula (8), the market equilibrium price of stock in t period is

$$P_t=\frac{d_t}{r_f}+\frac{f\left(S_t\right)\cdot\overline{\rho}}{r_f}+\frac{\left(\rho_t-f\left(S_t\right)\cdot\overline{\rho}\right)}{1+r_f}-\frac{2M\gamma g\left(S_t\right)\cdot\sigma^{2/\rho}}{Nr_f\left(1+r_f\right)^2}. \tag{9}$$

The first item in formula (9) is the fundamental value of the stock; it is unaffected by sentiment.

The second item in formula (9) indicates that when the overall sentiment of the investor is not 0, the price of stock will deviate from its fundamental value. If investors are generally optimistic about the future value of risky asset, that is, if $S_t>0$, $f\left(S_t\right)>0$. So the stock price is higher than its fundamental value.

The third item in formula (9) describes the volatility of risky asset prices caused by changes of investor sentiment in the market. If there are a larger proportion of the bullish traders on future market in a certain trader, their optimism will push up stock prices. While bearish traders on future market are in the majority, pessimism is expected to lead to a fall in stock prices. If traders have an average view of the future market, that is, when $\rho_t=\rho^*$, the third item is 0.

The last item in formula (9) represents the price restraining effect of investor sentiment volatility. When the general sentiment of the market tends to be optimistic, that is, if $S_t>0$, $g\left(S_t\right)<1$, it will lead to a decrease in the expected price bias and push up stock prices. On the contrary, if $S_t<0$, $g\left(S_t\right)>1$, it will lead to an increase in the expected price bias and cause a fall in stock prices. That is to say, the stock return is inversely proportional to the expected deviation of the price, and there is a nonlinear relationship between sentiment and stock return.

Compared with the classic DSSW model, first of all, the adjusted DSSW model represents the investor's cognitive bias ρ^* as a function of sentiment. It holds that when investor sentiment is generally optimistic, $f\left(S_t\right)>0$, $g\left(S_t\right)<1$, the corresponding average of expected price deviation ρ^* is positive, but the expected price bias fluctuation σ_ρ^2 decreases. On the contrary, when investor sentiment is generally pessimistic, $f\left(S_t\right)<0$, $g\left(S_t\right)>1$, the corresponding average of expected price deviation ρ^* is negative, but the expected price bias fluctuation σ_ρ^2 increases. We express the cognitive bias of investors as a function related to sentiment, which is more helpful to deduce the influence of investor's sentiment change on the stock market price in theory. Secondly, the adjusted DSSW model cancels parameter μ. It is believed that all investors in China's stock market will be affected by subjective sentiment when they trade. Because the majority of Chinese investors are retail investors, such assumptions are more in line with the investor's characteristics in Chinese stock market. In general, from the influence mechanism of sentiment on stock return based on DSSW model, we can find that there is not only a linear relationship between investor sentiment and stock market returns, but also a nonlinear relationship which behaves as the greater the volatility of the investor sentiment in the market, the lower the stock market return (i.e., "Friedman effect"). And the volatility of excess return in the stock market is positively related to the volatility of investor sentiment (i.e., "creative spatial effect"). Accordingly, we propose the following Hypothesis 1 and Hypothesis 2, which are to be verified.

Hypothesis 1. Investor sentiment volatility will decrease the stock market return.

Hypothesis 2. Frequent volatility of investor sentiment will increase the volatility of stock market.

3. Empirical Design

3.1. Data

3.1.1. Investor Sentiment Composite Index. Considering the larger proportion of individual investors in China's stock market, it is extremely easy to be influenced by short-term market volatility and then lead to irrational speculation. In order to more accurately track investor sentiment changes in the stock market, we innovatively adopt weekly data which have smaller information granularity and higher frequency to capture the immediate investor sentiment. We select five objective indicators through the optimization in the specific selection of proxy indicators, which are SWS Low Profit Margin Stock Index (LPM (0)), SWS High-P/E-Ratio Index (HPEI (0)), SWS High-P/B-Ratio Index (HPBI (0)), six-period lag new Number of IPO (NIPO (+6)), and a subjective indicator, New Fortune Analyst Index (CAI (0)) over the same period. We use China's commodity price index (CCPI) and the Central Bank weekly monetary net supply (MNS) as proxy variables to reflect the macroeconomic fundamentals.

Firstly, sentiment proxy index is orthogonally dealt with the proxy variables of economic fundamentals. Use the residuals $s\mathrm{LPM}(0)$, $s\mathrm{CAI}(0)$, $s\mathrm{HPEI}(0)$, $s\mathrm{HPBI}(0)$, $\mathrm{sNIPO}(+6)$ obtained from regression as sentiment proxy index. In this paper, we use LASSO regression algorithm to construct investor sentiment composite index. Through the LASSO regression, the investor sentiment composite index is constructed as follows:

$$\begin{aligned}\mathrm{SENT\_LASSO}_t &= 0.1045 \times s\mathrm{LPM}_t + 0.4154 \times sCAI_t \\ &\quad + 0.3701 \times s\mathrm{HPEI}_t.\end{aligned} \tag{10}$$

3.1.2. Rate of Stock Return (R_t). The concrete formula for R_t is

$$R_t = \ln(P_t) - \ln(P_{t-1}) = \ln\left(\frac{P_t}{P_{t-1}}\right). \tag{11}$$

Among them, R_t represents the weekly rate of the circulation index in t week.P_t and P_{t-1}, respectively, represent the closing price of weekend of the t week and the $t-1$ week.

