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Research on the Volatility of the Cotton Market under Different Term Structures: Perspective from Investor Attention

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Abstract: This study performed comprehensive investigations of the complex interconnections between investor attention and cotton futures price volatility under different term structures. In this paper, in-sample analysis, out-of-sample forecast, influencing mechanisms, as well as nonlinear connections are fully explored using several linear model specifications. The results can be summarized as follows: first, investor attention is the Granger causality of the cotton futures volatility and shows significant linear impacts on cotton volatility; second, models incorporated with investor attention significantly improve the prediction accuracy of cotton volatility in the long term compared with the commonly used AR benchmark model; third, the influence of investor attention on cotton volatility may occur through open interest; and fourth, investor attention presents nonlinear impacts on cotton volatility as well. Overall, the results of this article can provide strong supporting evidence for the important roles of investor attention in asset pricing applications.

Keywords: cotton volatility; investor attention; term structures; out-of-sample forecasts; open interest

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1. Introduction

Political unrest, geopolitical risks and COVID-19 have resulted in a complex and volatile international economic situation in recent decades. As one of the major crops in the world and a basic material for humans, cotton has undoubtedly become a focus. Consequently, cotton prices have experienced considerable fluctuations [1]. However, many difficulties remain to be solved in explaining and predicting cotton market volatility, which has attracted the attention of many researchers in this field [2–5].

In recent years, behavioral finance theory has rapidly developed. The emerging theory analyzes the financial markets from the perspective of cognitive psychology and argues that investor attention plays a crucial role in defining the characteristics of financial markets [6–9]. Considering the dramatic fluctuations and research puzzles in the cotton futures market, as well as the crucial roles of behavior finance in asset pricing, it is of particular interest to introduce investor attention to the cotton market and link the two issues for a comprehensive investigation.

Our purpose in this paper is to combine the studies of agricultural economics and behavior finance in order to discover the potential linkages between investor attention and cotton futures volatility under different term structures. The contributions of this study to the existing literature are multifaceted. First, this paper is the first attempt to connect investor attention and the cotton futures market, which may offer a new insight into the exploration of the internal changes in the cotton futures market from external factors, i.e., investor attention. Second, this paper adds further empirical evidence to demonstrate that a behavior-based variable, i.e., investor attention, plays an interesting role in the pricing of financial markets, which further improves and perfects the pricing theory. The empirical investigations can be generalized as follows: first, we implemented data processing to

divide the data into different term structures; second, we adopted several linear VAR-based model specifications to implement the in-sample analysis; third, based on all of the in-sample models, we evaluated the out-of-sample performance; fourth, we explain the influencing mechanisms ranging from investor attention to cotton volatility; and fifth, the nonlinear connections between investor attention and cotton volatility were researched. All the empirical results indicate that investor attention is a crucial external factor and should be focused on more in future research practice for cotton volatility.

This paper includes the following sections. Section 2 briefly reviews the literature on cotton markets and investor attention. The data and methodologies used in this paper are presented in Section 3. Section 4 shows the empirical results for the in-sample estimation and out-of-sample prediction.Section 5 provides further discussion. Section 6 is the conclusion.

2. Literature Review

This paper focuses on market explaining and forecasting in the agricultural market. In fact, numerous investigations regarding these two aspects have been undertaken. For example, Aloui et al. and Devadoss et al. explain the variations in the agricultural market from the aspect of macroeconomics, i.e., the federal fund rate, exchange rate, monetary factors and energy markets [10–12]. In addition, researchers also focus on the interconnections inside markets. For example, Working, Lautier, Ali and Gupta, and Chinn and Coibion investigate the connections between the spot and futures markets [13–16]. Allen et al. demonstrate a co-integration relationship between the agricultural products, ethanol and crude oil [17]. Adammer et al. argue the leadership of the U.S. agricultural market to European agricultural futures prices [18]. Market forecasting in the agricultural market is also a research hotspot and attracts numerous investigations. Existing studies are unfolded through two potential classifications. The first is focused on econometric methods. For example, Kulendran and Lim, respectively, adopt the ECM model to forecast the agricultural market; Zhang et al. select the MEA-SVM, while Weng et al. choose the ARIMA [19–22]. Another classification refers to the emerging artificial intelligence method [23,24]. Specifically, Jiang et al. combine EEMD and GSVM to show that the agricultural market in the short term can be forecasted with satisfactory accuracy [25]. Meanwhile, the BP neural network has proved to be an excellent model for analyzing and studying price prediction in the agricultural market [26].

Existing investigations also focus in particular on the cotton market. For example, Arnade et al. focus on the cotton market in different countries; Shrinivas and Gómez, Ertugrul et al., and He and Wang explore the co-movement of the Indian, Turkey and Chinese cotton markets and the international agricultural market, respectively [27–30]. More recently, Adhikari and Putnam and Dahl et al. illustrate the crucial roles of oil in cotton pricing; Singh and Soni investigate the relationship between the Chinese and the US cotton markets, while Li and Xiong investigate price discovery in the cotton market [2,3,31,32].

In recent decades, it has become increasingly common to explain puzzles in traditional economics and finance through the investor attention generated from behavioral finance theory [33]. Investor attention improves existing economic and financial frameworks by arguing that more focus will force investors to make trading decisions. Since the introduction of investor attention to the financial market, numerous studies have adopted several indicators to represent this variable. For example, Gervais et al. and Barber and Odean use the trading volume; Koster et al., Seasholes and Wu, Gödker and Lukas and Chae et al. select the extreme return; Grullon et al., Lou, Madson and Niessner and Focke et al. adopt advertising; and Barber and Loeffler, Liang, Engelberg and Parsons, Yuan and Yang et al. choose the news and headlines [8,9,34–45]. All the previous investigations prove that investor attention surely affects asset characteristics. Recently, with emerging technology in big data, more and more investigations adopt the Google search volume index (GSVI) to represent investor attention and prove that GSVI is a crucial element in asset pricing, i.e., commodity futures, currency, FX and emerging crypto-currency markets [46–49].

To sum up, the agricultural market has almost been fully researched, especially from the aspect of traditional financial factors. However, specific to the cotton market, current investigations seem to be limited, and the relevant investigations seem to not be involved in market forecasting. Considering the importance of cotton in the agricultural market and deficiencies in market explaining and forecasting, as well as the significant role of investor attention in asset pricing, it is of interest to link the two issues and make a comprehensive exploration between investor attention and the cotton market. Specifically, in this paper, we explain and forecast the volatility in the cotton market from the perspective of investor attention in different term structures, which may show great benefits in understanding the cotton market pricing and help investors with different risk-averse attitudes when investing in agricultural markets.

3. Data and Methodologies

3.1. Data

We obtained daily price data of cotton futures from 7 September 2007 to 25 March 2022 from the Intercontinental Exchange (ICE, https://www.theice.com/ (accessed on 30 May 2022)). In this paper, according to the existing literature, we calculated the daily absolute value of cotton futures return as price volatility [50,51].

Internet search engines have become an important instrument for accessing information, and Google seems to be the most popular search engine globally [46]. Thus, in this paper, we chose the Google search volume index (GSVI) to represent investor attention according to Li et al. [52]. Data on investor attention can be freely obtained from the global search statistics of Google Trends (https://trends.google.com/trends/ (accessed on 30 May 2022)). The process for obtaining GSVI is summarized as follows: we set the search area to "global" and searched for the keyword of "Cotton" in Google Trends for daily frequency from September 2007 to March 2022.

As we were going to analyze different term structures, we referred to the research of Corsi [53]. Specifically, we determined and calculated the daily, weekly and monthly frequencies as short, medium and long term for further empirical studies. A brief outline of cotton volatility and GSVI is depicted in Table 1.

Table 1. Descriptive statistics of cotton volatility and GSVI in different term structures.

