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Research Article

Dynamic Spillover Effects of Investor Sentiment and Return between China and the United States

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As the two largest economies in the world, the investor sentiment and stock return of China and the United States are the focus of global attention. In this paper, we study the dynamic spillover effects of investor sentiment and return between China and the United States. First, we use the relative price differences of 9 dual-listed companies in China and the United States simultaneously to verify whether investor sentiment affects stock returns. We find a significant positive correlation between the relative price difference of dual-listed companies and the difference of investor sentiment, indicating that the investor sentiment index indeed affects stock prices. Next, we construct the TVP-VAR model to study the dynamic spillover effects of investor sentiment and the return between China and the United States. Through the time-varying impulse response, we find investor sentiment has a significant dynamic impact on returns. Therefore, investment sentiment contagion and stock market linkage between China and the United States are obvious. In addition, we conduct various robust tests, and all results are consistent.

1. Introduction

The traditional financial theory assumes investors are rational and the financial market is efficient because all valuable information has been timely, accurately, and fully reflected in asset price. On the contrary, in practice, investors are not always rational, and their cognitive bias on the financial market leads to abnormal fluctuating asset prices. This phenomenon is particularly prominent in China's stock market where individual investors, without professional knowledge, account for a high proportion of all investors. Due to a lack of professional investment knowledge, individual investors often show emotional behaviors, such as blindly following the trend and over-trading [1, 2]. Individual investors also do not adjust their investment strategy when the investment circumstance changes, leading to heavy losses.

In the 2015 Chinese stock market turbulence, the Shanghai Composite Index fell by 35% in 1 month and experienced several abnormal fluctuations. Over half of all stocks were filed for suspension or fell to daily price limits. The traditional financial theory does not explain this phenomenon because the fundamentals do not change significantly in the short term. In August 2017, the United States launched Section 301 Investigation which confronted China on its state-led, market-distorting policies and practices, forced technology transfers, intellectual property practices, and cyber intrusions of the US commercial networks. After several unsuccessful United States-China dialogues, the two countries did not reach a consensus, which further aggravated the trade conflicts and the United States-China trade war began. The United States-China trade war created policy uncertainty, and investor sentiment rose and fell along with the United States-China dialogues. This made the two countries' stock markets fluctuate sharply and made investors vulnerable to the influence of market sentiment. Since optimistic or pessimistic investor sentiment will lead to large fluctuations in the financial market, we study the

dynamic spillover effect of investor sentiment and return between China and the United States. We find that investment sentiment contagion and stock market linkage are significant between China and the United States, indicating regulatory authorities in both countries should pay attention to the local investment sentiment and also to another country's investment sentiment.

To achieve our study of the dynamic spillover effects of investor sentiment and return between China and the United States, we first construct China's investor sentiment. Specifically, we obtain the investor sentiment by conducting principal component analysis on closed-end fund discount (CEFD), turnover (TURN), number of IPOs (an initial public offering (IPO) refers to the process of offering shares of a private corporation to the public in a new stock issuance.) (IPON), average first-day returns on IPOs (IPOR), number of accounts opened by new investors (NIA), and the consumer confidence index (CCI) from 2010 to 2019. We use the US Sentix investor confidence index as the US investor sentiment. Second, we use the relative price differences of 9 dual-listed companies (nine dual-listed companies: China Eastern Airlines, Guangshen railway, Huaneng Power, China Southern Airlines, Sinopec Shanghai Petrochemical, Aluminum Corporation of China, China Life Insurance, China Petroleum & Chemical, and PetroChina.) in the United States and China simultaneously to verify whether investor sentiment affects stock returns. The results show a significant positive correlation between the relative price difference of dual-listed companies and investor sentiment, which indicates the investor sentiment index indeed affects stock prices. Next, we construct the TVP-VAR model to study the dynamic spillover effects of investor sentiment and return between China and the United States. We analyze the dynamic spillover of investor sentiment on the return, the contagion of investor sentiment, and the stock market linkage through the time-varying impulse response. We find that investor sentiment has a significant dynamic impact on returns, investment sentiment contagion, and stock market linkage between China and the United States. Finally, we use different indicators to conduct robust tests: the VIX (VIX is a popular measure of the stock market's expectation of volatility based on S&P 500 index options and is often referred to as the fear index or fear gauge.) is used as investor sentiment of the United States, the Shanghai Composite Index is replaced by the CSI 300 Index, and the S & P 500 index is replaced by the Dow Jones industrial average index. All results are consistent.

We use the TVP-VAR model with stochastic volatility to study the dynamic spillover effects of investor sentiment and return between China and the United States. The model enables us to capture the potential time-varying nature of the underlying structure in the economy. All parameters in the VAR specification are assumed to follow the first-order random walk process, thus allowing both a temporary and permanent shift in the parameters. By the TVP-VAR model, we analyze the time-varying impulse responses and the impulse responses at different time points to comprehensively reflect the dynamic spillover effects of investor sentiment and return between China and the United States.

The main contributions of this paper are as follows: First, we construct China's investor sentiment by principal component analysis. Second, we select the dual-listed companies with the same cash flow from the micro-perspective to verify that investor sentiment will explain the price difference of dual-listed companies. Third, we find obvious investor sentiment contagion and stock market linkage between China and the United States, which can be explained from investor sentiment. Therefore, we suggest that investors should pay attention to investor sentiment and avoid the influence of investor sentiment when making investment decisions.

The remainder of the study is structured as follows: Section 2 provides a brief literature review. Section 3 constructs the investor sentiment. Section 4 verifies whether investor sentiment affects stock returns based on dual-listed companies. Section 5 introduces the TVP-VAR model and discusses the empirical results. Section 6 conducts the robustness test. Section 7 concludes the study.

2. Literature Review

Investor sentiment is an important aspect of behavioral finance. According to De Long et al. [3], investor sentiment is one factor affecting the asset pricing of the capital market. As early as Keynes [4] states, the existence of emotion-driven investors may lead to price deviation from the fundamental value. However, there are other opinions that emotion-driven investors will be eliminated by rational traders who seek to gain profit opportunities by mispricing. Miller [5] shows that short-selling constraints limit the ability of rational investors to profit by mispricing, which results in rational investors not being able to eliminate noise traders.

At present, there are two main indicators to measure investor sentiment: direct indicators and indirect indicators. Direct indicators mainly use questionnaires to directly investigate investors' expectations for the next period of market conditions. These are sentiment indicators for investors' subjective views on future market trends, such as AII Investor Sentiment Survey, Investors Intelligence Index, and Consensus Bullish Sentiment Index. On the contrary, indirect indicators are sentiment indicators that can objectively reflect the sentimental fluctuations of investors in the process of investing. These include but are not limited to closed-end fund discounts, the number of IPOs, the average first-day returns on IPOs, turnover, number of accounts opened by new investors, and mutual fund net redemption. Baker & Wurgler [6] construct investor sentiment by Principal Component Analysis (PCA) according to six single-sentiment indicators: the closed-end fund discount, NYSE share turnover, the number and average first-day returns on IPOs, the equity share in new issues, and the dividend premium. The investor sentiment constructed by Baker & Wurgler [6] is now widely used to study the relationship between investor sentiment and stock returns [7–12]. Chen et al. [13] also proposed a new way to measure investor sentiment in emerging markets. As such, the investor sentiment is obtained by principal component analysis of the short-selling volume, the Hong Kong Inter-

Bank Offered Rate (HIBOR), Relative Strength Index (RSI), Money Flow Index (MFI), the performances of the US and Japan equity markets, and market turnover. Recent studies constructed the investor sentiment based on a comprehensive textual analysis of sources from news wires, Internet news sources, and social media [14–16]. Baker et al. [17] create a global investor sentiment by principal component analysis using sentiment indices from Canada, France, Germany, Japan, the United Kingdom, and the United States. Aboody et al. [18] calculate overnight stock returns to measure investor sentiment at the company level. In this paper, China's investor sentiment is constructed by Baker & Wurgler's [6] method.

Research on investor sentiment mainly focuses on how investor sentiment affects stock market returns. Brown & Cliff [19] find that investor sentiment significantly impacts stock market returns only in the long term (1 to 3 years). Baker & Wurgler [6, 20] find that investor sentiment has a greater impact on the return of stocks with valuations that are highly subjective and difficult to arbitrage. The higher the investor sentiment is, the lower the following return is on small-cap, newly issued, high volatility, unprofitable, no dividend, extreme growth, and financial distress stocks. These results from noise traders mispricing at an extreme level, and then arbitrageurs take advantage of the mispricing to perform a large number of transactions and ultimately the price returns to the fundamental value. Corredor et al. [21] analyze the relationship between investor sentiment and stock returns in four key European stock markets (France, Germany, Spain, and the United Kingdom) and find that the sentiment effect is different in corporate characteristics and countries. Huang et al. [22] find that investor sentiment has a strong predictive ability for monthly returns in the United States. Ni et al. [23] discover that investor sentiment greatly impacts smaller companies, growth companies, and companies with higher risks and past returns in China's stock market. Due to high speculation and short-sales constraints in China's stock market, the market volatility is high and often rises and falls sharply in the short term [24, 25]. Han and Li [26] reveal that investor sentiment can predict China's stock market returns in the short term, different from the United States and other developed financial markets; and China's investor sentiment is a reliable momentum indicator for predicting monthly market returns; therefore, they propose a profitable trading strategy based on China's investor sentiment. Rashid et al. [27] find investor sentiment has a significant impact on the required rate of returns. Baker et al. [17]; Hribar and Mcinnis [28]; Stambaugh et al. [11]; Neely et al. [29]; and Baek [30] obtain similar conclusions. The previous literature mainly verifies the relationship between investor sentiment and return empirically, emphasizing the ability of investor sentiment to predict stock returns. In this paper, we regard investor sentiment as an endogenous variable, and we study the dynamic spillover effect directly between investor sentiment and stock market return.