3.1.3. Volatility of Stock Return (VOLAT_t). VOLAT_t is used to measure the volatility of stock return in Chinese stock market. The formula of VOLAT_t is

$$\mathrm{VOLAT}_t = \frac{5}{N_t - 1}\sum_{d=1}^{N_t}\left[\left(R_{t,d} - r_{t,d}\right) - \frac{1}{N_t}\sum_{d=1}^{N_t}\left(R_{t,d} - r_{t,d}\right)\right]^2. \tag{12}$$

3.2. Descriptive Statistics. The sample range of this paper is the weekly data of Chinese stock market from January 4, 2008, to May 30, 2014. Descriptive statistical analysis results of time series data of investor sentiment index SENT, stock market return R, changes in investor sentiment ΔSENT, volatility of stock return VOLAT, and risk-free interest rate r are given in the following Table 1.

According to the statistical results of Table 1, we can firstly find that the mean value and the standard deviation of investor sentiment index SENT are 0.32 and 0.16. Similarly, the mean value and the standard deviation of CSI circulation index settlement P are 3370.72 and 824.07. From the point of view of mean value and standard deviation, the overall sentiment in the market is low and fluctuates widely and the possibilities of speculation and risk in the stock market are remarkable in the whole study interval. In addition, investor sentiment index SENT and CSI circulation index settlement P both deny the assumption of a normal distribution at the significant level of 5%. Among them, CSI circulation index settlement series have an obvious feature of "high peak and thick tail". And they both do not pass the test of ADF unity root at the significant level of 5%, which proves that they are nonstationary sequence. Second, investor sentiment fluctuation index ΔSENT, its square term $(\Delta\mathrm{SENT})^2$, the yield of CSI circulation index P, the excess return $(R-r)$, and the volatility VOLAT all disobey the assuming of normal distribution. But they all pass the test of ADF unity root. We consider that the above time series are the stable sequence and they can be used in the empirical analysis of the following empirical analysis.

3.3. Empirical Model. In order to analyze the nonlinear effects of sentiment on stock market return and validate the hypothesis, we construct a nonlinear model between sentiment and stock return of CSI circulation index (13) and a nonlinear model between sentiment and volatility of CSI circulation index (14):

$$\begin{aligned}R_t - r_t &= \alpha_0 + \alpha_1 \Delta\mathrm{SENT}_t \cdot I_t + \alpha_2 \Delta\mathrm{SENT}_t \cdot \left(1 - I_t\right) \\ &\quad + \alpha_3 \Delta\mathrm{SENT}_t^2 \cdot I_t + \alpha_4 \Delta\mathrm{SENT}_t^2 \cdot \left(1 - I_t\right) \\ &\quad + \alpha_5 \left(R_{t-1} - r_{t-1}\right) + \mu_t,\end{aligned} \tag{13}$$

R_t represents logarithmic rate of return of CSI circulation index in the t period, and r_t represents risk-free interest rate in the t period. $\Delta\mathrm{SENT}_t = \mathrm{SENT}_t - \mathrm{SENT}_{t-1}$ represents changes in investor sentiment. $\Delta\mathrm{SENT}_t^2$ represents fluctuations in investor sentiment. I_t are indicator variables, which are used to distinguish rising and falling of investor sentiment. When $\Delta\mathrm{SENT}_t > 0$, $I_t = 1$. If $\Delta\mathrm{SENT}_t < 0$, $I_t = 0$.

$$\begin{aligned}\mathrm{VOLAT}_t &= \lambda_0 + \lambda_1 \Delta\mathrm{SENT}_t \cdot I_t + \lambda_2 \Delta\mathrm{SENT}_t \cdot \left(1 - I_t\right) \\ &\quad + \lambda_3 \Delta\mathrm{SENT}_t^2 \cdot I_t + \lambda_4 \Delta\mathrm{SENT}_t^2 \cdot \left(1 - I_t\right) \\ &\quad + \lambda_5 \left(R_{t-1} - r_{t-1}\right) + \sum_{k=1}^{3} \lambda_{5+k} \mathrm{VOLAT}_{t-k} + \theta_t,\end{aligned} \tag{14}$$

$\mathrm{VOLAT}_\mathrm{t}$ represents weekly volatility of CSI circulation index. We regress formula (13) and formula (14) using ordinary least square regression to discuss nonlinear influence of investor sentiment on mean change of stock return and volatility.

If the OLS regression of formula (13) shows that the corresponding p value is significant, it shows that both optimistic and pessimistic investor sentiment fluctuations have a significant impact on the stock return of the stock market.

If $\alpha_3 > 0$, the volatility of optimism will drive up the average return of the stock market. Otherwise, if $\alpha_3 < 0$, the reverse relation will exist between them.

When $\alpha_4 > 0$, it shows that when investor sentiment tends to be pessimistic, the repeated fluctuation of pessimistic sentiment can boost the stock price and gain

Table 1: Descriptive statistics of empirical variables.

Variable	Mean value	Standard deviation	Skewness	Kurtosis	J-B statistic	Prob	ADF test	Prob.
SENT	0.32	0.16	0.70	0.98	47.04	0.001	−1.31	0.860
P	3370.72	824.07	1.60	4.78	533.00	0.001	0.47	0.990
ΔSENT	$6.56e-4$	0.03	−0.60	2.90	158.62	0.001	−5.80	0.010
R	$8.07e-4$	0.04	−0.34	2.04	7.47	0.001	−5.64	0.010
$(\Delta\text{SENT})^2$	$1.03e-3$	$2.27e-3$	5.45	35.93	$2.25e+4$	0.001	−3.74	0.022
VOLAT	$1.29e-3$	$1.83e-3$	3.27	12.92	$3.35e+3$	0.001	−3.90	0.014
r	$7.48e-4$	$2.69e-4$	−0.57	−0.74	29.59	0.001	−2.02	0.570
$(R-r)$	$1.45e-4$	0.04	−0.34	2.03	74.59	0.001	−5.62	0.010

Notes. Prob. represents the value p corresponding to the statistics on the left; when p is smaller, it means that refusing the null hypothesis is more justified.

abnormal return. Otherwise, if $\alpha_4 > 0$, the same direction relation will exist between them. If $\alpha_3 < 0$ and $\alpha_4 < 0$, it indicates whether the volatility is caused by high or low sentiment; the volatilities both will reduce the average value of the stock market return. Such regression results show that the Freedman effect does exist. That is, irrational investor sentiment tends to induce investors to make incorrect decisions and Hypothesis 1 is validated.