Panel A: Cotton Volatility							
Period	**Obs.**	**Mean**	**Max**	**Min**	**Skewness**	**Kurtosis**	**Std. Dev.**
Daily	3796	0.0122	0.2300	0.0000	4.7733	52.0405	0.0139
Weekly	760	0.0004	0.0280	7.49×10^{-6}	16.5295	341.6691	0.0012
Monthly	175	0.0004	0.0029	0.0001	3.6170	21.1747	0.0004
Panel B: GSVI							
Period	**Obs.**	**Mean**	**Max**	**Min**	**Skewness**	**Kurtosis**	**Std. Dev.**
Daily	3796	−0.0105	0.8427	−0.5447	0.9462	17.3290	0.0698
Weekly	760	−0.0003	0.1000	−0.1788	−2.3306	31.7883	0.0162
Monthly	175	−0.0105	0.0293	−0.0536	0.1681	4.9887	0.0108

As shown in Table 1, the number of observed values for short, medium and long term are 3796, 760 and 175, respectively. The mean values for cotton volatility in short, medium and long term are 0.0122, 0.0004 and 0.0004, while the standard deviations are 0.0139, 0.0012 and 0.0004, respectively. In addition, the skewness and kurtosis indicate that all the time series in different term structures show similarities with the common financial time series. As shown in Panel B of Table 1, the difference between maximized and minimized investor attention is significantly higher than the difference in the cotton volatility series, whether in the short, medium or long term. At the same time, the standard deviation of investor

attention is much greater than the cotton market. As a result, the volatility for investor attention is high.

The VAR model is a commonly used econometric model in exploring the interconnections between financial assets and was also adopted in this study. The data used for VAR modelling should be stationary. Thus, in this subsection, stationary status of the time series was tested as our sample ranged from September 2007 to March 2022, covering the financial crisis in 2008 and the recent COVID-19 epidemic, which may result in some structural breakpoints in the time series. Thus, the commonly adopted ADF test may be misleading. Considering the deficiencies of ADF test for a series with potential breaks and the advantages of Phillips–Perron test, this paper performed the ADF-KPSS-PP joint test to identify the stationarity status on the selected series before VAR modelling. The results of the joint test are reported in Table 2.

Table 2. ADF-KPSS-PP joint test of cotton volatility and investor attention.

Variables	Period	Type	Statistic	Conclusion
Cotton Volatility	Daily	ADF	−21.3192 ***	Stationary
		KPSS	2.9052	Stationary
		PP	−60.1673 ***	Stationary
	Weekly	ADF	−26.9363 ***	Stationary
		KPSS	1.4075	Stationary
		PP	−26.7682 ***	Stationary
	Monthly	ADF	−6.9884 ***	Stationary
		KPSS	0.9199	Stationary
		PP	−6.3965 ***	Stationary
Investor Attention	Daily	ADF	−29.0940 ***	Stationary
		KPSS	0.6391	Stationary
		PP	−76.1367 ***	Stationary
	Weekly	ADF	−35.2551 ***	Stationary
		KPSS	0.1806	Stationary
		PP	−36.1291 ***	Stationary
	Monthly	ADF	−4.9213 ***	Stationary
		KPSS	0.3098	Stationary
		PP	−12.6104 ***	Stationary

Notes: The null hypothesis of the ADF and PP test is that the series has a unit root. The null hypothesis of the KPSS test is that the series is stationary. *** represents that the statistic is significant at 1% level.

According to the results of the ADF-KPSS-PP test, these six series could be used for VAR modelling as all of them are stationary. In this paper, the function of investor attention in out-of-sample forecasts was explored. Thus, the full sample was divided into two parts. Specifically, the time period from 7 September 2007 to 25 August 2017 was selected for in-sample analysis, and the remaining sample from 26 August 2017 to 25 March 2022 was used for the out-of-sample forecasting. The parts contained the period of the Russia–Ukraine conflict, COVID-19 and post-COVID-19 and may show great guidelines for investors during turbulence, especially the period when public health was suffering from a pandemic.

3.2. Granger Causality Test

Since the introduction of the linear Granger causality test, this approach quickly became a standard for evaluating linear causality [54,55]. In this section, similar to numerous previous investigations [46–49], we combined the GSVI on cotton and cotton volatility to implement a basic linear Granger causality test to explore whether there is a linear causal relationship between investor attention and cotton market volatility under different term

structures. The standard specification of Granger causality tests can be summarized by the following Equations (1) and (2) according to Han et al. [56]:

$$V_t = \alpha_{01} + \alpha_{11}V_{t-1} + \cdots + \alpha_{n1}V_{t-n} + \beta_{11}Att_{t-1} + \cdots + \beta_{n1}Att_{t-n} + \varepsilon_t \quad (1)$$

$$Att_t = \alpha_{02} + \alpha_{12}V_{t-1} + \cdots + \alpha_{n2}V_{t-n} + \beta_{12}Att_{t-1} + \cdots + \beta_{n2}Att_{t-n} + e_t \quad (2)$$

where V_t and Att_t represent the cotton volatility and investor attention in different term structures at time t, respectively. α_{01} and α_{02} represent the constant in the equations, and ε_t and e_t mean the error term. $(\alpha_{11}, \ldots, \alpha_{n1}, \beta_{11}, \ldots \beta_{n1})$ and $(\alpha_{12}, \ldots, \alpha_{n2}, \beta_{12}, \ldots \beta_{n2})$ represent coefficients of the multivariate linear models of (1) and (2), respectively. The Granger causality test in this paper was particularly interested in the joint significance of $(\beta_{11}, \ldots \beta_{n1})$. Technically, we depended on the χ^2 statistic to verify the Granger causality between investor attention and cotton volatility.

3.3. VAR Model

The VAR model is a commonly used econometric model in estimating and predicting financial time series, which is mainly attributed to the fact that VAR model incorporates a "lead-lag" relationship between variables [49,57,58]. Based on the perfect applicability of the VAR model in financial markets, the VAR model was implemented in this study to briefly explore the interconnection between investor attention and cotton market volatility in short, medium and long term, respectively. The VAR model can be generalized by the following Equation (3):

$$X_t = c + \sum_{i=1}^{p} \beta_i X_{t-i} + \varepsilon_t \quad (3)$$

where X_t represents the vectors in the current time, including investor attention and the corresponding cotton volatility in short, medium or long term, respectively. p represents the lag length and is the same as the Granger causality test during the subsequent empirical investigations, and β is the coefficient of the lagged terms.

3.4. Interactive Relationship

Inspired by existing studies, in this subsection, we further explored the relationship between investor attention and the cotton market by incorporating the interaction terms between the lagged two variables into the model [49,56]. The relevant model for this subsection is shown below in Equation (4):

$$V_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i V_{t-i} + \sum_{i=1}^{p} \beta_i Att_{t-i} + \sum_{i=1}^{p} \lambda_i Att_{t-i} * V_{t-i} + \varepsilon_t \quad (4)$$

where p denotes the lag period and is the same as the lag length in previous models during the following investigations. The coefficient of λ in Equation (4) measures the effects of the interaction terms on future cotton market volatility.

3.5. Control Variables

Considering the impacts of macroeconomic and traditional factors on the cotton market, this paper attempted to incorporate relevant markets into the regression model to further identify the complex relationship between investor attention and cotton volatility [59,60]. Drawing on existing studies, the specific regression model is presented in Equation (5):

$$V_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i V_{t-i} + \sum_{i=1}^{p} \beta_i Att_{t-i} + \sum_{i=1}^{p} \lambda_i Att_{t-i} * V_{t-i} + \varepsilon_t \quad (5)$$

where p denotes the lag length and is set the same as in above models in the previous subsections. *Control* represents the control variables. The coefficient of θ represents the effects of control variable on the cotton market.

3.6. Indicators for Out-of-Sample Forecasts

Over-fitting is a common existing question regarding in-sample analysis. Thus, one significant variable may be poorly performed when performing out-of-sample forecasts [61]. To avoid such problems, this paper further explored the out-of-sample prediction ability of investor attention for cotton volatility under different term structures. Specifically, the rolling window method with a fixed window size was implemented to predict the volatility of cotton based on the models incorporated with investor attention. In this paper, several indicators, i.e., out-of-sample R squared (R^2_{oos}), mean squared forecast error (MSFE), MSFE-adjusted statistic and the related p value, were adopted as the criteria.