Baker et al. [17] observe that investor sentiment is highly contagious in Canada, France, Germany, Japan, the United Kingdom, and the United States, mainly because of global capital flows. Hudson and Green [31] conclude that the investor sentiment in the United Kingdom can predict the investor sentiment in the United States. However, after adding the investor sentiment of the United States and the United Kingdom into the model for predicting the United Kingdom's stock market return, only the investor sentiment of the United States can predict the United Kingdom's stock market return; this is possible because the investor sentiment of the United States generates the investor sentiment in the United Kingdom. Feldman and Liu [32] show that the correlation of investor sentiment in the United States, the United Kingdom, Europe, Australia, Japan, and Canada could predict the correlation of stock market returns even stronger in a bear market, which partially explains the increase of return correlation during the financial crisis. Niţoi and Pochea [33] also note that investor sentiment can increase the correlation of the stock market, especially in a crisis, and investor sentiment is an important channel to make the market move in the same direction. Previous studies focus on the contagion of investor sentiment between developed countries. In this paper, we study the contagion of investor sentiment between only China and the United States.

With increased globalization and economic integration, the linkage of the global stock market is gradually enhanced. One view is that economic fundamentals are a key factor for the linkage of the stock market. McQueen and Roley [34] show that the change of macroeconomic indicators will simultaneously affect the future cash flow and the discount rate of listed companies at home and abroad; thus, the change of economic fundamentals is the source of the stock market linkage. Adler and Dumas [35] find that international arbitrage investors will change their asset portfolio based on the fundamentals of different countries in the global capital market, which further proves that economic fundamentals are the root of stock market linkage. With the rapid growth of global trade, barriers to the free flow of goods, services, financial assets, and human capital are lowered, and the linkage of global financial markets is becoming stronger [36]. Pentecôte et al. [37] indicate that international trade greatly impacts the linkage between markets. Another view is that economic fundamentals cannot fully explain the stock market linkage. Instead, investor behavior and market characteristics are more important reasons for the stock market linkage [38, 39]. Monetary integration and financial integration are important factors affecting the stock market linkage [40, 41], which increases as the financial crisis influences the global financial market. In this paper, we show that stock market linkage results from the interaction of economic fundamentals, investor behavior, and market characteristics. Economic fundamentals are the macro reasons for the stock market linkage, while investor behavior and market characteristics are the micro reasons.

Although this paper focuses specifically on the stock market dynamic spillover effect of the United States and China, it is important to note the studies of the stock market linkage regarding investor sentiment contagion in various other Asian and African countries. Chevallier et al. [42]

demonstrate a spillover effect between stock markets in the Asia Pacific; the spillover effect is enhanced over time, which may reduce the benefits of regional diversification strategy and increase the risk contagion in the region. Guo and Ibhagui [43] show that before and during the financial crisis, the stock market linkage between China and Africa's five major stock markets (South Africa, Morocco, Egypt, Nigeria, and Kenya) is stronger. Nonetheless, after the crisis, the stock market linkage gradually declines, which may be the disconnection between the real economy of Africa and the stock market. Hung [44] finds that the spillover effect between China and four Southeast Asian countries (Vietnam, Thailand, Singapore, and Malaysia) strengthened during and after the financial crisis. Sehgal et al. [45] show a dynamic spillover effect among the stock markets of 12 Asian countries, among which Singapore has the highest correlation with other markets. In addition, the dynamic spillover effect of all markets is amplified during the crisis, and the contagion of the crisis is more obvious. Zhang et al. [46] find dynamic spillover effects are constantly strengthening between US stock volatility and China's stock market crash risk: when the US stock volatility increases, China's stock market crash risk increases. Previous literature directly studies the stock market linkage in different countries, while this paper focuses on the stock market dynamic spillover effect of China and the United States under investor sentiment contagion.

3. China and the US Investor Sentiment

3.1. China Investor Sentiment. We construct a measure of China investor sentiment using principal component analysis (PCA). PCA is the process of computing the principal components to summarize the information contained in the data in a limited number of factors.

$\mathbf{X} = (X_1, X_2, \ldots, X_p)'$ is the $p \times 1$ vector of observed variables. μ is the mean of $\mathbf{X}$, and Σ is the covariance matrix of $\mathbf{X}$. Consider $\mathbf{Y} = (Y_1, Y, \ldots, Y_p)'$ is the linear transformation of $\mathbf{X}$, then

$$\begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_p \end{pmatrix} = \begin{pmatrix} \alpha_{11} & \alpha_{12} & \cdots & \alpha_{1p} \\ \alpha_{21} & \alpha_{22} & \cdots & \alpha_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{p1} & \alpha_{p2} & \cdots & \alpha_{pp} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_p \end{pmatrix}. \tag{1}$$

Given $\alpha_i = (\alpha_{i1}, \alpha_{i2}, \ldots, \alpha_{ip})'$ and $A = (\alpha_i, \alpha_2, \cdots, \alpha_p)'$. Then

$$\mathbf{Y} = A\mathbf{X}, \quad i = 1, 2, \cdots, p, \tag{2}$$

and

$$\begin{aligned} \operatorname{var}(Y_i) &= \alpha_i' \Sigma \alpha_i, \quad i = 1, 2, \cdots, p, \\ \operatorname{cov}(Y_i, Y_j) &= \alpha_i' \Sigma \alpha_j, \quad i, j = 1, 2, \cdots, p. \end{aligned} \tag{3}$$

From equations (1) and (2), the statistical characteristics of $\mathbf{Y}$ are different when $\mathbf{X}$ is scaled arbitrarily. In order to make Y_i reflect the information of the original variables as much as possible, the greater the variance of Y_i means that it contains more information. But from equation (3), it can be seen that expanding the coefficient vector will make the variance of Y_i increase infinitely. To eliminate this uncertainty, the constraint $\alpha_i'\alpha_i = 1$ is added. At the same time, to effectively reflect the information of the original variable, the information contained in different components of $\mathbf{Y}$ should not overlap. Therefore, the linear transformation in equation (1) should satisfy the following two constraints:

(1) $\alpha_i'\alpha_i = 1$, that is $\alpha_{i1}^2 + \alpha_{i2}^2 + \cdots + \alpha_{ip}^2 = 1$, $i = 1, 2, \ldots, p$.

(2) Y_1 has the largest variance under constraint (1), that is, $\alpha_i'\alpha_i = 1$; Y_2 has the largest variance under constraint (1) and does not correlate with Y_1; $\cdots Y_p$ has the largest variance under constraint (1) and does not correlate with $Y_1, Y, \ldots, Y_{p-1}$.

The new variables $Y_1, Y, \ldots, Y_p$ obtained by satisfying the aforementioned constraints are called the first principal component, the second principal component, $\cdots$ the pth principal component of the original variables $X_1, X_2, \ldots, X_p$, respectively. Besides, the proportion of each component variance in the total variance decreases successively.

According to China's financial market, we construct China's investor sentiment index based on Baker and Wurgler [6]. Specifically, we select the closed-end fund discount (CEFD), that is, the average difference between the net asset values (NAV) of closed-end stock fund shares and their market prices; the turnover (TURN), that is the ratio of trading volume to the average number of shares outstanding; the number of IPOs (IPON); the average first-day returns on IPOs (IPOR); number of accounts opened by new investors (NIA); consumer confidence index (CCI) to construct China's investor sentiment by the principal component analysis. All data are from the CSMAR database. The sample period is from January 2010 to November 2019. First, the six variables are standardized, and then the principal component analysis (PCA) is performed.

The results of the principal component analysis are shown in Table 1. The cumulative variance contribution of the first to fourth principal components is 89.61%. If we only use the first principal component (variance contribution is only 36.48%), it may lead to too much information loss. Therefore, we use the weighted average of the first four principal components. The coefficients of the first four principal components are weighted as

$$\begin{aligned} f_{ij} &= \frac{l_{ij}}{\sqrt{r_i}}, \\ \text{isentiment}_j &= \frac{\sum_{i=1}^{i=4} f_{ij} * p_i}{\sum_{i=1}^{i=4} p_i}, \end{aligned} \tag{4}$$

where l_{ij} is the coefficient of variable j in the ith principal component from Table 1, f_{ij} is the real coefficient of variable j in the ith principal component, and r_i is the eigenvalue of the ith principal component. isentiment$_j$ is the coefficient of

Table 1: Principal component analysis.

Panel A: The coefficients of the principal component analysis						
	PC1	PC2	PC3	PC4	PC5	PC6
$DCEF_t$	0.3070	0.5533	0.4202	−0.1346	0.6357	−0.0289
$TURN_t$	0.4856	−0.3542	−0.4743	0.2146	−0.1678	0.5827
$IPON_t$	0.3510	−0.3239	0.5898	−0.4136	0.4273	0.2667
$IPOR_t$	0.2625	0.1893	0.4219	0.8310	0.1625	−0.0195
NIA_t	0.6228	−0.1957	−0.0595	−0.0953	−0.2224	−0.7153
CCI_t	0.3009	0.6240	0.2629	−0.2554	−0.5562	0.2764
Panel B: Variance contribution and eigenvalues						
Principal component	Variance contribution rate		Cumulative variance contribute rate			Eigenvalue
PC1	0.3648		0.3648			2.18905
PC2	0.2193		0.5841			1.31569
PC3	0.1638		0.7479			0.982512
PC4	0.1482		0.8961			0.889115
PC5	0.083		0.9791			0.497952
PC6	0.0209		1			0.125676

Notes: This table shows the results of the principal component analysis. Panel A reports the coefficients of the principal component analysis. Panel B reports variance contribution rates and eigenvalues of principal component analysis.

variable j, and p_i is the variance contribution of ith principal component, $i = 1, 2, 3, 4, \ldots$.

Finally, we obtain China's investor sentiment:

$$\text{Sent}_t^{\text{China}} = 0.1014\text{CEFD}_t + 0.0082\text{TURN}_t + 0.0635\text{IPON}_t + 0.3362\text{IPOR}_t + 0.1019\text{NIA}_t + 0.2196\text{CCI}_t. \quad (5)$$

3.2. The US Investor Sentiment. First, we choose the US Sentix investor confidence index as US investor sentiment. US Sentix investor confidence index is a monthly report issued by Sentix, a market research firm, based on a survey of more than 4000 institutions and investors. The Sentix investor confidence index is designed to evaluate the sentiment of investors as it pertains to the current and future performance of the economy. The higher the investor confidence index is, the higher the investor sentiment is. In addition, we also choose VIX to represent the US investor sentiment. VIX is a panic index of the financial market and is used as an indicator of investor sentiment [47]. VIX expresses investors' expectations of the stock market volatility in the future. The higher VIX is, the higher the future stock market volatility is. The VIX reflects the stock market volatility and the investors' expectations, and the VIX is also known as investor sentiment. The VIX is a reverse indicator, and we choose the reciprocal of the VIX as the investor sentiment. The above data are all from the Wind database, and the sample period is from January 2010 to November 2019.