If the OLS regression of formula (14) shows that the corresponding p values of λ_3 and λ_4 are significant, it shows that both optimistic and pessimistic investor sentiment fluctuations have a significant impact on the volatility of stock return. If $\lambda_3 < 0$, it shows that the volatility of optimism will lead to volatility in the stock market's stock return. Otherwise, if $\lambda_3 < 0$, it shows that the volatility of optimism can slow the volatility of the stock return of the stock market. If $\lambda_4 < 0$, it shows when investors are more bearish on the market outlook, sentiment fluctuations also exacerbate stock market volatility. Otherwise, if $\lambda_4 < 0$, the reverse relation will exist between them. In general, we are more inclined to believe $\lambda_3 < 0$ and $\lambda_4 < 0$ at the same time. That is, as long as investors in the market are uncertain about the future, sentiment fluctuations exacerbate stock market volatility. This conclusion suggests that the "creative space effect" does exist. That is, irrational investor sentiment can lead to increased risk in the stock market and Hypothesis 2 is validated.

In fact, since most financial time series do not obey the normal distribution hypothesis, it has the characteristics of "higher peak and fat tail" and OLS regression cannot find the effective information at the top and bottom. Therefore, in order to explore the nonlinear effect of overall investor sentiment on the extreme value (high/low yield, high/low volatility) of stock market return, we will use the quantile regression method to regress formulas (15) and (20), and their specific form is as follows:

$$R_t - r_t = \alpha_0(\tau) + \alpha_1(\tau)\Delta\text{SENT}_t \cdot I_t + \alpha_2(\tau)\Delta\text{SENT}_t \cdot (1 - I_t) + \alpha_3(\tau)\Delta\text{SENT}_t^2 \cdot I_t + \alpha_4(\tau)\Delta\text{SENT}_t^2 \cdot (1 - I_t) + \alpha_5(\tau)(R_{t-1} - r_{t-1}) + \mu(\tau)_t. \quad (15)$$

Among them, $\alpha_0(\tau)$ is an intercept term for quantile regression equations and $\alpha_i(\tau)$ $(i = 1, 2, 3, 4, 5)$ is return for the CSI circulation index at different loci τ, explaining regression coefficients corresponding to explanatory variables.

$$\text{VOLAT}_t = \lambda_0(\tau) + \lambda_1(\tau)\Delta\text{SENT}_t \cdot I_t + \lambda_2(\tau)\Delta\text{SENT}_t \cdot (1 - I_t) + \lambda_3(\tau)\Delta\text{SENT}_t^2 \cdot I_t + \lambda_4(\tau)\Delta\text{SENT}_t^2 \cdot (1 - I_t) + \lambda_5(\tau)(R_{t-1} - r_{t-1}) + \sum_{k-1}^{3} \lambda_{5+1}(\tau)\text{VOLAT}_{t-k} + \theta(\tau)_t. \quad (16)$$

Among them, $\lambda_0(\tau)$ is an intercept term for quantile regression equations. For the fluctuation rate of the stock return of China's tradable index, the regression coefficient $\lambda_i(\tau)$ $(i = 1, 2, 3, 4, 5, 6, 7, 8)$ corresponding to the variable is explained at different subloci τ. Based on formula (15) and formula (16), we can get the stock market return and quantile regression of all the results when the stock market fluctuation is in different subloci τ. No matter what τ values are, if formula (15) regression results show that $\alpha_3(\tau) < 0$ and $\alpha_4(\tau) < 0$ were established all the time and it indicates that in different market situations ("bull" or ("bear"), it will make the stock market return decreased, as long as the investor sentiment is volatile. That is to say, the suspect is robustness in Hypothesis 1. On the contrary, it shows that the regression results of nonlinear models are significantly different at different subloci τ, which can separately analyze the nonlinear effects of sentiment on the stock return of stock markets in different market environments. Similarly, no matter what τ values are, if formula (16) regression results show that $\lambda_3(\tau) > 0$ and $\lambda_4(\tau)$ were established at the same time. It indicates that as long as the volatility of investors in the market fluctuates, the volatility of stock return will be exacerbated. This conclusion has nothing to do with the volatility of stock market return; that is to say, the "creation space effect" is reflected by the DSSW model existing in any market environment, and the conjecture in assuming 2 is robust. We will analyze and discuss the nonlinear relationship between investor sentiment and stock market return through empirical analysis.

4. Empirical Analysis

4.1. OLS Nonlinear Regression

4.1.1. An Empirical Analysis of Hypothesis 1. In order to verify the assumption 1, we will first use ordinary least squares regression method (OLS) to regress formula (13) in

Table 2: Linear regression results of OLS.