Technically and statistically, a positive R^2_{oos} is preferred as it indicates an increased forecasting accuracy compared with the benchmark. The R^2_{oos} was calculated as follows:

$$R^2 = R^2_{oos} = 1 - \frac{\sum_{k=t+1}^{T} \left(R_k - \hat{R}_k\right)^2}{\sum_{k=t+1}^{T} \left(R_k - \overline{R_k}\right)^2} \tag{6}$$

where T is the number for out-of-sample forecasts. R_k represents the real value, and $\hat{R}_k$ is the forecasted value by the predictive equation. $\overline{R_k}$ is the predicted value of the benchmark model. Financially, for a financial asset, the basic AR model always beats some sophisticated models when predicting future volatility. Thus, in this paper, AR was set as the benchmark.

Another important statistical indicator is the MSFE-adjusted of Clark and West, which is used to test whether the increment in forecast accuracy is significant or not [62]. Details about MSFE-adjust are shown below:

$$R^2 = R^2_{oos} = 1 - \frac{\sum_{k=t+1}^{T} \left(R_k - \hat{R}_k\right)^2}{\sum_{k=t+1}^{T} \left(R_k - \overline{R_k}\right)^2} \tag{7}$$

where $MSFE_a$ and $MSFE_b$ denote the MSFE statistic calculated by the predictive model and the AR model, respectively. For more details on these statistics, refer to Yin et al. [63].

4. Results

4.1. Results for In-Sample Analysis

4.1.1. Granger Causality Test

According to the AIC, and SC among other criteria, this article set the daily and weekly lag lengths to 4 and the monthly lag length to 1. The related Granger causality test results of Equations (1) and (2) for the in-sample period are shown in Table 3.

Table 3. Granger causality test results between investor attention and cotton market.

Sample Frequency		χ^2-Statistic
Daily	H0: Investor attention does not Granger cause volatility in the cotton market	8.6485 *
	H0: Volatility in the cotton market does not Granger cause investor attention	11.873 **
Weekly	H0: Investor attention does not Granger cause volatility in the cotton market	9.0748 *
	H0: Volatility in the cotton market does not Granger cause investor attention	9.0219 *
Monthly	H0: Investor attention does not Granger cause volatility in the cotton market	7.8304 ***
	H0: Volatility in the cotton market does not Granger cause investor attention	0.2730

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

The above results illustrate important facts about the cotton market and investor attention. In the short and medium term, there is a bidirectional Granger causality between

cotton volatility and investor attention; in the long term, there is a unidirectional Granger causality from investor attention to cotton volatility. Investor attention Granger causes volatility in the cotton market in the long term. In conclusion, the findings of the Granger causality test briefly indicate the fact that investor attention is a non-negligible factor in the cotton market and deserves further exploration.

4.1.2. VAR Analysis

Based on the lag length certified in the above subsection of 4.1.1, we set the lag length to 4 for the short and medium term and to 1 for the long term. We implemented a VAR analysis for different term structures, and the detailed results are shown in the following Table 4.

Table 4. VAR estimation results under different term structures.

	Panel A. Daily		**Panel B. Weekly**		**Panel C. Monthly**	
	V_t	Att_t	V_t	Att_t	V_t	Att_t
V_{t-1}	0.2245 ***	0.1395	0.0538	−1.3490 ***	0.6698 ***	−1.3422
	(0.0196)	(0.0985)	(0.0440)	(0.4737)	(0.0682)	(2.5670)
V_{t-2}	0.1481 ***	−0.0051	0.0121	−0.1388	—	—
	(0.0201)	(0.1008)	(0.0443)	(0.4773)	—	—
V_{t-3}	0.0491 **	0.2745 ***	0.0211	−0.2486	—	—
	(0.0201)	(0.1007)	(0.0443)	(0.4773)	—	—
V_{t-4}	0.0380 *	−0.1195	-5.91×10^{-6}	−0.2331	—	—
	(0.01962)	(0.0985)	(0.0441)	(0.4757)	—	—
Att_{t-1}	−0.0067 *	−0.2484 ***	−0.0085 **	−0.2639 ***	0.0068 ***	0.1062
	(0.0039)	(0.0196)	(0.0041)	(0.0440)	(0.0024)	(0.0913)
Att_{t-2}	0.0067 *	−0.1507 ***	−0.0021	−0.0883 *	—	—
	(0.0040)	(0.0202)	(0.0042)	(0.0454)	—	—
Att_{t-3}	−0.0032	−0.0689 ***	−0.0056	0.0041	—	—
	(0.0040)	(0.0202)	(0.0042)	(0.0454)	—	—
Att_{t-4}	−0.0004	−0.0301	0.0060	0.0670	—	—
	(0.0039)	(0.0196)	(0.0040)	(0.0436)	—	—
Intercept	0.0069 ***	−0.0176	0.0004 ***	0.0001	0.0002 ***	−0.0077 ***
	(0.0005)	(0.0024)	(0.0001)	(0.0008)	(0.0000)	(0.0016)
R^2	0.1121	0.0690	0.0202	0.0911	0.4511	0.0149

Note: Values in parentheses represent standard errors. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

From the regression results, we can draw the following main findings. First, investor attention in one period lag has a significant impact on the current cotton market, whether in the short, medium or long term. In particular, the coefficient of investor attention for the lag length of 2 is significant in the short term, despite the signal being the opposite. Second, the current investor attention was also significantly affected by the volatility in the previous period, i.e., in the short and medium term. In both the short and medium term, the influence of investor attention on the cotton volatility quickly vanishes as the subsequent term is insignificant. Furthermore, cotton volatility has no effect on investor attention in the long term as the relevant coefficient is not significant. An impulse response analysis can be implemented under the VAR framework to visualize the response of one variable to another. We show the interesting results under different term structures in Figures 1–3, respectively.

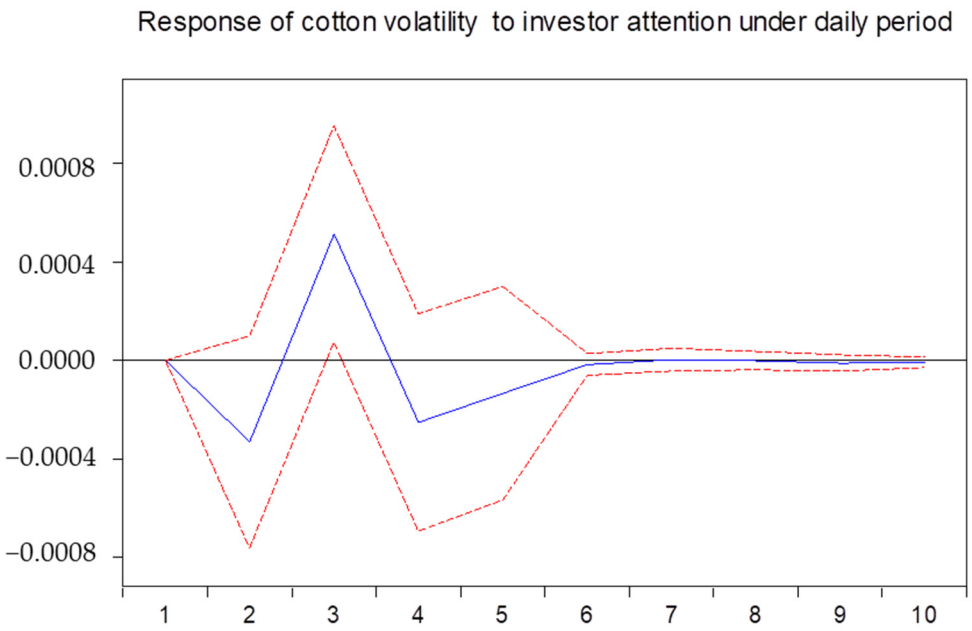

Figure 1. Response of cotton daily volatility to shock from investor attention. Note: The line in blue color represents the values of the interested variable after a certain shock. The line in red color shows the corresponding significance level of 95%.