3.3. The United States and China Investor Sentiment Analysis. Figure 1 shows the standardized investor sentiment of the United States and China (the US investor confidence index), and Figure 2 shows the standardized investor sentiment of the United States and China (VIX), where SentUS represents the US investor sentiment and SentCN represents the China investor sentiment. As shown in Figures 1 and 2, the 2011 Tōhoku earthquake and tsunami caused nuclear accidents,

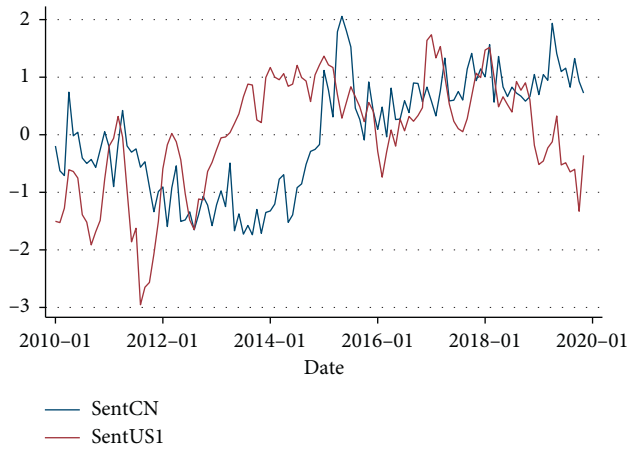


Figure 1: The United States and China investor sentiment (investor confidence).

which led to the leakage of the Fukushima nuclear power plant, resulting in a global stock market crash, and investor sentiment in both China and the United States declined sharply. Chinese stock market turbulence in 2015 made the China investor sentiments fluctuate widely. The China-United States trade war in 2018 also caused the investor sentiment to decline. Therefore, the indicators we selected can reflect the investor sentiment in both China and the United States.

4. Validation with Dual-Listed Companies

We validate the correlation between investor sentiment and stock return based on the dual-listed companies. We connect the investor sentiment to the international violations of the law of one price observed in dual-listed companies. Dual-listed companies are textbook violations of arbitrage [48]. Price differences are more or less observed in dual-listed companies [49–51]. Froot and Dabora [50] explain the price gaps with structural reasons, such as discretionary uses of dividend income by parent companies, differences in parent expenditures, voting rights issues, currency fluctuations, ex-

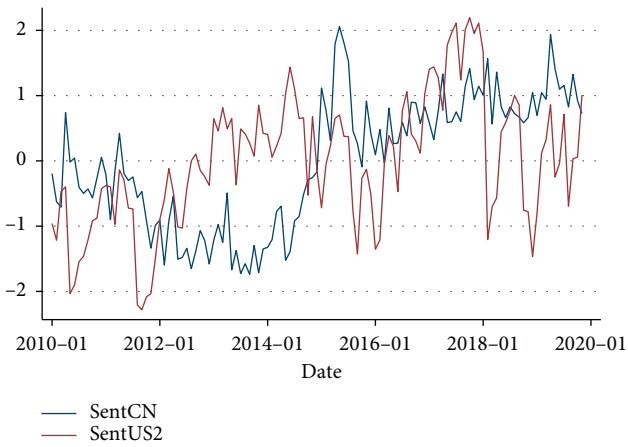


Figure 2: The United States and China investor sentiment (VIX).

dividend-date timing issues, and tax-induced investor heterogeneity. Although structural reasons can explain some of the price gaps, we follow the method proposed by Baker et al. [17] and select dual-listed companies in China and the United States to verify the relationship between the price difference and investor sentiment.

We choose nine dual-listed companies: China Eastern Airlines, Guangshen railway, Huaneng Power, China Southern Airlines, Sinopec Shanghai Petrochemical, Aluminum Corporation of China, China Life Insurance, China Petroleum & Chemical, and PetroChina. All nine companies are listed on the Shanghai Stock Exchange and the New York Stock Exchange.

Stock prices listed in China and the United States are priced in different currencies, so we calculated the stock returns and standardized it. We use the standardized stock return difference to represent the price difference between China and the United States. When the price difference is equal to zero, it represents theoretical parity. Then the price difference is regressed on the difference between the US investor sentiment and China investor sentiment, and the following model is constructed:

$$P_{i,t}^{\mathrm{US}} - P_{i,t}^{\mathrm{China}} = \alpha\left(\mathrm{Sent}_t^{\mathrm{US}} - \mathrm{Sent}_t^{\mathrm{China}}\right) + u_{i,t}, \tag{6}$$

where $\mathrm{Sent}_t^{\mathrm{US}}$ and $\mathrm{Sent}_t^{\mathrm{China}}$ are investor sentiment in China and the United States, and $P_{i,t}^{\mathrm{US}}$ and $P_{i,t}^{\mathrm{China}}$ are dual-listed companies' standardized stock returns in the United States and China. All variables in regression are stationary. The empirical results are shown in Table 2, which shows that the α coefficients are significant, indicating that the difference in investor sentiment does affect stock prices. Therefore, we can conclude that the differences in investor sentiment partly drive the price differences in dual-listed companies (most of R^2 are around 30%).

Table 2: Validation with dual-listed companies.

Company	α	T-statistic	P value	R-squared
CEA	0.0877*	1.79	0.0760	0.03
GSH	0.3985***	8.54	0.0000	0.38
HNP	0.6016***	10.73	0.0000	0.50
ZNH	0.1496***	3.66	0.0000	0.10
SHI	0.1454**	1.76	0.0800	0.03
ACH	0.0840***	2.78	0.0060	0.06
LFC	0.5756***	5.44	0.0000	0.20
SNP	0.4566***	7.42	0.0000	0.32
PTR	0.3879***	7.37	0.0000	0.32

Notes: This table reports time-series regressions for nine dual-listed companies in China and the United States, respectively. The dependent variables are the price difference of nine dual-listed companies in China and the United States between January 2010 and November 2019. The independent variable is the difference between the US investor sentiment and China investor sentiment. The US Sentix investor confidence index is used as US investor sentiment. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

5. Dynamic Spillover Effects of Investor Sentiment and Stock Market Return

This paper constructs a TVP-VAR model to study the dynamic spillover effects of investor sentiment and return between China and the United States. In this part, we first introduce the TVP-VAR model, then estimate the TVP-VAR model, and finally analyze the results.

5.1. Time-Varying Parameter VAR (TVP-VAR) Model. Sims [52] proposed the famous VAR model, which is widely used in macroeconomics; however, the hypothesis of its fixed parameters made explanatory power greatly constrained. Cogley and Sargent [53] propose a VAR model with time-varying coefficients but assumed that the variance and covariance are constant. Later, Cogley and Sargent [54] further extend the VAR model by assuming the coefficients and the variances are time-varying but still assume the synchronous correlations are constant. Primiceri [55] eventually develop the VAR model to allow the coefficients, variance, and covariance terms to change over time, which is the widely used TVP-VAR model in macroeconomics now.

The basic structural VAR model is defined as

$$Ay_t = F_1 y_{t-1} + F_2 y_{t-2} + \cdots + F_s y_{s-1} + u_t, \quad t = s+1, \cdots, n, \tag{7}$$

where y_t is the $k \times 1$ vector of observed variables and $A, F_1, \ldots, F_s$ are $k \times k$ matrix of the coefficients. u_t is a $k \times 1$ structural shock. By Nakajima [56], we specify the simultaneous relations of the structural shock by recursive identification, assuming that A is lower-triangular,

$$A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{pmatrix}. \tag{8}$$

We rewrite model (7) as the following reduced form VAR model:

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_s y_{s-1} + A^{-1} \sum \varepsilon_t, \quad \varepsilon_t \sim N(0, I_k), \tag{9}$$

where $B_i = A^{-1} F_i, i = 1, 2, 3, \cdots, s$, and

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \cdots & \cdots & \sigma_k \end{pmatrix}. \tag{10}$$

The $\sigma_i (i = 1, \ldots, k)$ is the standard deviation of the structural shock. Stacking the elements in the rows of the $B_i (i = 1, \ldots, s)$ to form β which is $sk^2 \times 1$ vector, and defining $X_t = I_k \otimes (y'_{t-1} \cdots y'_{t-k})$, the model can be written as

$$y_t = X_t \beta + A^{-1} \Sigma \varepsilon_t. \tag{11}$$

All parameters in equation (11) are time-invariant. Next, we construct the TVP-VAR model by allowing these parameters to vary over time.

$$y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t, \quad t = s + 1, \cdots, n, \tag{12}$$

where the coefficients β_t and the parameters A_t and Σ_t are all time-varying. We can consider many ways to model the process for these time-varying parameters. Let a_t be a stacked vector of the lower triangular elements in A_t and $h_t = (h_{1t} \cdots h_{kt})'$ with $h_{1t} = \log \sigma_{jt}^2$ for $j = 1 \cdots k$, and $t = s + 1, \ldots, n$. As suggested by Primiceri [55], we assume that the parameters in (12) follow a random walk process as follows:

$$\begin{aligned} \beta_{t+1} &= \beta_t + u_{\beta t} \\ a_{t+1} &= a_t + u_{at} \\ h_{t+1} &= h_t + u_{ht} \end{aligned} \begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix}\right), \tag{13}$$

for $t = s + 1, \ldots, n$, where $\beta_{s+1} \sim N(u_{\beta_0}, \Sigma_{\beta_0})$, $a_{s+1} \sim N(u_{a_0}, \Sigma_{a_0})$, and $h_{s+1} \sim N(u_{h_0}, \Sigma_{h_0})$. The shocks to the innovations of the time-varying parameters are assumed uncorrelated among the parameters β_t, a_t and h_t. We further assume that Σ_β, Σ_a, and Σ_h are all diagonal matrices. The drifting coefficients and parameters are modeled to capture possible changes of the VAR structure over time fully. Moreover, as discussed by Primiceri [55], the random-walk assumption can capture the possible gradual (or sudden) structural change in stochastic volatility.

5.2. Data and Variables. We construct the TVP-VAR model with the Shanghai Composite Index return RCN, the S & P 500 Index return RUS, the US investor sentiment (Sentix investor confidence index) SentUS, and China investor sentiment SentCN. TVP-VAR model does not need the data to be stationary, so there is no need for the stationarity test. The lag order determined by the SIC criterion is 1.