Variant	Parameter	Parameter estimate	Standard error	The value of T	The value of p
Regression 1: when the independent variable does not introduce the investor sentiment fluctuation item					
Intercept term	α_0	-0.0076^{***}	0.0013	−5.675	0.001
$\Delta\text{SENT}_t \cdot I_t$	α_1	1.3771^{***}	0.0556	24.782	0.001
$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	0.7506^{***}	0.0407	18.436	0.001
$(R_{t-1} - r_{t-1})$	α_5	0.0372	0.0236	1.575	0.116
F test statistic: F-statistic = 482.3, p value = 0.001					
Multiple R square: multiple R-squared = 0.7946					
Adjusted R square: adjusted R-squared = 0.7930					
Regression 2: when the investor sentiment fluctuation is introduced into the independent variable					
Intercept term	α_0	0.0010	0.0012	0.840	0.401
$\Delta\text{SENT}_t \cdot I_t$	α_1	1.2618^{***}	0.0858	14.704	0.001
$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.6157^{***}	0.0562	28.753	0.001
$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	-2.0680^{*}	1.1242	−1.840	0.067
$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-5.7787^{***}	0.3053	−18.929	0.001
$(R_{t-1} - r_{t-1})$	α_5	−0.0019	0.0166	−0.114	0.909
F test statistic: F-statistic = 676.2, p value = 0.001					
Multiple R square: multiple R-squared = 0.9009					
Adjusted R square: adjusted R-squared = 0.8995					

Notes: 1. ***, ***represent significance at level when at 1%, 5%, and 10%. 2. me − n represents $m \times 10^{-n}$ in the form.

order to explore that the high and low sentiment fluctuations in market were how to affect the stock market stock return. The OLS regression results are shown in Table 2.

The regression results shown in Table 2 show that α_3 and α_4 are significant at 10% of the significant level. Moreover, sentiment fluctuation really has explanatory power to the stock return of stock market, which shows that there is a nonlinear relationship between sentiment and stock return of stock market except for a significant linear relationship. We observe size and symbol of α_3 and α_4; firstly from the symbol of regression coefficient, $\alpha_3 < 0$ and $\alpha_4 < 0$ were set up at a significant level of 10%. It shows that investor sentiment fluctuation will always depress the average stock return of stock market. Based on the hypothesis, the conjecture in 1 has been preliminarily proved. That is to say, the Freedman effect in Chinese stock market does exist. Secondly, from $|\alpha_3| < |\alpha_4|$, it shows that when the investor sentiment is pessimistic, the volatility will lead to reducing the average stock return of the stock market.

By analyzing the reasons for such results, we believe that when the overall market sentiment is pessimistic, most investors are more likely to fall into panic mood, are more sensitive to the so-called "good" information disseminated in the market, and are unwilling to seriously analyze the accuracy of the information and the intrinsic value of stock. In this case, the fluctuation of sentiment is more likely to cause the decline of stock market return.

4.1.2. An Empirical Analysis of Hypothesis 2. The above made the preliminarily validation on the Hypothesis 1 by OLS regression. In order to further explore the nonlinear effects of investor sentiment on the stock return, that is, the influence of investor sentiment fluctuation on average volatility of stock market, we will also use OLS regression method to analyze this model based on formula (14). The regression results are shown in Table 3.

The results shown in Table 3 show the goodness of fit of the OLS regression is $R^2 = 0.2633$. Although the model independent variable for the stock return volatility explanation ability is weak, considering the stock market stock return volatility not only is affected by sentiment, but also may be affected by other information interference. Therefore, if the goodness of fit is not taken into consideration, the explanation of investor sentiment and its volatility and the lagged return of stock market volatility can be explained by 26.33% of the current stock return volatility. Besides, only when $\widehat{\lambda}_4 > 0$, it will be remarkable at 10% of the significant level. This shows that the average fluctuation of pessimistic sentiment indeed will aggravate the stock market stock return, and the effect is obvious. Although the optimistic sentiment fluctuation can aggravate the average fluctuation of the stock return of stock market, the influence is not significant.

4.2. Quantile Regression Analysis

4.2.1. An Empirical Analysis of Hypothesis 1. The OLS regression method can only reveal the effect of sentiment fluctuation on the average volatility of stock return. While at "peak and tail," or other sites, the nonlinear relationship between sentiment and stock return may be different from the result of OLS regression. Therefore, in order to make the assumption 1 conjecture more convincing and in order to study the influence of sentiment fluctuation on stock return under different market conditions, the nonlinear quantile regression method will be used to regress equation (15). The regression results are in Table 4.

According to Table 4 and Figure 1, it can be seen preliminarily that at different quantile τ, significant differences exist in regression results of nonlinear quantile. From the fitting effect of the graph, the results reflect that corresponding to model parameters under high quantile ($\tau = 0.95$,

Table 3: Linear regression results of OLS.

Variant	Parameter	Parameter estimate	Standard error	The value of T	The value of p
Intercept term	λ_0	0.0005^{***}	0.0002	3.255	0.001
$\Delta\text{SENT}_t \cdot I_t$	λ_1	−0.0107	0.0105	−1.016	0.310
$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	-0.0158^{**}	0.0071	−2.222	0.027
$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.1494	0.1384	1.079	0.281
$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.0648^{*}	0.0379	1.708	0.088
$(R_{t-1} - r_{t-1})$	λ_5	-0.0057^{***}	0.0021	−2.780	0.006
VOLAT_{t-1}	λ_6	0.2150^{***}	0.0494	4.354	0.001
VOLAT_{t-2}	λ_7	0.1734^{***}	0.0506	3.423	0.001
VOLAT_{t-3}	λ_8	0.1422^{***}	0.0484	2.936	0.004
F test statistic: F-statistic = 16.4, p value = 0.001					
Multiple R square: multiple R-squared = 0.2633					
Adjusted R square: adjusted R-squared = 0.2473					

Note: ********stands at significant levels of 1%, 5%, and 10%, respectively.