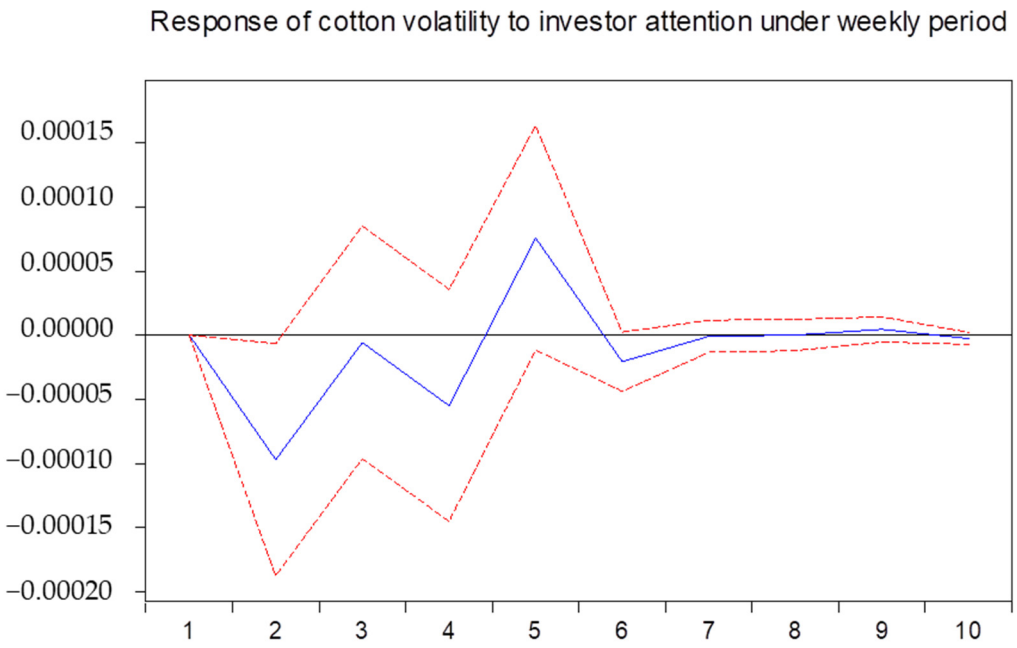

Figure 2. Response of cotton weekly volatility to shock from investor attention. Note: The line in blue color represents the values of the interested variable after a certain shock. The line in red color shows the corresponding significance level of 95%.

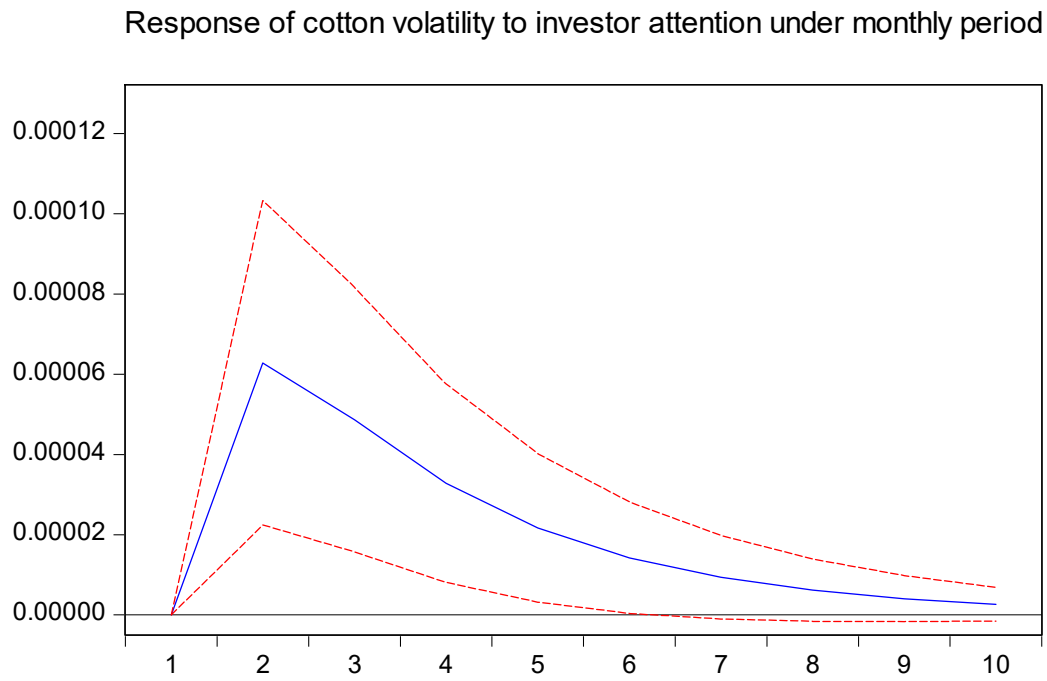

Figure 3. Response of cotton monthly volatility to shock from investor attention. Note: The line in blue color represents the values of the interested variable after a certain shock. The line in red color shows the corresponding significance level of 95%.

As shown in Figures 1–3, we can see that investor attention does affect cotton volatility, whether in the short, medium or long term. One shock from investor attention lasts for about 5 days, 6 weeks and 9 months in cotton volatility in the short, medium and long term, respectively. All the results demonstrate that investor attention is an interesting item in cotton pricing. Thus, the influence of investor attention on cotton market volatility under different term structures deserves more investigation.

4.1.3. Interactive Relationship

Wu et al. argue a feedback loop between investor attention and market characteristics [64]. Thus, we added the interactive terms as Equation (4) and estimated the related coefficients under different term structures in Table 5.

Table 5. The estimation results of Equation (4) under different term structures.

	Panel A. Daily	Panel B. Weekly	Panel C. Monthly
V_{t-1}	0.2270 ***	0.1216 *	1.0376 ***
	(0.0201)	(0.0737)	(0.0872)
V_{t-2}	0.1223 ***	0.0590	—
	(0.0205)	(0.0743)	—
V_{t-3}	0.0735 ***	0.0099	—
	(0.0203)	(0.0743)	—
V_{t-4}	0.0433 **	0.0252	—
	(0.0198)	(0.0737)	—
Att_{t-1}	−0.0082 *	−0.0083 **	−0.0062 **
	(0.0049)	(0.0042)	(0.0031)
Att_{t-2}	−0.0137 **	−0.0023	—
	(0.0050)	(0.0044)	—
Att_{t-3}	0.0095 **	−0.0065	—
	(0.0051)	(0.0043)	—

Table 5. *Cont.*

	Panel A. Daily	Panel B. Weekly	Panel C. Monthly
Att_{t-4}	0.0115 **	0.0056	—
	(0.0050)	(0.0042)	—
$V_{t-1} \times Att_{t-1}$	0.2021	−2.0509	16.7070 ***
	(0.2168)	(1.7130)	(2.8380)
$V_{t-2} \times Att_{t-2}$	1.5273 ***	−1.4466	—
	(0.2197)	(1.7284)	—
$V_{t-3} \times Att_{t-3}$	−0.8176 ***	0.1365	—
	(0.2217)	(1.7281)	—
$V_{t-4} \times Att_{t-4}$	−0.7462 ***	−0.8612	—
	(0.2189)	(1.7103)	—
Intercept	0.0068 ***	0.0003 ***	9.06×10^{-7}
	(0.0005)	(0.0001)	(0.0001)
R^2	0.1369	0.0255	0.5774

Note: Values in parentheses represent standard errors. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

As shown in Table 5, when we added the lagged interaction terms between investor attention and cotton volatility, investor attention still shows excellent explanatory ability in cotton volatility, whether in the short, medium or long term as some related items are significant.

4.1.4. Joint Impact with Other Assets

In this paper, for macroeconomic factors, we chose two indicators, i.e., the federal funds rate (Rate) and the EUR/USD exchange rate (Exchange) [10]; for agricultural markets, we chose corn (Corn), wheat (Wheat), soybean (Bean) markets from CBOT and Chinese cotton futures (Cot) markets from the Zhengzhou Commodity Exchange [4,65,66]; for capital markets, we chose Nasdaq (Nas), S&P 500 (SP) and the Dow Jones Industrial Index (Dow) [67]; for the energy market, we chose the WTI crude oil (WTI) and Brent crude oil (Brent) markets [68,69]; and for the precious metals market, we chose gold (Gold), silver (Silver) and copper metal (Copper) [12,70,71]. The detailed regression results of Equation (5) are shown in the Appendix A of Tables A1–A3, respectively. As can be seen in Tables A1–A3, we discovered two interesting findings. On the one hand, no matter in the short, medium or long term, after introducing the relevant markets as control variables, investor attention is still significant; thus, investor attention still shows explanatory ability on the cotton volatility. On the other hand, after controlling for corn, wheat, soybean, gold and silver, investor attention significantly increases the impact on cotton volatility in the medium term; after controlling for corn, soybean, gold and copper markets, investor attention shows an enhanced effect on cotton volatility in the long term.