5.3. Parameter Estimation. We estimate the TVP-VAR model using OxMetrics 6 (OxMetrics is an econometric software for the econometric and financial analysis of time series, forecasting, econometric model selection, and for the statistical analysis of cross-sectional data and panel data. The TVP-VAR class is written in Ox and can be used by creating an object in Ox source codes.). The MCMC algorithm in the context of a Bayesian inference is used to estimate the TVP-VAR model. The MCMC algorithm is introduced in detail by Nakajima [56]. The sample of the MCMC algorithm is set to 10000, and the initial 1000 samples are discarded (As an MCMC algorithm is rarely initialized from its invariant distribution, there might be some concern that its initial values might bias results even if it does approach this equilibrium distribution later on. To compensate for this, a burn-in period is often implemented: the first N samples being discarded, with N being chosen to be large enough that the chain has reached its stationary regime by this time). Table 3 and Figure 3 report the estimation results for the selected parameters of the TVP-VAR model. The results show that the MCMC algorithm produces posterior draws efficiently. Table 3 provides the estimates for posterior means, standard deviations, 95% credible intervals, the CD of Geweke [57], and the inefficiency factors. From Table 3, we find the null hypothesis of the convergence to the posterior distribution is not rejected for the parameters at the 5% significance level based on the CD statistics except the first parameter $(\Sigma_\beta)_1$. The inefficiency factors are very low and less than 100, which indicates an efficient sampling for the parameters in the TVP-VAR model. Figure 3 shows the sample autocorrelation function, the sample paths, and the posterior densities for the selected parameters. From Figure 3, after discarding the samples in the burn-in period (initial 1,000 samples), we find the sample paths look stable, and the sample autocorrelations drop stably, indicating our sampling method efficiently produces uncorrelated samples.

The TVP-VAR model focuses on the analysis of coefficients and variances that change with time. Heteroscedasticity is an important feature of the TVP-VAR model, which is different from the other VAR models. Figure 4 shows the trend of the four variables, and Figure 5 shows the stochastic volatilities of the four variables. As shown in Figures 4 and 5, when the volatilities of stock market return and investor sentiment are large, the posterior volatilities show obvious time-varying characteristics, which confirms that it is necessary to apply the heteroscedastic VAR model. If the constant variance VAR model is used, the parameter estimation will be biased.

5.4. Results and Discussions. In this part, we analyze the dynamic spillover effects of investor sentiment and return between China and the United States. Due to the parameters of the TVP-VAR model being time-varying, we can analyze the time-varying impulse responses and the impulse responses at different time points to comprehensively reflect the dynamic spillover effects of investor sentiment and return between China and the United States. Next, we focus on two aspects of the analysis: time-varying impulse responses and impulse responses at different time points.

5.4.1. Time-Varying Impulse Responses. We analyze the time-varying impulse responses for three different lead times: 1, 6, and 12 months, which correspond to the short-term, medium-term, and long-term effects.

Table 3: Estimation results of the selected parameters in the TVP-VAR model.

Parameter	Mean	SD	95% interval	CD	Inefficiency
$(\sum_\beta)_1$ (sb1)	0.0227	0.0026	[0.0183, 0.0285]	0.001	5.66
$(\sum_\beta)_2$ (sb2)	0.0227	0.0027	[0.0182, 0.0286]	0.085	6.82
$(\sum_a)_1$ (sa1)	0.0725	0.0221	[0.0424, 0.1293]	0.882	35.49
$(\sum_a)_2$ (sa2)	0.0384	0.0065	[0.0278, 0.0529]	0.653	12.73
$(\sum_h)_1$ (sh1)	0.3729	0.115	[0.1733, 0.623]	0.484	64.32
$(\sum_h)_2$ (sh2)	0.1789	0.0717	[0.0824, 0.3621]	0.531	62.34

Notes: This table reports the estimation results of the selected parameters in the TVP-VAR model. The Σ_β, Σ_a, and Σ_h are all diagonal matrices. $(\Sigma_\beta)_i$, $(\Sigma_\alpha)_i$, and $(\Sigma_h)_i$ are the ith diagonals of the covariance matrices. The estimates of Σ_β and Σ_α are multiplied by 100.

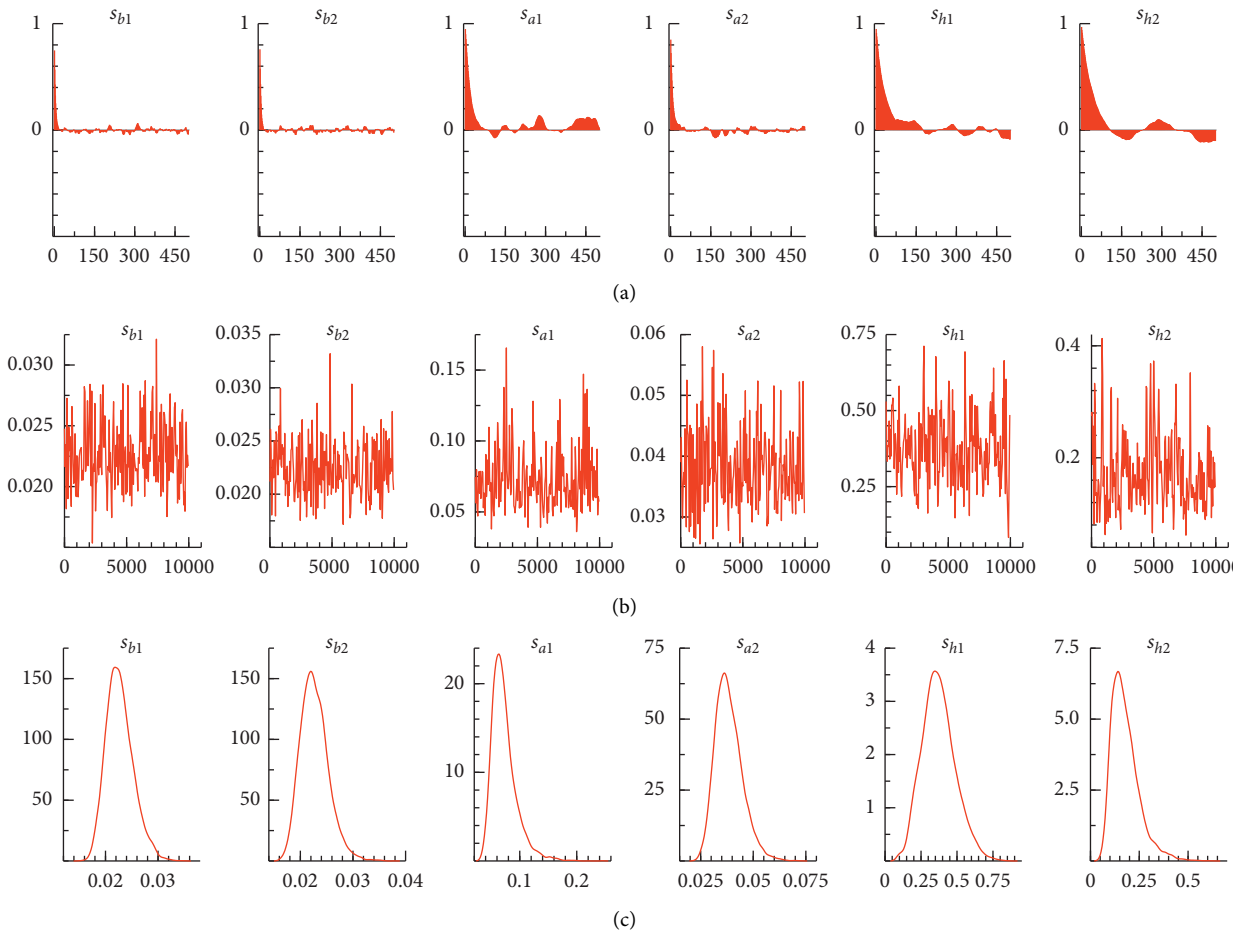


Figure 3: Estimation results of selected parameters in the TVP-VAR model. Sample autocorrelations (a), sample paths (b), and posterior densities (c).

(1) The dynamic spillover effects of the United States and China investor sentiment on China stock market return:

From Figure 6, we can see the impulse response of 1 month is the largest, followed by 6 months, and 12 months is close to zero, indicating that both the United States and China investor sentiment have a greater impact on China stock market return in the short term, and China investor sentiment is negatively correlated with China stock market return, which is the same findings obtained in previous literature [17], while the US investor sentiment is almost always positively correlated to China stock market return. The possible reason is the flight to quality. The flight to quality here refers to capital outflow of China because of the falling global market. Specifically, when the US investor sentiment is low, the global market goes down, which may lead the capital flows out from China stock market. As a result of capital outflow, the China stock market return declines. The most obvious turning point in the upper part of Figure 6 occurred in September 2013, where the impulse response of China investor