Table 4: Linear quantile regression results.

Quantile	Variant	Parameter	Parameter estimate	Standard error	Test statistic	The value of p
$\tau = 0.05$	Intercept term	α_0	-0.0072^{***}	0.0023	−3.1546	0.002
	$\Delta\text{SENT}_t \cdot I_t$	α_1	0.8210^{***}	0.2633	3.1177	0.002
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	2.1849^{***}	0.3057	7.1480	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	0.3653	4.5069	0.0810	0.935
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-7.6732^{*}	4.5645	−1.6811	0.094
	$(R_{t-1} - r_{t-1})$	α_5	0.0211	0.096	0.5323	0.595
$\tau = 0.10$	Intercept term	α_0	-0.0064^{***}	0.0013	−4.8166	0.001
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.1261^{***}	0.2029	5.5510	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.8929^{***}	0.2256	8.3903	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	−2.8902	4.0800	−0.7084	0.479
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-5.3013^{**}	2.4862	−2.1323	0.034
	$(R_{t-1} - r_{t-1})$	α_5	0.118	0.0189	0.6242	0.533
$\tau = 0.25$	Intercept term	α_0	-0.0038^{***}	0.0013	−2.9439	0.003
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.2229^{***}	0.1155	10.5878	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.6067^{***}	0.1267	12.6828	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	−3.1349	2.1302	−1.4717	0.142
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-5.8078^{***}	1.8330	−3.1685	0.002
	$(R_{t-1} - r_{t-1})$	α_5	−0.0120	0.0168	−0.7114	0.477
$\tau = 0.50$	Intercept term	α_0	-0.0012^{*}	0.0013	−0.1578	0.875
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.3420^{***}	0.1110	12.0919	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.4465^{***}	0.1254	11.5384	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	-4.3235^{**}	2.0591	−2.0997	0.036
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-5.3730^{***}	1.5299	−3.5120	0.001
	$(R_{t-1} - r_{t-1})$	α_5	0.0123	0.0181	0.6819	0.496
$\tau = 0.75$	Intercept term	α_0	0.0033^{**}	0.0013	2.5631	0.011
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.3134^{***}	0.1853	7.0881	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.3555^{***}	0.1001	13.5374	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	−0.2813	4.2528	−0.0661	0.947
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-4.9790^{***}	1.2560	−3.9643	0.001
	$(R_{t-1} - r_{t-1})$	α_5	0.0427^{*}	0.0232	1.8444	0.066
$\tau = 0.90$	Intercept term	α_0	0.0071^{***}	0.0014	5.0546	0.001
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.2901^{***}	0.2870	4.4949	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.3266^{***}	0.1119	11.8529	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	5.3718	8.9331	0.6013	0.548
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-4.8159^{***}	1.7592	−2.7376	0.006
	$(R_{t-1} - r_{t-1})$	α_5	0.0449^{**}	0.0216	2.0834	0.038
$\tau = 0.95$	Intercept term	α_0	0.0083^{***}	0.0027	3.0918	0.002
	$\Delta\text{SENT}_t \cdot I_t$	α_1	1.2442^{***}	0.3521	3.5340	0.001
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	α_2	1.2426^{***}	0.1986	6.2559	0.001
	$\Delta\text{SENT}_t^2 \cdot I_t$	α_3	12.1335	8.4079	1.4431	0.150
	$\Delta\text{SENT}_t^2 (1 - I_t)$	α_4	-4.4787^{*}	2.6115	−1.7150	0.087
	$(R_{t-1} - r_{t-1})$	α_5	0.0846^{***}	0.0271	3.1228	0.002

Note: ********stands at significant levels of 1%, 5%, and 10%, respectively.

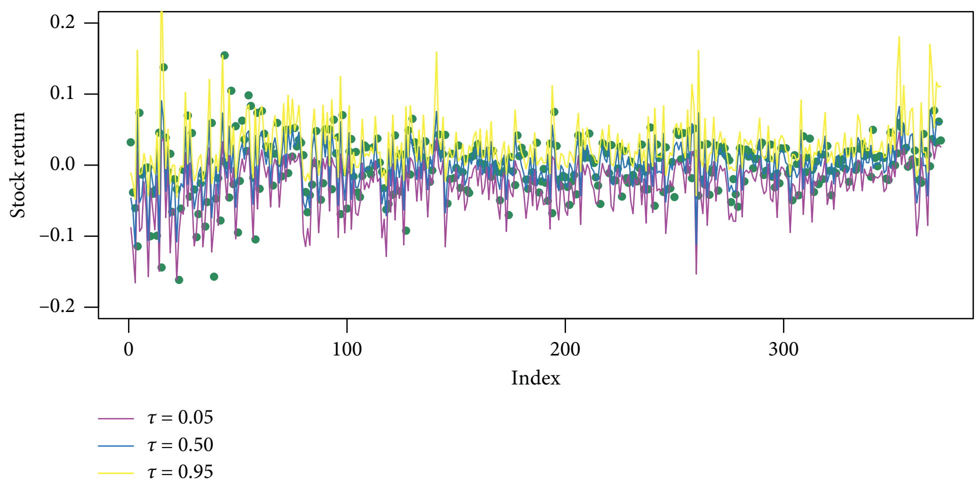


FIGURE 1: Comparison of fitting effects of different subloci ($\tau = 0.05, 0.50, 0.95$)

highlighted with yellow in the picture), the fitting values are also higher, which can be used to explain the high level of abnormal return on the stock market. In contrary, corresponding to model parameters under low quantile ($\tau = 0.05$, highlighted with red in the picture), the fitting values are relatively small, which can be used to explain the low level of abnormal return on the stock market. As mentioned above, the results can completely cover the influence of investor sentiment and sentiment volatility on the abnormal return in the stock market in the future of different quantile, i.e., the different market conditions.