To sum up, investor attention shows a significant explanatory ability in cotton volatility. The results are consistent with two types of previous investigations. The first type may refer to the importance of investor attention on the particular agricultural markets. For example, Tomáš Mišečka et al. and Peri and Vandone test and certify that investor attention is a crucial factor in agricultural futures pricing [72,73]. The second type may refer to the application of investor attention on general financial markets. For example, Han et al. and Kou et al. argue the importance of investor attention in the international and Chinese commodity futures market [74,75]. Wu et al. highlight the importance of investor attention in exchange rate determination [64]. The interesting phenomenon of how investor attention affects the cotton market may be explained by the following reason: the amount of information acquisition affects the expectation of an investment; thus, the decision-making process of investors is affected. Consequently, the price volatility of one financial asset is affected. Specific to the volatility under different term structures in the cotton market, the results in the above subsections may be accounted for by the following reasons. First, the market is full of speculators in the daily and weekly data frequencies; once the market receives a potential shock which may increase the attention according to the limited attention theory in behavior

finance, the speculators may only be able to analyze partial information that is increased to the market. Then, these speculators may perform two types of behaviors to achieve certain goals, i.e., sell the asset for profits or continue to buy the asset in order to decrease the holding cost. The proportion of speculators in these activities is unknown; therefore, the influence of investor attention on cotton volatility may be positive or negative in the short or medium term [72]. Second, in the long term, on the one hand, numerous investors may follow the judgement of the whole market according to the theory of herd effects, and investors may make irrational trading decisions under irrational market conditions. Consequently, the trading activities converge to the same, which may increase the volatility of the cotton market; on the other hand, through Internet search engines, the cost of acquiring public information has decreased to almost zero, which may also result in investors making similar trading decisions, enhancing the herd effect [74]. Thereby, in the long term, investor attention increases the cotton volatility.

However, significant explanatory power does not imply that investor attention can predict cotton markets during out-of-sample periods. Obviously, all the models for the in-sample analysis contain a "lead-lag" relationship. Therefore, in the following subsection, we will present and evaluate the forecast accuracy during the out-of-sample period for all the in-sample methods based on the investor attention.

4.2. Out-of-Sample Forecast

As previously mentioned, the rolling window method with a fixed window size was implemented. Due to the availability and validity of the data, we set the sample from 7 September 2007 to 25 August 2017 as the first window for the short term; accordingly, the medium and long term were set approximately from 3 September 2007 to 21 August 2017 and 1 September 2007 to 1 September 2017, respectively. The indicators for the out-of-sample analysis are generalized in Table 6.

Table 6. Out-of-sample prediction results under different term structures.

	Panel A: Daily		**Panel B: Weekly**		**Panel C: Monthly**	
	R^2	**MSFE−Adj**	R^2	**MSFE−Adj**	R^2	**MSFE−Adj**
VAR	0.0006	1.0968 *	−0.0108	0.3071	0.0175	2.1363 **
Interactive	−0.0050	−0.1054	−0.0212	0.7053	−0.0641	0.0995
Forecast with Rate	0.0027	1.9000 **	−0.0280	0.3090	−0.1306	0.2358
Forecast with Exchange	−0.0032	0.4716	−0.0596	−1.0663	0.0064	2.2479 **
Forecast with Corn	−0.0032	−0.0098	−0.0298	0.6230	0.0131	2.0668 **
Forecast with Wheat	−0.0057	−0.3204	−0.0109	1.7331 **	0.0274	2.9566 ***
Forecast with Bean	−0.0026	0.5922	−0.0463	0.2390	0.0180	2.2442 **
Forecast with Cot	0.0024	1.6558 **	−0.0754	−1.0101	−0.0554	0.6762
Forecast with Nas	0.0042	2.2204 **	−0.0520	0.3073	0.0243	2.4208 ***
Forecast with SP	0.0046	2.2999 **	−0.0297	0.4915	0.0503	3.1279 ***
Forecast with Dow	0.0040	2.2019 **	−0.0360	0.6491	0.0765	3.3832 ***
Forecast with WTI	−0.0043	1.3951 *	−0.1814	−0.9984	0.0138	2.5390 ***
Forecast with Brent	−0.0057	0.5889	−0.2027	−1.2050	0.0259	2.5639 ***
Forecast with Gold	−0.0019	1.0387	−0.0693	−0.7292	0.0411	3.2293 ***
Forecast with Silver	0.0003	1.4640 *	−0.0993	−0.4374	−0.0105	1.2384 *
Forecast with Copper	−0.0007	1.0428	−0.0523	0.0708	0.0311	2.1737 **

Note: *, ** and *** represent the significance at 10%, 5% and 1%, respectively.

Table 6 summarizes the out-of-sample forecast results for all of the in-sample models under different term structures. From the prediction results in Table 6, we can draw the following interesting findings. One is that, in the short term, the linear VAR forecast of cotton volatility outperforms the benchmark model, and in the long term, this result still holds true. In addition, in the medium term, all the predictive models do not show better accuracy than the benchmark model. Second, from the out-of-sample forecast results of the joint effects, in the long term, after adding control variables such as the EUR/USD

exchange rate, corn, wheat, soybean, capital market, energy market, gold, copper, etc., the out-of-sample prediction accuracy of the model including investor attention is still significantly better than the benchmark model. In the short term, after adding control variables such as the U.S. federal funds rate, the cotton futures market of China, the capital market and silver, the out-of-sample prediction accuracy of the model that incorporates investor attention also shows better performance than the benchmark model. Finally, despite the out-of-sample R squared in the short term being positive with the MSFE-adj indicator being significant, the value is too small to regard it as an excellent performance. To sum up, although investor attention during the in-sample period can significantly explain cotton volatility, the out-of-sample forecasting does not show an advantage in all aspects compared with the AR benchmark model, i.e., in the medium term.

In conclusion, forecasting models incorporating investor attention can indeed be used to predict short- and long-term cotton volatility, and especially the long-term forecasting ability is superior.

5. Further Discussion

5.1. Potential Influencing Mechanism

The above sections illustrate that investor attention affects the volatility of the cotton market. According to the research of Hong and Yogo, market performance is affected by changes in open interest [76]; according to behavior finance theory, investor attention will affect the purchasing behavior of investors, and the changes in purchasing behavior directly lead to changes in open interest. Based on this theoretical connection, this paper further discusses the impact of investor attention on open interest in the cotton futures market to gain a deeper understanding of the relationship between investor attention and cotton market volatility. Considering the availability of data, we obtained weekly data about open interest from the CFTC (https://www.cftc.gov/ (accessed on 30 May 2022)) and repeated the above research process for examining the Granger causality and the linear connections. The results are shown in Tables 7 and 8.

Table 7. Granger causality test results between investor attention and open interest.

Equation	Excluded	χ^2-Statistic
Open Interest	Investor Attention	8.243 *
Investor Attention	Volatility	8.2463 *

Note: * represent the significance at 10%.

Table 8. The estimation results between investor attention and open interest.