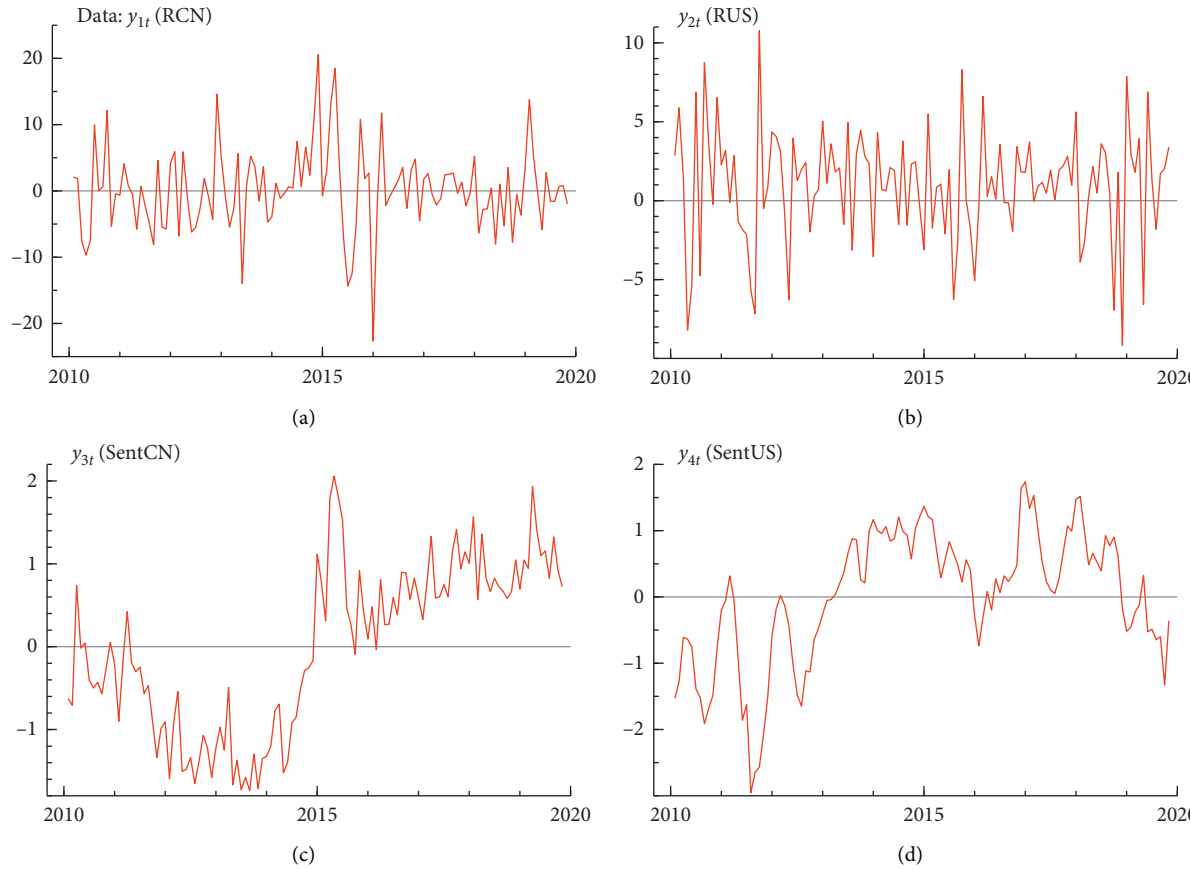


Figure 4: China stock index return, US stock index return, US investor sentiment, China investor sentiment.

sentiment shock on China stock market return began to decline, as a result of the establishment of China (Shanghai) Pilot Free Trade Zone in September 2013, which had an impact comparable to the establishment of the Shenzhen Special Economic Zone in 1979. Due to the new open policy, investors were more optimistic about China's economic development, and the impact of investor sentiment shock on stock market returns gradually diminished. Besides the 2018 United States-China trade war, economic uncertainty is high, resulting in a gradual increase in the impact of China's investor sentiment shock on the stock market return.

(2) The dynamic spillover effects of the United States and China investor sentiment on the US stock market return:

From Figure 7, we can see the impulse response of 1 month is the largest, followed by 6 months, and 12 months is close to zero, indicating that both the investor sentiment has a greater impact on the US stock market return in the short term, which is consistent with the impact on China stock market return. The US investor sentiment has a negative relationship on the US stock market return, which is also consistent with the previous literature findings [17]. China investor sentiment and the US stock market return are also negatively correlated; the higher the China investor sentiment, the lower the US stock market return. This is opposite to the positive correlation of the US investor sentiment on China stock market return, possibly because when China investor sentiment is high, money flows into China from the United States, which leads the US stock market return to decrease. The obvious turning point in the lower part of Figure 7 occurred in December 2015 when the Fed announced its first interest rate hike since June 2006. The United States then entered an interest rate hike cycle, which influenced US investor sentiment on the US stock market return increase. Therefore, the economic uncertainty may increase the impact of investor sentiment shock on stock market return.

(3) The dynamic spillover effects between the United States and China investor sentiment:

From Figure 8, we can see the 1-month impulse response of China investor sentiment on the US investor sentiment is positive, while the 6-month and 12-month are negative. Meanwhile, the 1-month, 6-month, and 12-month impulse response of the US investor sentiment on China investor sentiment are positive. The short-term spillover of China investor sentiment on the US investor sentiment is positive,

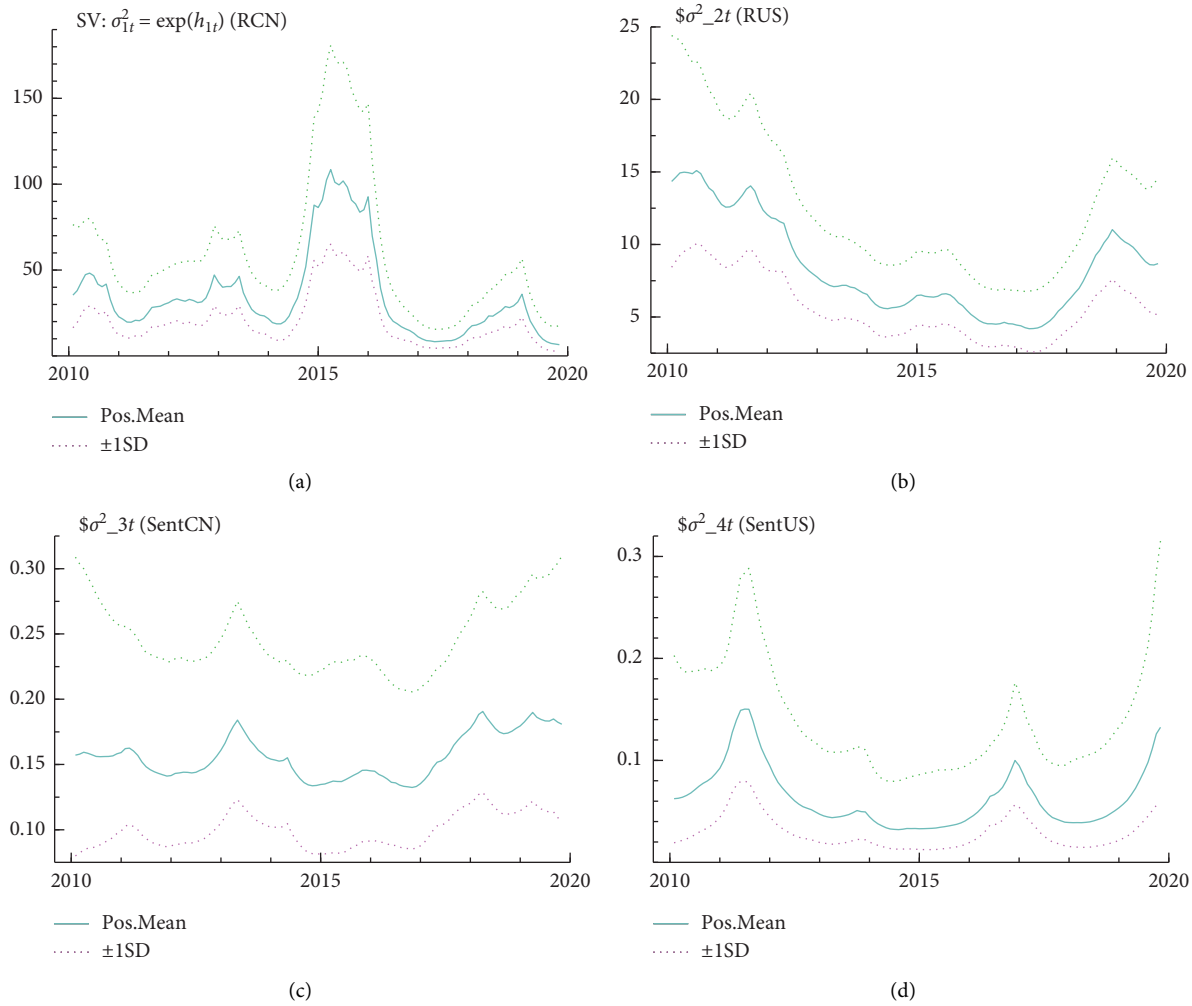


Figure 5: Posterior estimates for stochastic volatility of structural shock.

and the medium-term and long-term spillover are negative. A possible reason is that the short-term investors are susceptible to optimism, but the long-term investors will be more objective and rational. Moreover, when China investor sentiment is low, capital is shifted from China to the United States, which leads to an increase in the US investor sentiment. As for the positive spillover of US investor sentiment on China investor sentiment, one of the possible reasons is that the United States, as the world's most developed financial market, and impacts global markets. When the US investor sentiment is higher, it also means that investors are more optimistic about the global economy, which has a positive impact on China investor sentiment. Regarding the magnitude of the mutual spillover of investor sentiment between the two countries, the US investor sentiment has a greater spillover to China. In contrast, the spillover of China investor sentiment to the United States is only pronounced pre-2015 and post-2018. The obvious turning points occur in September 2013 and August 2017, corresponding to China (Shanghai) Pilot Free Trade Zone in September 2013 and the beginning of the United States-China trade war.

(4) The dynamic spillover effects between the United States and China stock market return:

From Figure 9, we can see the 1-month impulse response is the largest, and the 6 and 12 month are close to zero, which indicates that the spillover effects of the stock market are significant in the short run. The negative correlation between the United States and China stock market return in the short run is mainly due to the incomplete rationality of the market participants, as it is easier to cause convergence and herding behavior under the conditions of asymmetric information. In this case, changes in the international market conditions will affect the expectations of the domestic market. When the China stock market return is high, Chinese investors are optimistic. As mentioned earlier, China investor sentiment has a positive impact on the US investor sentiment, but

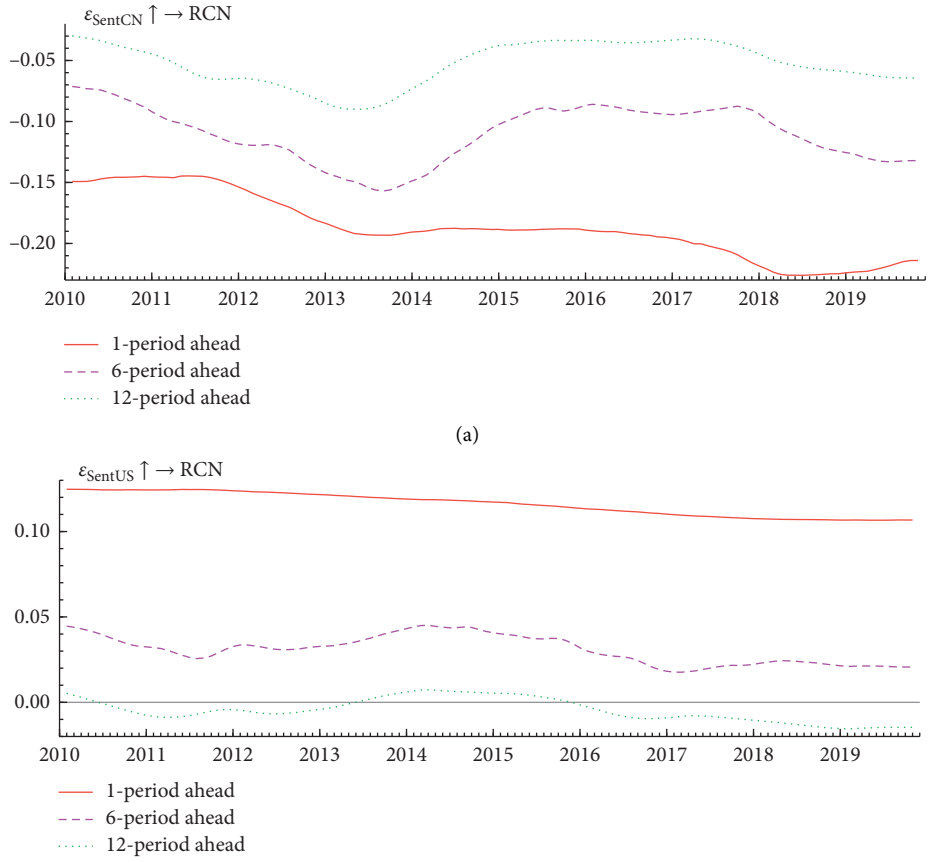


Figure 6: Time-varying impulse responses of China stock market return.