Then, based on the results of the above nonlinear quantile regression, we can also examine whether Hypothesis 1 is established. First of all, let us start with the estimation $\alpha_3(\tau)$ and $\alpha_4(\tau)$ of the significance of the analysis. In contrast with regression results of traditional OLS, only near the median quantile ($\tau = 0.50$), high sentiment volatility can significantly affect the abnormal return of the stock market. However, the nonlinear relationship between the fluctuation of the depressed sentiment and the stock return remains remarkable. Only when stock market returns are at moderate levels, excess stock returns are sensitive to changes in optimism. But In the general market condition, the low level of sentiment fluctuations has a significant negative impact on the stock return.

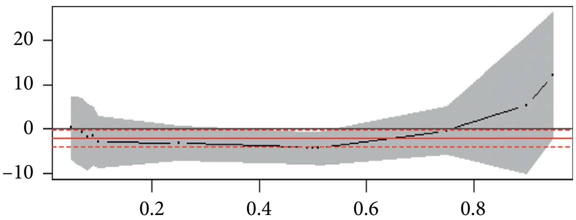
The second is to observe the size and symbols of $\widehat{\alpha}_3(\tau)$ and $\widehat{\alpha}_4(\tau)$. According to the nonlinear quantile regression results of Table 4, combined with Figure 2, we can see that there are significant differences between nonlinear quantile regression results and OLS regression results. In extreme market conditions, $\widehat{\alpha}_3(\tau)$ neither sets up; that is to say, only when the stock market is relatively in moderate conditions, optimistic sentiment volatility will depress the stock market excess return. Otherwise, optimistic sentiment volatility will stimulate or induce the stock market excess return increase in extreme market conditions. $\widehat{\alpha}_4(\tau)$ will increase with the increase of quantile and $\widehat{\alpha}_4(\tau)$ will set up in any quantile. This shows that the fluctuation of pessimism will significantly reduce the stock market returns under any market conditions. In general, when the stock market returns are in a moderate level, there is a significant nonlinear relationship between optimistic investor sentiment and stock market returns. Positive investor sentiment volatility will significantly reduce stock market returns. However, the nonlinear relationship between pessimism and stock returns always holds; that is, whether the current stock market is a bull market or a bear market, the fluctuation of pessimism will have a significant negative impact on stock returns. So Hypothesis 1 is tested.

Based on the analysis results of OLS regression method, we can only see the estimated values of regression parameters when the volatility of stock returns is at the mean level. We cannot analyze the nonlinear effect of investor sentiment on stock returns when they are at different levels. Therefore, regression (16) will be carried out based on nonlinear quantile regression. The regression results are shown in Table 5.

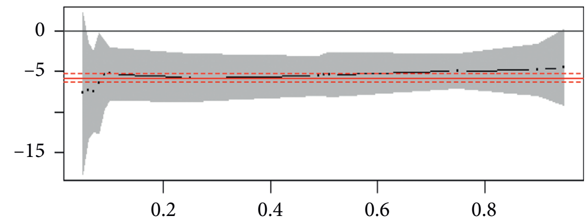
Similarly, according to Table 5 and Figure 3, we can make the initial judgment that there are significant differences in different quantile regression results τ. Therefore, we can analyze whether Hypothesis “2” is correct or not under different abnormal return according to the above nonlinear quantile regression results. That is, whether the fluctuation of investor sentiment can significantly increase the volatility of stock return in Chinese stock market.

We firstly analyze the significance of the estimated values $\lambda_3(\tau)$ and $\lambda_4(\tau)$. Compared with the results of OLS regression, from nonlinear quantile regression results, we can find that the pessimistic sentiment fluctuation has the remarkable nonlinear influence on the stock market stock return volatility in the lower quartiles or below ($\tau \leq 0.25$). The fluctuation of pessimism will obviously lead to the fluctuation of stock market, but the influence of optimism is not significant. That is to say, when the stock market is more stable, the volatility of pessimism will cause the stock market to fluctuate greatly.

We secondly analyze sizes and symbols of $\widehat{\lambda}_3(\tau)$, $\widehat{\lambda}_4(\tau)$. According to Table 5 nonlinear quantile regression results and combined with Figure 4, we can see that when the stock market volatility is below 75% quantile points, both



(a)



(b)

FIGURE 2: Estimation formula (15) of regression coefficients at different loci (2). An empirical analysis of Hypothesis 2. (a) $\widehat{\alpha}_3$ under different loci. (b) $\widehat{\alpha}_4$ under different loci.

TABLE 5: Quantile regression results of equation.