	Panel A: VAR		Panel B: Interactive	
	OI_t	Att_t		OI_t
OI_{t-1}	0.2899 ***	−0.0266 *	OI_{t-1}	0.2836 ***
	(0.0435)	(0.0155)		(0.0440)
OI_{t-2}	−0.1229 ***	−0.0109	OI_{t-2}	−0.1236 ***
	(0.0452)	(0.0161)		(0.0455)
OI_{t-3}	−0.0643	0.0232	OI_{t-3}	−0.0649
	(0.0453)	(0.0161)		(0.0456)
OI_{t-4}	−0.1123 ***	0.0104	OI_{t-4}	−0.1112 **
	(0.0435)	(0.0155)		(0.0439)
Att_{t-1}	−0.1396	−0.2797 ***	Att_{t-1}	−0.1660
	(0.1227)	(0.0437)		(0.1251)
Att_{t-2}	−0.2035	−0.0771 **	Att_{t-2}	−0.2232 *
	(0.1271)	(0.0452)		(0.1292)

Table 8. *Cont.*

	Panel A: VAR		**Panel B: Interactive**	
	OI_t	Att_t		OI_t
Att_{t-3}	−0.3294 ***	0.0102	Att_{t-3}	−0.3836 ***
	(0.1272)	(0.0453)		(0.1296)
Att_{t-4}	−0.0340	0.0730 *	Att_{t-4}	−0.0687
	(0.1225)	(0.0436)		(0.1248)
—	—	—	$OI_{t-1} \times Att_{t-1}$	3.9085
	—	—		(4.0031)
—	—	—	$OI_{t-2} \times Att_{t-2}$	2.5966
	—	—		(4.0073)
—	—	—	$OI_{t-3} \times Att_{t-3}$	8.2810 **
	—	—		(3.9928)
—	—	—	$OI_{t-4} \times Att_{t-4}$	7.1929 *
	—	—		(3.9856)
Intercept	−0.0002	−0.0007	Intercept	0.0004
	(0.0019)	(0.0007)		(0.0020)
R^2	0.1268	0.0897	R^2	0.1398

Note: The table includes two sections with regression results for the VAR and interaction effects. The value of the standard error is shown in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

From Tables 7 and 8, it can be inferred that investor attention has a significant impact on open interest in the cotton market. Thus, the influence of investor attention on cotton volatility may occur through the influence of investor attention on open interest.

5.2. Nonlinear Relationships

All of the above-mentioned models are trying to perform a comprehensive investigation regarding linear connections between investor attention and cotton volatility. However, according to Zhang et al., investor attention may show nonlinear impacts on financial markets [60]. Thus, in this paper, in order to fully investigate the influence of investor attention on cotton volatility, we particularly focused on this potential nonlinear aspect. The nonlinear regression model used in this paper is shown below in Equation (8). Similarly, the lag length was set to 4 for the short and medium term and 1 for the long term. The detailed regression results are shown in the following Table 9.

$$V_t = \alpha_{01} + \alpha_{11} V_{t-1} + \cdots + \alpha_{n1} V_{t-n} + \beta_{11} {Att_{t-1}}^2 + \cdots + \beta_{n1} {Att_{t-n}}^2 + \varepsilon_t \quad (8)$$

Table 9. Nonlinear connections estimated by Equation (8).

	Panel A: Daily	**Panel B: Weekly**	**Panel C: Monthly**
V_{t-1}	0.2180 ***	0.0428	0.7445 ***
	(0.0162)	(0.0365)	(0.0616)
V_{t-2}	0.1269 ***	0.0302	—
	(0.0166)	(0.0367)	—
V_{t-3}	0.0407 **	0.0154	—
	(0.0166)	(0.0367)	—
V_{t-4}	0.0416 **	0.0201	—
	(0.0162)	(0.0367)	—
${Att^2}_{t-1}$	−0.0017	0.0155	−0.2673 ***
	(0.0112)	(0.0311)	(0.0703)
${Att^2}_{t-2}$	0.0247 **	−0.0201	—
	(0.0112)	(0.0311)	—
${Att^2}_{t-3}$	−0.0074	0.0180	—
	(0.0112)	(0.0311)	—
${Att^2}_{t-4}$	0.0140	−0.0018	—
	(0.0112)	(0.0310)	—
Intercept	0.0069 ***	0.0003	0.0002 ***
	(0.0004)	(0.0001)	(0.00003)
R^2	0.0956	0.0051	0.4624

Note: ** and *** represent the significance at 5% and 1%, respectively.

From the above Table 9, several interesting phenomena can be observed. First, the cotton volatility series still shows the characteristics of autoregression in the short and long term; and second, and the most interested finding, the investor attention shows a nonlinear impact on the cotton volatility in the short and long term as some high-order terms of investor attention are significant.

6. Conclusions

The novelty of this paper lies in the combination of investor attention and cotton volatility in different term structures, which may be important extensions for both investor attention application and the agricultural commodity futures market. In this paper, several linear models were used for an in-sample period to analyze the connections between investor attention and cotton volatility and were extended to out-of-sample forecasts. Furthermore, the influencing mechanism and nonlinear impact from investor attention to cotton volatility were explored. The empirical results indicate that, first, investor attention does linear Granger cause the variations in cotton volatility under short-, medium- and long-term structures; second, in both the short and long term, the inclusion of investor attention does improve the accuracy of forecasts compared with the commonly used volatility forecasting model, i.e., the AR model; third, open interest may act as the intermediary variable between the investor attention and cotton volatility; and fourth, investor attention shows both linear and nonlinear impacts on cotton volatility. In summary, investor attention does matter in the pricing of the cotton market.

The results in this paper also show several policy implications. On the one hand, volatility shows a great role in risk aversion, and this paper provides a novel perspective for market supervisions to understand cotton volatility from investor behavior. On the other hand, according to the results, especially in the long term, investor attention shows an excellent prediction accuracy, which may be useful to some mutual funds when constructing portfolios. However, this paper also has some limitations. For example, nonlinear Granger causality is out of consideration in this paper. In addition, agricultural commodity markets are tightly connected, and spillover effects of investor attention among different markets have not been explored. In addition, financial markets fluctuate, and this paper does not involve the potential structural breaks in the model constructions. In this paper, the above limitations have not been taken into account and should be focused on in future investigations on the topic.

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Appendix A

Table A1. The estimation results of joint impact in short term.