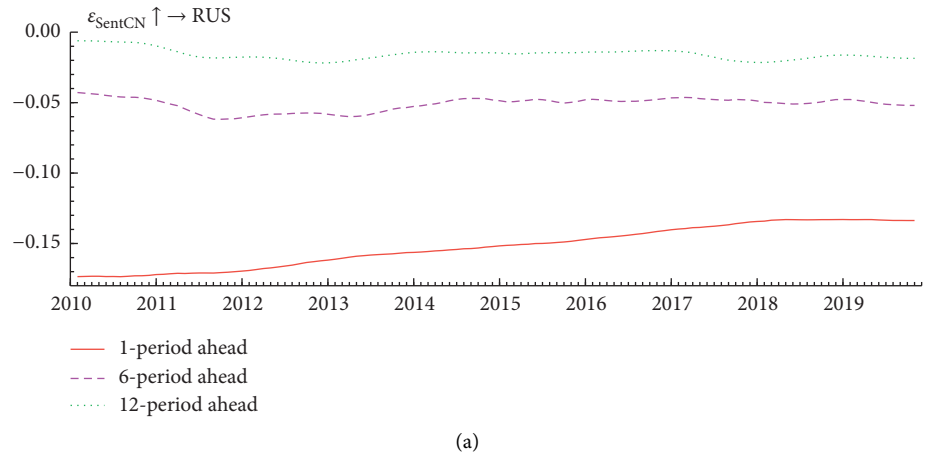
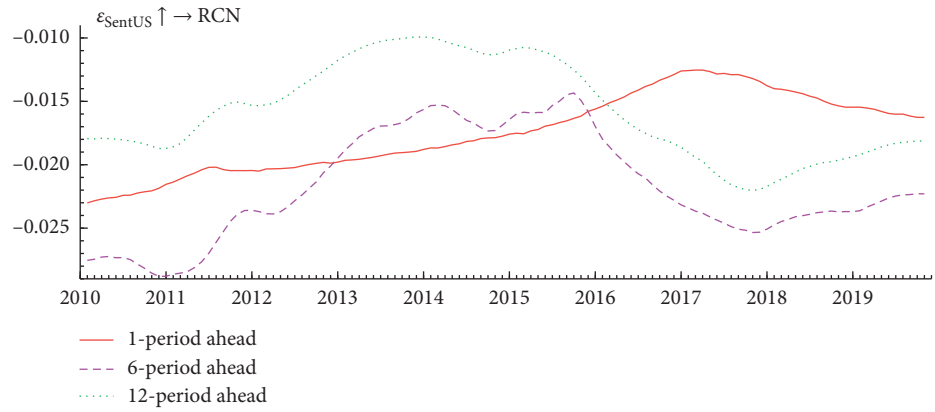
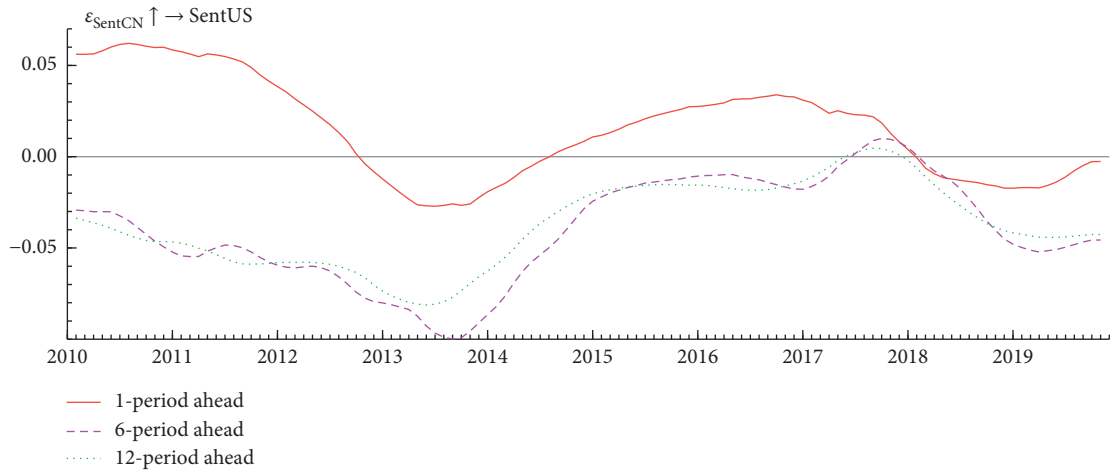


Figure 7: Continued.

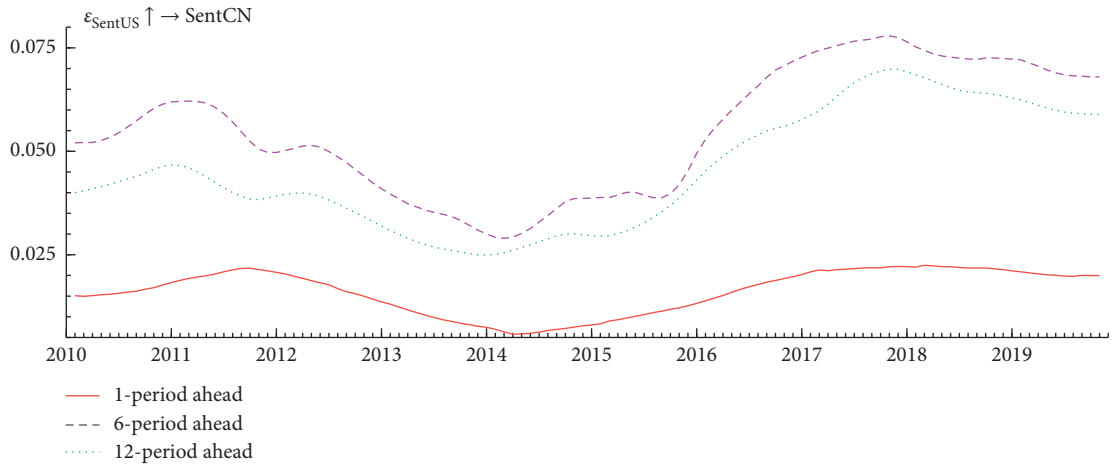


(b)

Figure 7: Time-varying impulse responses of the US stock market return.



(a)



(b)

Figure 8: Time-varying impulse responses of China and the US investor sentiment.

the US investor sentiment has a negative impact on the US stock market return. Therefore, the increase of US investor sentiment will cause the US stock market to fall. The contagion of investor sentiment between China and the United States leads to a change in investor behavior, which affects the returns of the stock market in each country.

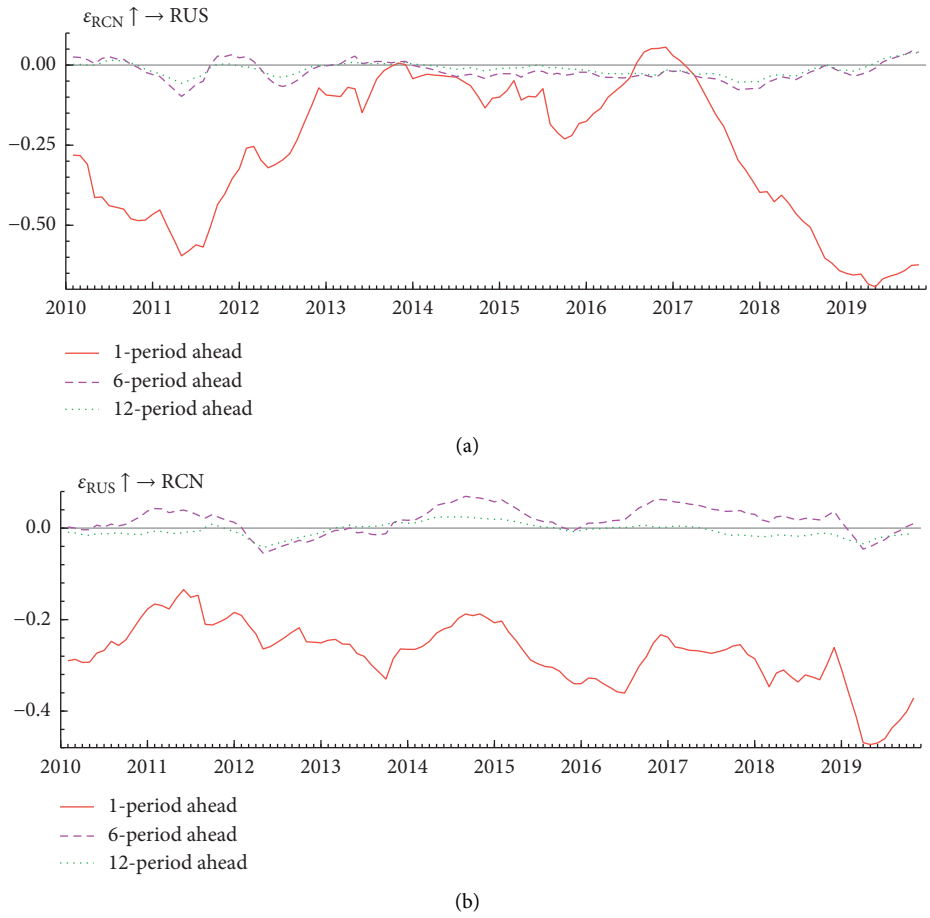


Figure 9: Time-varying impulse responses of China and the US stock market return.