Quantile	Variant	Parameter	Parameter estimate	Standard error	Test statistic	The value of p
	Intercept term	λ_0	2.00e−5	4.00e−5	0.4174	0.677
	$\Delta\text{SENT}_t \cdot I_t$	λ_1	−0.0025	0.0042	−0.6002	0.549
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	−0.0030	0.0046	−0.6571	0.512
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.0316	0.0793	0.4036	0.687
$\tau = 0.05$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.0723*	0.0417	1.7361	0.083
	$(R_{t-1} - r_{t-1})$	λ_5	0.0016	0.0009	0.5918	0.554
	VOLAT_{t-1}	λ_6	0.0170	0.0202	0.8397	0.402
	VOLAT_{t-2}	λ_7	0.0722***	0.0196	3.6886	0.001
	VOLAT_{t-3}	λ_8	0.0313	0.0226	1.3840	0.167
	Intercept term	λ_0	0.0001***	4.00e−5	2.5875	0.010
	$\Delta\text{SENT}_t \cdot I_t$	λ_1	−0.0022	0.0045	−0.4801	0.631
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	−0.0061	0.0043	−1.4137	0.158
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.0416	0.0933	0.4456	0.656
$\tau = 0.10$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.0688**	0.0554	2.0444	0.042
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0004	0.0009	−0.4270	0.670
	VOLAT_{t-1}	λ_6	0.0379	0.0265	1.4266	0.155
	VOLAT_{t-2}	λ_7	0.0641**	0.0250	2.5639	0.011
	VOLAT_{t-3}	λ_8	0.0221	0.0256	0.8636	0.388
	Intercept term	λ_0	0.0002***	7.00e-5	2.6685	0.008
	$\Delta\text{SENT}_\text{t} \cdot I_t$	λ_1	0.0016	0.0069	0.2315	0.817
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	−0.0044	0.0051	−0.8640	0.388
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.0042	0.1498	0.0279	0.978
$\tau = 0.25$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.1255**	0.0558	2.2502	0.025
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0025*	0.0014	−1.8215	0.069
	VOLAT_{t-1}	λ_6	0.0620	0.0513	1.2079	0.228
	VOLAT_{t-2}	λ_7	0.1120*	0.0645	1.7366	0.083
	VOLAT_{t-3}	λ_8	0.0316	0.0397	0.7953	0.427
	Intercept term	λ_0	0.0002**	0.0001	2.4313	0.016
	$\Delta\text{SENT}_\text{t} \cdot I_t$	λ_1	0.0041	0.0090	0.4552	0.649
	$\Delta\text{SENT}_\text{t} \cdot (1 - I_t)$	λ_2	−0.0095	0.0064	−1.4823	0.139
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.0590	0.1975	0.2988	0.765
$\tau = 0.50$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.0365	0.0802	0.4548	0.650
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0044***	0.0015	−2.8686	0.004
	VOLAT_{t-1}	λ_6	0.1206**	0.0587	2.0535	0.041
	VOLAT_{t-2}	λ_7	0.2015***	0.0733	2.7508	0.006
	VOLAT_{t-3}	λ_8	0.1041	0.0646	1.6111	0.108
	Intercept term	λ_0	0.0004**	0.0002	2.3038	0.022
	$\Delta\text{SENT}_t \cdot I_t$	λ_1	−0.0037	0.0109	−0.3379	0.736
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	−0.0314**	0.0126	−2.5015	0.013
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.1850	0.2134	0.8667	0.387
$\tau = 0.75$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	0.0235	0.1937	0.1214	0.903
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0024	0.0023	−1.0288	0.304
	VOLAT_{t-1}	λ_6	0.3779***	0.1208	3.1274	0.002
	VOLAT_{t-2}	λ_7	0.2949***	0.1066	2.7656	0.006
	VOLAT_{t-3}	λ_8	0.0919	0.1075	0.8548	0.393

Table 5: Continued.

Quantile	Variant	Parameter	Parameter estimate	Standard error	Test statistic	The value of p
	Intercept term	λ_0	0.0007	0.0004	1.5945	0.112
	$\Delta\text{SENT}_t \cdot I_t$	λ_1	0.0130	0.0226	0.5724	0.567
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	-0.0682^{***}	0.0259	−2.6278	0.009
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	−0.1892	0.3192	−0.5928	0.554
$\tau = 0.90$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	−0.4332	0.4023	−1.0766	0.282
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0035	0.0067	−0.5239	0.601
	VOLAT_{t-1}	λ_6	0.3130	0.2140	1.4631	0.144
	VOLAT_{t-2}	λ_7	0.5113^{***}	0.1958	2.6119	0.009
	VOLAT_{t-3}	λ_8	0.3136	0.3183	0.9853	0.325
	Intercept term	λ_0	0.0014	0.0010	1.3922	0.165
	$\Delta\text{SENT}_t \cdot I_t$	λ_1	−0.0277	0.0504	−0.5502	0.583
	$\Delta\text{SENT}_t \cdot (1 - I_t)$	λ_2	−0.0493	0.0521	−0.9460	0.345
	$\Delta\text{SENT}_t^2 \cdot I_t$	λ_3	0.0969	0.5566	0.1741	0.862
$\tau = 0.95$	$\Delta\text{SENT}_t^2 (1 - I_t)$	λ_4	−0.4344	0.5416	−0.8021	0.423
	$(R_{t-1} - r_{t-1})$	λ_5	−0.0003	0.0098	−0.0310	0.975
	VOLAT_{t-1}	λ_6	0.7158	0.4719	1.5167	0.130
	VOLAT_{t-2}	λ_7	0.3633^{*}	0.2113	1.7190	0.087
	VOLAT_{t-3}	λ_8	0.8527^{**}	0.3915	2.1782	0.030

Note: 1. ********stands at significant levels of 1%, 5%, and 10%, respectively.