	Rate	Exchange	Corn	Wheat	Bean	Cot	Nas
V_{t-1}	0.2242 ***	0.2254 ***	0.2243 ***	0.2235 ***	0.2220 ***	0.2252 ***	0.2247 ***
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)
V_{t-2}	0.1487 ***	0.1454 ***	0.1485 ***	0.1477 ***	0.1494 ***	0.1477 ***	0.1479 ***
	(0.0201)	(0.0202)	(0.0201)	(0.0202)	(0.0201)	(0.0202)	(0.0202)
V_{t-3}	0.0492 **	0.0515 **	0.0489 **	0.0508 **	0.0506 **	0.0496 **	0.0480 **
	(0.0201)	(0.0202)	(0.0201)	(0.0201)	(0.0201)	(0.0202)	(0.0201)
V_{t-4}	0.0365 *	0.0357 *	0.0379 *	0.0399 **	0.0362 *	0.0359 *	0.0371 *
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0198)	(0.0197)
Att_{t-1}	−0.0070 *	−0.0076 *	−0.0064 *	−0.0068 *	−0.0068 *	−0.0068 *	−0.0064
	(0.0039)	(0.0039)	(0.0040)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Att_{t-2}	0.0063	0.0064	0.0063	0.0068 *	0.0061	0.0063	0.0070 *
	(0.0041)	(0.0040)	(0.0041)	(0.0040)	(0.0040)	(0.0041)	(0.0040)
Att_{t-3}	−0.0035	−0.0035	−0.0034	−0.0030	−0.0038	−0.0034	−0.0030
	(0.0041)	(0.0040)	(0.0041)	(0.0040)	(0.0040)	(0.0040)	(0.0040)
Att_{t-4}	−0.0006	−0.0007	−0.0008	−0.0005	−0.0010	−0.0007	−0.0003
	(0.0039)	(0.0039)	(0.0040)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
$Control_{t-1}$	−0.0032	−0.0311	0.0032	0.0037	0.0117	0.0128	−0.0299
	(0.0279)	(0.0444)	(0.0146)	(0.0133)	(0.0179)	(0.0209)	(0.0210)
$Control_{t-2}$	−0.0065	0.0869 *	−0.0078	−0.0150	0.0018	−0.0097	0.0139
	(0.0281)	(0.0444)	(0.0147)	(0.0133)	(0.0179)	(0.0210)	(0.0211)
$Control_{t-3}$	−0.0182	−0.0825 *	0.0010	−0.0140	−0.0186	0.0089	−0.0363 *
	(0.0281)	(0.0444)	(0.0146)	(0.0133)	(0.0179)	(0.0210)	(0.0211)
$Control_{t-4}$	0.0206	−0.0267	0.0148	−0.0060	−0.0071	0.0139	0.0005
	(0.0280)	(0.0444)	(0.0146)	(0.0133)	(0.0179)	(0.0209)	(0.0210)
$Att_{t-1} \times Control_{t-1}$	−0.0166	0.4249	−0.0936	−0.0871	−0.0538	−0.1260	−0.1398
	(0.0279)	(0.5727)	(0.1680)	(0.1854)	(0.2358)	(0.2561)	(0.2753)
$Att_{t-2} \times Control_{t-2}$	−0.0065	0.8078	0.0996	0.1807	0.3445	0.2927	0.1495
	(0.0281)	(0.5722)	(0.1682)	(0.1854)	(0.2361)	(0.2564)	(0.2774)
$Att_{t-3} \times Control_{t-3}$	−0.0182	0.7755	0.0590	0.2245	0.5405 **	−0.0050	−0.3031
	(0.0281)	(0.5725)	(0.1677)	(0.1852)	(0.2356)	(0.2565)	(0.2773)
$Att_{t-4} \times Control_{t-4}$	0.0206	0.2098	0.0454	0.0122	0.2291	0.1651	0.1714
	(0.0280)	(0.5732)	(0.1674)	(0.1852)	(0.2352)	(0.2562)	(0.2743)
Intercept	0.0069 ***	0.0069 ***	0.0069 ***	0.0068 ***	0.0068 ***	0.0069 ***	0.0069 ***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
R^2	0.1134	0.1112	0.1129	0.1142	0.1157	0.1134	0.1146
	Sp	**Dow**	**WTI**	**Brent**	**Gold**	**Silver**	**Copper**
V_{t-1}	0.2245 ***	0.2252 ***	0.2267 ***	0.2263 ***	0.2239 ***	0.2243 ***	0.2252 ***
	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)	(0.0197)
V_{t-2}	0.1475 ***	0.1475 ***	0.1495 ***	0.1495 ***	0.1476 ***	0.1480 ***	0.1481 ***
	(0.0202)	(0.0202)	(0.0202)	(0.0202)	(0.0201)	(0.0201)	(0.0202)
V_{t-3}	0.0476 **	0.0480 **	0.0452 **	0.0464 **	−0.0497 **	0.0485 **	0.0462 **
	(0.0201)	(0.0201)	(0.0202)	(0.0202)	(0.0202)	(0.0202)	(0.0201)
V_{t-4}	0.0370 *	0.0374 *	0.0393 **	0.0378 *	0.0367 *	0.0370 *	0.0376 *
	(0.0197)	(0.0197)	(0.0198)	(0.0198)	(0.0198)	(0.0197)	(0.0197)
Att_{t-1}	−0.0063	−0.0064	−0.0065 *	−0.0064 *	−0.0069 *	−0.0066 *	−0.0063 *
	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Att_{t-2}	0.0071 *	0.0069 *	0.0064	0.0066 *	0.0060	0.0063	0.0065 *
	(0.0040)	(0.0040)	(0.0040)	(0.0040)	(0.0041)	(0.0040)	(0.0040)
Att_{t-3}	−0.0029	−0.0030	−0.0034	−0.0033	−0.0038	−0.0036	−0.0032
	(0.0040)	(0.0040)	(0.0040)	(0.0040)	(0.0041)	(0.0040)	(0.0040)
Att_{t-4}	−0.0002	−0.0002	−0.0003	−0.0002	−0.0012	−0.0010	−0.0004
	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
$Control_{t-1}$	−0.0393 *	−0.0414 *	0.0051	0.0068	−0.0014	0.0108	0.0065
	(0.0224)	(0.0244)	(0.0116)	(0.0129)	(0.0245)	(0.0137)	(0.0162)
$Control_{t-2}$	0.0116	0.0151	0.0105	0.0070	0.0165	0.0154	0.0213
	(0.0226)	(0.0246)	(0.0116)	(0.0129)	(0.0244)	(0.0137)	(0.0162)
$Control_{t-3}$	−0.0448 **	−0.044 *	−0.0196 *	−0.0198	−0.0051	−0.0085	−0.0294 *
	(0.0226)	(0.0246)	(0.0116)	(0.0129)	(0.0243)	(0.0137)	(0.0162)
$Control_{t-4}$	−0.0001	0.0036	0.0071	0.0121	0.0209	0.0165	0.0038
	(0.0224)	(0.0244)	(0.0116)	(0.0128)	(0.0243)	(0.0137)	(0.0162)

Table A1. *Cont.*

	Sp	Dow	WTI	Brent	Gold	Silver	Copper
$Att_{t-1} \times Control_{t-1}$	−0.1715	−0.1637	0.1109	0.0780	0.0436	−0.0195	0.4434 **
	(0.2847)	(0.3018)	(0.1696)	(0.1820)	(0.3392)	(0.1814)	(0.2093)
$Att_{t-2} \times Control_{t-2}$	0.2282	0.3221	0.0373	0.1627	0.2816	0.1362	0.3494 *
	(0.2860)	(0.3028)	(0.1697)	(0.1818)	(0.3396)	(0.1814)	(0.2095)
$Att_{t-3} \times Control_{t-3}$	−0.4140	−0.4176	−0.0383	−0.0994	0.2051	0.0890	0.1514
	(0.2860)	(0.3027)	(0.1692)	(0.1818)	(0.3386)	(0.1809)	(0.2091)
$Att_{t-4} \times Control_{t-4}$	0.1426	0.2420	0.1380	0.0522	0.7676 **	0.3245 *	−0.0029
	(0.2843)	(0.3020)	(0.1694)	(0.1825)	(0.3403)	(0.1808)	(0.2091)
Intercept	0.0069 ***	0.0069 ***	0.0069 ***	0.0069 ***	0.0069 ***	0.0069 ***	0.0069 ***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
R^2	0.1156	0.1157	0.1140	01140	0.1144	0.1146	0.1164

Note: *, ** and *** represent the significance at 10%, 5% and 1%, respectively.

Table A2. The estimation results of joint impact in medium term.