To summarize, the investor sentiment has a greater short-term spillover on stock market return. China investor sentiment has a negative impact on China's stock market return and a positive impact on the US stock market return, while the US investor sentiment has a negative impact on the stock market return of China and the United States. Moreover, we find an obvious sentiment contagion effect between China and the United States. Specifically, China's investor sentiment has a positive short-term impact on the US investor sentiment. On the contrary, China's investor sentiment has a negative medium-term and long-term impact on the US investor sentiment. Nevertheless, the US investor sentiment always has a positive impact on China's investor sentiment. Also, the US investor sentiment has a bigger impact on the China investor sentiment. On the contrary, China's investor sentiment has an obvious impact on the US investor sentiment in some periods. In addition, the spillover effect of the stock market between China and the United States is only pronounced in the short term, and the spillover effect of the US stock market return to China stock market return is negative.

5.4.2. Impulse Response at Different Time Points. We obtain spillover effects between China and the US investor sentiment and the stock market through the time-varying impulse response analyses. To observe impulse response at different points, we choose four key time points: the European Debt Crisis (February 2010), the 2015 China stock market turbulence (June 2015), the Federal Reserve rate hike since 2006 (December 2015), and the China-United States trade war (April 2018).

(1) The impulses response of China stock market return at different time points:

The impulse responses of China stock market return at different time points are listed in Figure 10. When the shock of China investor sentiment is positive, the impulse responses of China stock market return at different time points are negative, reach the minimum value at the first period, and then increase to zero gradually. Meanwhile, when the shock of the US investor sentiment is positive, the impulse responses of China stock market return at different time points are positive, reach the maximum value at the first period, and then decrease to zero gradually. The results are consistent with the time-varying impulse responses in Figure 6: the short-term spillovers are more pronounced than long-term spillovers. Moreover, compared with the European Debt Crisis, the impact of China investor sentiment on China stock market return is greater at the China-United States trade war.

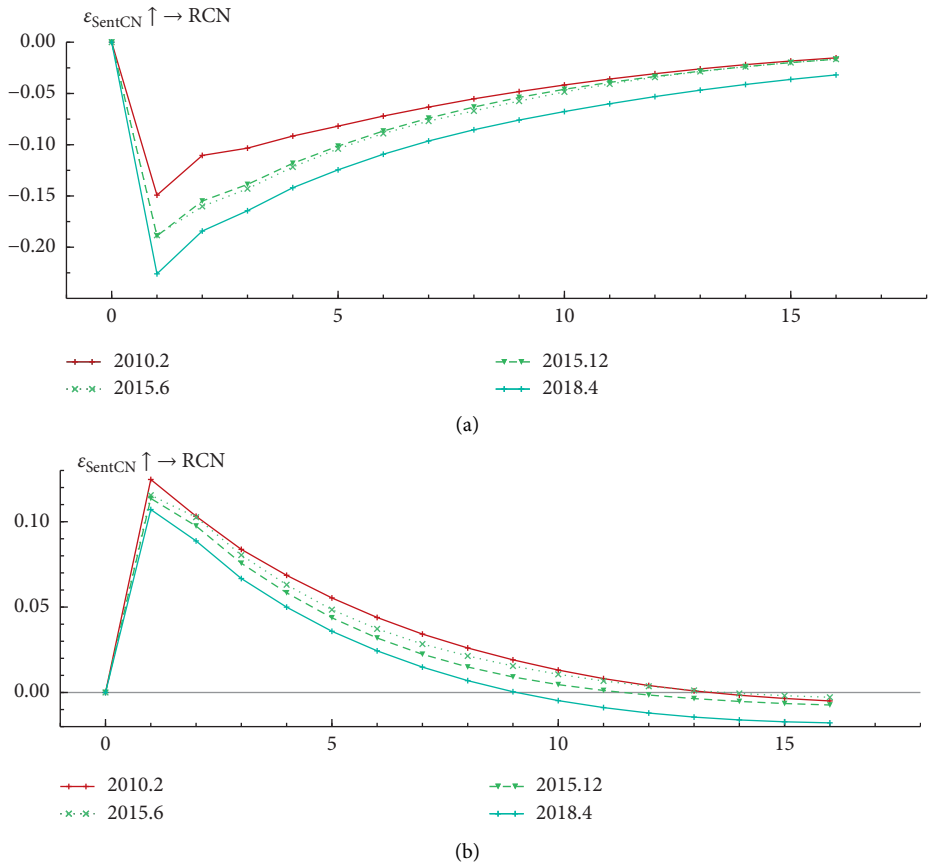


Figure 10: The impulse response of China stock market return at different time points.

(2) Impulse responses of the US stock market return at different time points:

The impulse responses of the US stock market return at different time points are shown in Figure 11. When the shock of China and the US investor sentiment are positive, the impulse responses of the US stock market return at different time points are negative. The spillovers of China investor sentiment on the US stock market return reach the minimum value at the first period and then increase to zero gradually, while the spillovers of the US investor sentiment on the US stock market return are high until the medium term, and increase to zero slowly. The results are consistent with the time-varying impulse responses in Figure 7. The spillovers of investor sentiment on the US stock market return is greatest at the European Debt Crisis, mainly because the US stock market is the center of the global finance, and the economic linkage between the United States and Europe is high, the impact on the US stock market is naturally the greatest.

(3) The impulse response of investor sentiment of China and the United States at different time points:

The impulse responses of investor sentiment of China and the United States at different time points are shown in Figure 12. As can be seen from Figure 12, the US investor sentiment immediately responds to the shock of China investor sentiment at different time points, and then decreases to zero quickly. The current impulse responses of the US investor sentiment are due to the developed financial market and market efficiency of the United States. On the contrary, China investor sentiment responses at the first period to the shock of the US investor sentiment at different time points are positive, and then increase gradually. In addition, the impulse responses of the US investor sentiment at different time points except the China-United States trade war are positive before the first three periods, and then turn to negative, which is in line with the results in Figure 8 (short-term and long-term effects are opposite). The impulse responses of the US investor sentiment at the China-United States trade war are always negative, while the impulse response of China investor sentiment at the China-United States trade is the largest. This is mainly because the China-United States trade war aggravates both countries' economic uncertainty simultaneously, but China's investor sentiment is affected more than the US investor sentiment.

(4) Impulse responses of stock market return of China and the United States at different time points:

The impulse responses of the stock market return of China and the United States at different time points are shown in Figure 13. As can be seen from Figure 13, The US stock market return immediately

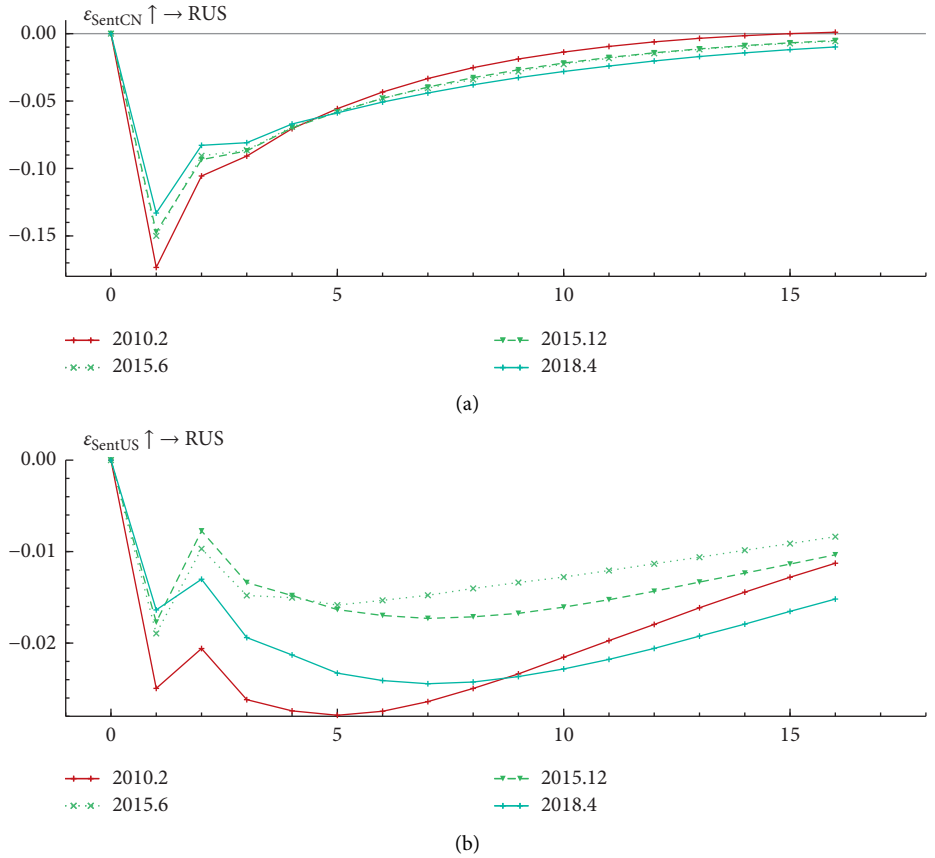


Figure 11: The impulse response of the US stock market return at different time points.