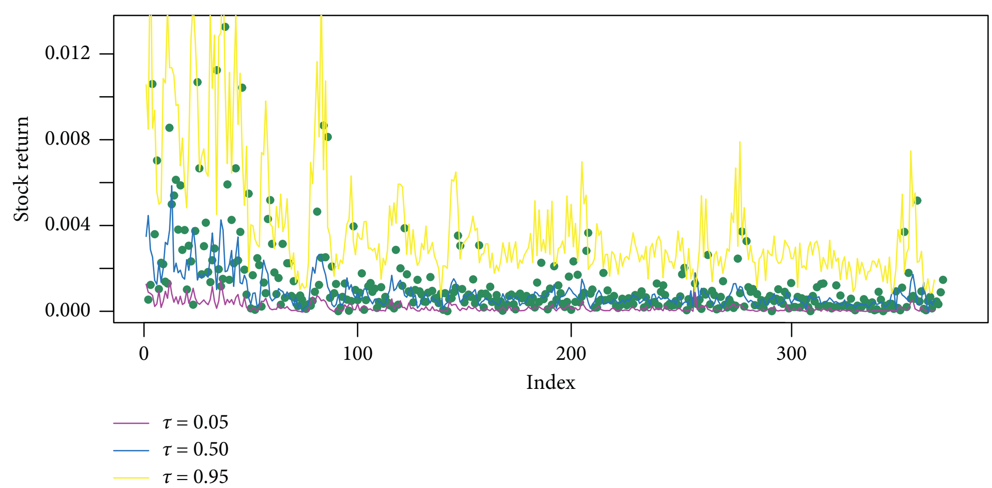


Figure 3: Comparison of fitting effects of different subloci ($\tau = 0.05, 0.50, 0.95$)

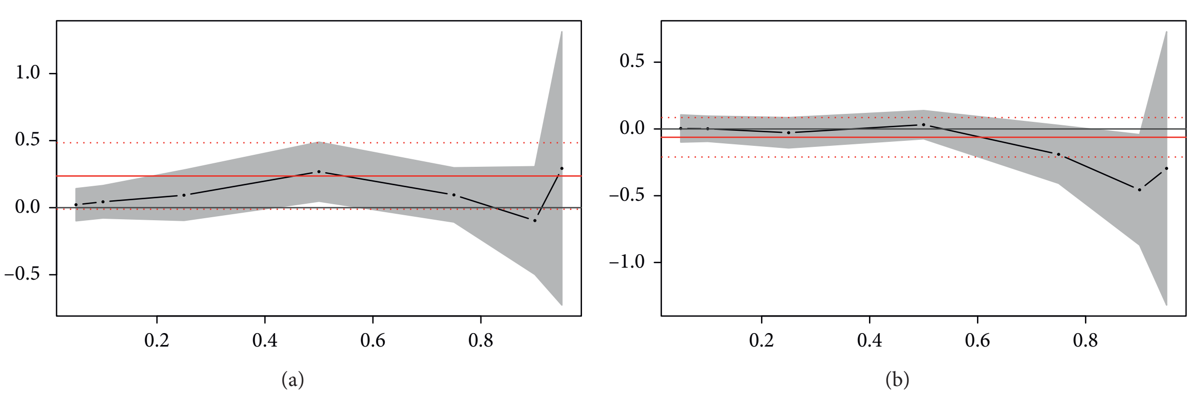


Figure 4: Estimation formula (16) of regression coefficients at different loci. (a) Under different loci $\widehat{\lambda}_3$. (b) Under different loci $\widehat{\lambda}_4$.

optimistic and pessimistic sentiment changes will cause the stock market to fluctuate up and down. While the stock market volatility itself is large ($\tau \geq 0.90$) $\widehat{\lambda}_4(\tau) < 0$, it illustrates that there is a significant nonlinear relationship between pessimistic sentiment and stock market volatility. That is, pessimistic sentiment will exacerbate the stock volatility. But the relationship between optimism and stock return is not significant. Quantile regression shows that the "creation space effect" in Hypothesis 2 does exist, but it only exists in the stable market environment. This shows that when the stock market itself is very speculative, the fluctuation of pessimism will slow down the fluctuation of stock return. This may be because when the stock market is volatile, most investors tend to be negative and start to rethink their trading behavior profoundly. They start to buy and sell their stocks rationally and cautiously. Rational investor sentiment will reduce the volatility of the stock market.

5. Conclusions

On the basis of the DSSW noise trader model proposed by De and Long, this paper adjusts its assumptions accordingly and analyzes the nonlinear influence mechanism of investor sentiment on stock market return. Using the ordinary least squares method and quantile regression method, this paper discusses the nonlinear effects of investor sentiment fluctuation on stock market return under different market conditions and draws the following conclusions. Firstly, the influence of investor sentiment fluctuation in different states on the abnormal return of different levels of stock is asymmetric. The results of OLS regression show that there is a significant nonlinear relationship between investor sentiment and stock return of stock market. Investor sentiment fluctuations will reduce average stock return of the stock market. Quantile regression results show that there is a significant nonlinear relationship between optimistic investor sentiment and stock return of stock market only when the market returns are relatively moderate, while the relationship between pessimism and stock return of stock market is always significant. Secondly, the influence of investor sentiment fluctuation in different states on the volatility of stock return is also asymmetric. The results of OLS are consistent with the results of linear quantile regression, significant nonlinear relationship only exists between pessimistic sentiment and stock return volatility, while the relationship between optimism and stock return is not significant.

From the current situation of domestic investor structure, China needs to further strengthen the construction of institutional investors. American stock market is a typical institutional market, so the trading behavior of the American investors is more rational as a whole. While China's stock market is a typical retail market, retail investors are more vulnerable to the impact of extreme market prices and make wrong decision when trading, and retail sentiment is more likely to infect each other, thus breeding the herding effect of the stock market. Therefore, it is necessary to increase institutional investors and improve their behavior standards, so that they can play the role of market stability. In addition, the regulatory authorities should guide investors' behavior reasonably and restrain the momentum of investor irrational sentiment of chasing up and killing down cultivate investors to develop the concept of value investment.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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