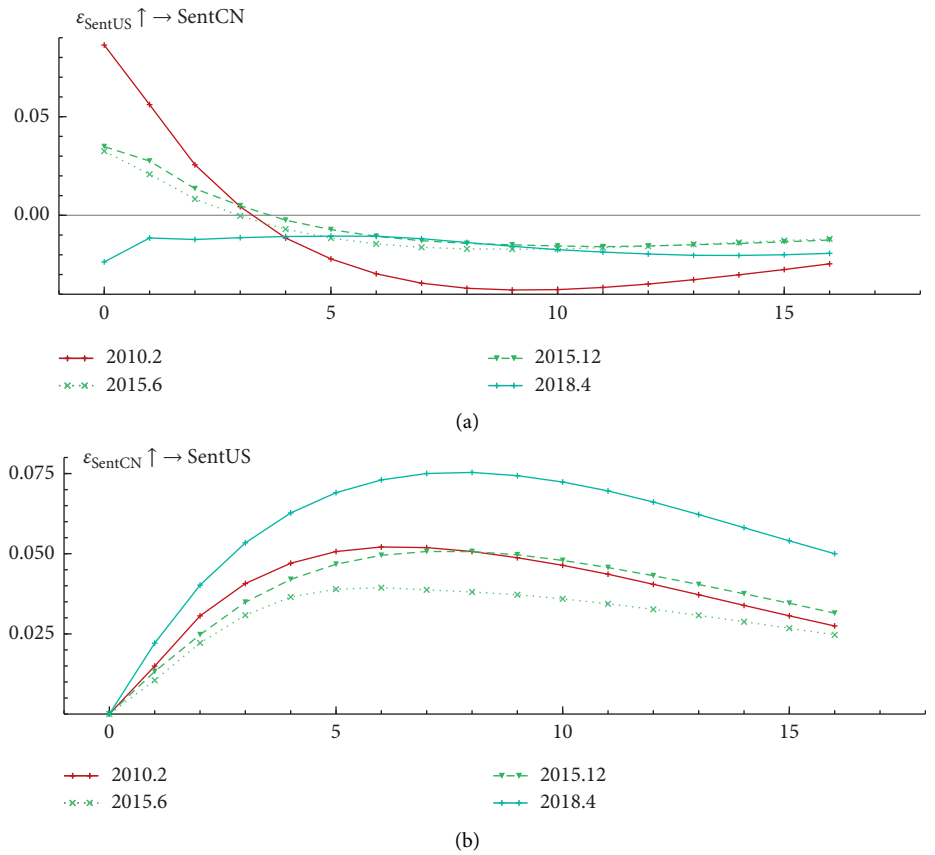


Figure 12: The impulse response of China and the US investor sentiment at different time points.

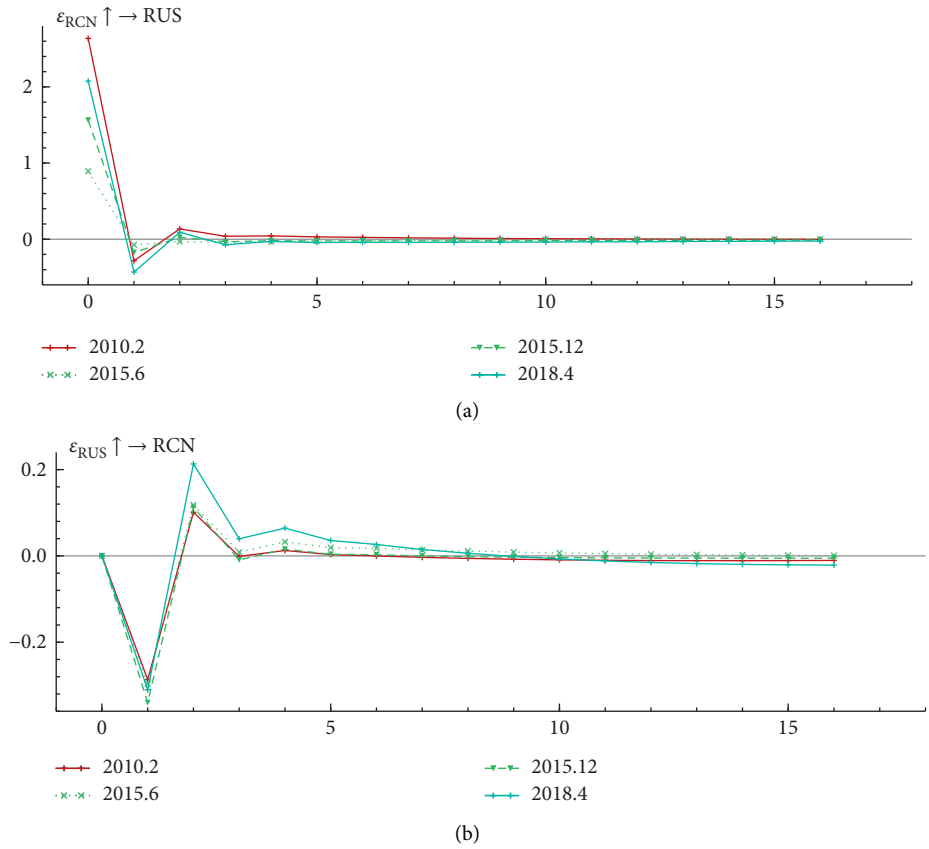


Figure 13: The impulse response of China and the US stock market return at different time points.

responds to the shocks of China stock market return at different time points, and then decreases to zero after 2 months, indicating that the developed financial market of the US transmits information faster. However, China's stock market return responses at the first period to the shock of the US stock market return at different time points are negative and positive at the second period and then decrease to zero after 3 months. The results are in line with the time-varying impulse responses in Figure 9. The impulse responses at each different time point are consistent.

The results of impulse responses at different time points show that the European Debt Crisis had a greater impact on the United States than China, while the China-United States trade war had an opposite impact. When it comes to stock market return, China stock market return responses at the first period to the shocks of China and the US investor sentiment at different time points, but the US stock return response immediately to the shocks of China and the US investor sentiment at different time points. Meanwhile, in the case of the sentiment contagion between the United States and China, the impulse responses of the US investor sentiment to the shock of China investor sentiment (except during the China-United States trade war) are positive in the short term and negative in the long term, while the impulse responses of China investor sentiment to the shock of the US investor sentiment are all negative. For the dynamic spillovers of stock market return, the impulse responses of the US stock market return are positive in the current period, and negative in the first period, while the impulse responses of China stock market return are negative in the first period, and positive in the second period. The results show that the dynamic spillover effects only exist in the short term, consistent with the time-varying impulse responses in Figure 9.

5.5. Robustness Test

5.5.1. Validation with Dual-Listed Companies. We use VIX to represent the US investor sentiment further to validate the correlation between investor sentiment and stock return. The inverse of the VIX is standardized as the US investor sentiment. The empirical results are shown in Table 4. As can be seen from Table 4, we find that most of the α coefficients are significant, indicating that the differences in investor sentiment drive the price differences in dual-listed companies.

5.5.2. The US Investor Sentiment. We use the VIX as US investor sentiment and construct the TVP-VAR model with the Shanghai Composite Index return RCN, the S & P 500 Index return RUS, the US investor sentiment (VIX) SentUS, and China investor sentiment SentCN. All the results are consistent with Section 5.4.

Table 4: Validation with dual-listed companies.

Company	α	T-statistic	P value	R-squared
CEA	0.04627	0.96	0.338	0.01
GSH	0.3404***	7.03	0.495	0.30
HNP	0.4641***	7.30	0.000	0.31
ZNH	0.1233*	3.06	0.003	0.07
SHI	0.1158	1.44	0.153	0.02
ACH	0.1021***	3.55	0.001	0.10
LFC	0.4887***	4.62	0.000	0.15
SNP	0.4184***	6.83	0.000	0.29
PTR	0.4052***	8.23	0.000	0.37

Notes: This table reports time-series regressions for nine dual-listed companies in China and the United States, respectively. The dependent variables are the price difference of nine dual-listed companies in China and the United States between January 2010 and November 2019. The independent variable is the difference between the US investor sentiment and China investor sentiment. The inverse of the VIX is standardized as the US investor sentiment. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

5.5.3. China and the US Stock Market Return. We first replace the Shanghai Composite Index return with the CSI 300 to construct the TVP-VAR model and then replace the S & P 500 Index return with the Dow Jones industrial average to construct the TVP-VAR model. The results are consistent with Section 5.4.

6. Conclusion

A growing body of recent research shows that stock returns respond to variables related to factors such as oil price [58], Exchange Rates [59], capital flow [60], fiscal policy [61], and monetary policy [62]. In this paper, we study the dynamic spillover effects of investor sentiment and return between China and the United States. First, we construct China's investor sentiment by conducting principal component analysis on the closed-end fund discount, turnover, the number of IPOs, the average first-day returns on IPOs, the number of accounts opened by new investors, and the consumer confidence index from 2010 to 2019. Second, we use the relative price differences of 9 dual-listed companies in the United States and China simultaneously and confirm that the investor sentiment index does affect stock prices. Next, we construct the TVP-VAR model to study the dynamic spillover effects of investor sentiment and return between China and the United States. We analyze the dynamic spillover of investor sentiment on the return, the contagion of investor sentiment, and the stock market linkage through the time-varying impulse response. Finally, we conduct various robust tests, such as the VIX used as investor sentiment of the United States and then the Shanghai Composite Index is replaced by the CSI 300 Index, and the S & P 500 Index is replaced by the Dow Jones industrial average index, and all the results are consistent.

We find the dynamic spillover effects of investor sentiment and stock market return between China and the United States from the TVP-VAR model. The impacts of investor sentiment on the stock market return are negative. When the investor sentiment is high, the number of noise traders increases. Rational investors will use this opportunity to arbitrage, which makes the price adjust to the fundamental value and decreases the stock market return. If the investor sentiment positively impacts the stock market return and investor sentiment and stock returns reinforce each other, then the stock may be mispriced, which will not happen in the long term. Moreover, with the economic uncertainty, investor sentiment impacts the stock market return because investors are uncertain of future economic development.

In addition, we investigate the sentiment contagion and the stock market linkage between China and the United States. Since the investors are not particularly rational in the short term compared to the medium and long run, which are easy to be influenced by optimism or pessimism, the impacts of China investor sentiment on the US investor sentiment are positive in the short term and negative in the long term. The impacts of the US investor sentiment on China's investor sentiment are always positive, and since the United States is the center of world finance, the US investor sentiment, for the most part, represents the global investor sentiment, which, in turn, has a positive impact on China's investor sentiment. Similarly, the linkage of China and the United States stock market return is only obvious in the short term.

Overall, investor sentiment has an obvious influence on stock market return in the short term, and sentiment contagion and stock market linkage are also pronounced in the short term. In this paper, we only consider dual-listed companies between China and the United States. In future studies, we can expand the dual-listed companies to the global stock market and investigate whether investor sentiment is one driving factor of price difference globally. Besides, we find the sentiment contagion and stock market linkage between China and the United States. This result enlightens us to explore if the sentiment contagion and stock market linkage are universal.

Data Availability

All the data were taken from the CSMAR database.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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