	Rate	Exchange	Corn	Wheat	Bean	Cot	Nas
V_{t-1}	0.0495	0.0386	0.0533	0.0569	0.0533	0.0538	0.0535
	(0.0446)	(0.0450)	(0.0448)	(0.0446)	(0.0447)	(0.0446)	(0.0447)
V_{t-2}	0.0046	0.0365	−0.0115	0.0008	−0.0425	0.0036	0.0125
	(0.0452)	(0.0454)	(0.0455)	(0.0444)	(0.0456)	(0.0453)	(0.0449)
V_{t-3}	0.0193	0.0177	0.0251	0.0226	0.0141	0.0211	0.0221
	(0.0452)	(0.0454)	(0.0456)	(0.0444)	(0.0456)	(0.0454)	(0.0449)
V_{t-4}	0.0016	0.0142	−0.0195	0.0252	−0.0341	−0.0068	0.0012
	(0.0451)	(0.0447)	(0.0451)	(0.0439)	(0.0448)	(0.0453)	(0.0447)
Att_{t-1}	−0.0122 ***	−0.0010 **	−0.0100 **	−0.0099 **	−0.0111 ***	−0.0091 **	−0.0092 **
	(0.0045)	(0.0005)	(0.0041)	(0.0041)	(0.0041)	(0.0042)	(0.0042)
Att_{t-2}	−0.0035	−0.0003	−0.0030	−0.0026	−0.0041	−0.0023	−0.0025
	(0.0047)	(0.0005)	(0.0043)	(0.0042)	(0.0042)	(0.0043)	(0.0043)
Att_{t-3}	−0.0045	−0.0005	−0.0075 *	−0.0061	−0.0069 *	−0.0066	−0.0052
	(0.0047)	(0.0005)	(0.0043)	(0.0042)	(0.0042)	(0.0043)	(0.0043)
Att_{t-4}	0.0079 *	0.0008 *	0.0048	0.0071 *	0.0051	0.0057	0.0066
	(0.0045)	(0.0463)	(0.0041)	(0.0041)	(0.0040)	(0.0041)	(0.0041)
$Control_{t-1}$	−0.0003	−0.0111 **	0.0019	−0.0005	0.0009	0.0004	0.0004
	(0.0003)	(0.0057)	(0.0015)	(0.0017)	(0.0018)	(0.0023)	(0.0032)
$Control_{t-2}$	−0.0003	0.0028	0.0017	0.0031 *	0.0032 *	0.0006	0.0016
	(0.0004)	(0.0059)	(0.0015)	(0.0017)	(0.0018)	(0.0024)	(0.0033)
$Control_{t-3}$	−0.0003	0.0001	−0.0005	−0.0014	0.0011	0.0011	−0.0049
	(0.0004)	(0.0059)	(0.0015)	(0.0017)	(0.0018)	(0.0023)	(0.0033)
$Control_{t-4}$	−0.0003	0.0062	−0.0005	0.0021	−0.0015	−0.0033	0.0007
	(0.0003)	(0.0057)	(0.0015)	(0.0017)	(0.0017)	(0.0023)	(0.0031)
$Att_{t-1} \times Control_{t-1}$	−0.0333	0.1189 ***	−0.1631 *	−0.2513 **	−0.4304 ***	−0.2699	−0.2721
	(0.0242)	(0.0460)	(0.1013)	(0.1195)	(0.1212)	(0.2125)	(0.2241)
$Att_{t-2} \times Control_{t-2}$	−0.0083	−0.0124	−0.007	−0.1030	−0.0540	−0.0278	−0.0472
	(0.0244)	(0.0462)	(0.1005)	(0.1194)	(0.1225)	(0.2134)	(0.2240)
$Att_{t-3} \times Control_{t-3}$	0.0124	0.0646	−0.2903 ***	−0.3104 ***	−0.4633 ***	−0.1677	0.1493
	(0.0243)	(0.0463)	(0.0999)	(0.1197)	(0.1228)	(0.2147)	(0.2242)
$Att_{t-4} \times Control_{t-4}$	0.0257	0.0166	−0.0183	0.4281 ***	−0.1819	−0.1306	0.0315
	(0.0242)	(0.0463)	(0.0997)	(0.1206)	(0.1220)	(0.2120)	(0.2262)
Intercept	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
R^2	0.0313	0.0480	0.0471	0.0785	0.0735	0.0299	0.0280
	Sp	**Dow**	**WTI**	**Brent**	**Gold**	**Silver**	**Copper**
V_{t-1}	0.0382	0.0432	0.0543	0.0482	0.0729 *	0.0581	0.0456
	(0.0449)	(0.0447)	(0.0441)	(0.0441)	(0.0449)	(0.0447)	(0.0445)
V_{t-2}	−0.0022	−0.0053	0.005	0.0126	−0.0335	−0.0364	0.0136
	(0.0464)	(0.0468)	(0.0447)	(0.0452)	(0.0462)	(0.0456)	(0.0447)

Table A2. *Cont.*

	Sp	Dow	WTI	Brent	Gold	Silver	Copper
V_{t-3}	0.0459	0.0444	0.0108	0.0216	0.0131	0.0161	0.0399
	(0.0464)	(0.0468)	(0.0447)	(0.0452)	(0.0463)	(0.0457)	(0.0447)
V_{t-4}	0.0491	0.0584	0.0093	−0.0019	0.0048	−0.0201	0.0147
	(0.0464)	(0.0467)	(0.0444)	(0.0450)	(0.0457)	(0.0451)	(0.0441)
Att_{t-1}	−0.0091 **	−0.0086 **	−0.0122 ***	−0.0116 ***	−0.0083 **	−0.0114 ***	−0.0055
	(0.0041)	(0.0041)	(0.0043)	(0.0042)	(0.0041)	(0.0041)	(0.0043)
Att_{t-2}	−0.0002	−0.0002	−0.0047	−0.0046	−0.0036	−0.0048	−0.0012
	(0.0043)	(0.0043)	(0.0044)	(0.0043)	(0.0042)	(0.0043)	(0.0044)
Att_{t-3}	−0.0033	−0.0035	−0.0090 **	−0.0085 **	−0.0070 *	−0.0086 **	−0.0077 *
	(0.0043)	(0.0043)	(0.0044)	(0.0043)	(0.0042)	(0.0043)	(0.0044)
Att_{t-4}	0.0043	0.0045	0.0037	0.0048	0.0051	0.0031	0.0045
	(0.0041)	(0.0041)	(0.0041)	(0.0041)	(0.0040)	(0.0041)	(0.0043)
$Control_{t-1}$	−0.0072 **	−0.0078 **	0.0006	0.0005	0.0003	0.0006	0.0021
	(0.0033)	(0.0036)	(0.0012)	(0.0014)	(0.0024)	(0.0014)	(0.0017)
$Control_{t-2}$	0.0007	0.0012	0.0013	0.0021	−0.0014	−0.0012	−0.0025
	(0.0033)	(0.0036)	(0.0012)	(0.0014)	(0.0024)	(0.0014)	(0.0017)
$Control_{t-3}$	0.0029	0.0028	0.0001	−0.0001	0.0035	0.0010	−0.0007
	(0.0033)	(0.0036)	(0.0013)	(0.0014)	(0.0024)	(0.0014)	(0.0016)
$Control_{t-4}$	0.0004	0.0011	−0.0020 *	−0.0012	−0.0016	0.0005	0.0011
	(0.0032)	(0.0035)	(0.0013)	(0.0014)	(0.0024)	(0.0014)	(0.0016)
$Att_{t-1} \times Control_{t-1}$	0.5485 **	0.5899 **	−0.0820	0.0362	−0.6186 ***	−0.3510 ***	−0.3254 **
	(0.2356)	(0.2536)	(0.0888)	(0.1004)	(0.1855)	(0.1065)	(0.1279)
$Att_{t-2} \times Control_{t-2}$	−0.1651	−0.2094	−0.0374	−0.0403	0.0815	−0.0115	−0.0076
	(0.2358)	(0.2545)	(0.0883)	(0.1011)	(0.1878)	(0.1082)	(0.1264)
$Att_{t-3} \times Control_{t-3}$	−0.9617 ***	−1.0998 ***	−0.0347	−0.1203	−0.3615 *	−0.3322 ***	0.2733 **
	(0.2359)	(0.2543)	(0.0872)	(0.1008)	(0.1875)	(0.1080)	(0.1256)
$Att_{t-4} \times Control_{t-4}$	−0.9617	0.1307	−0.3253 ***	−0.3730 ***	−0.6137 ***	−0.2134 **	0.2996 **
	(0.2320)	(0.2477)	(0.0893)	(0.1004)	(0.1832)	(0.1063)	(0.1275)
Intercept	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***	0.0004 ***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
R^2	0.0661	0.0724	0.0555	0.0527	0.0746	0.0674	0.0646

Note: *, ** and *** represent the significance at 10%, 5% and 1%, respectively.

Table A3. The estimation results of joint impact in long term.

	Rate	Exchange	Corn	Wheat	Bean	Cot	Nas
V_{t-1}	0.6501 ***	0.6894 ***	0.6865 ***	0.6899 ***	0.6807 ***	0.6723 ***	0.6962 ***
	(0.0710)	(0.0722)	(0.0688)	(0.0710)	(0.0687)	(0.0698)	(0.0735)
Att_{t-1}	0.0066 ***	0.0074 ***	0.0064 ***	0.0073 ***	0.0061 **	0.0065 **	0.0060 **
	(0.0025)	(0.0025)	(0.0024)	(0.0025)	(0.0024)	(0.0025)	(0.0025)
$Control_{t-1}$	−0.0018	0.0148	0.0149 *	0.0099	0.0219 **	0.0018	−0.0243
	(0.0017)	(0.0230)	(0.0080)	(0.0088)	(0.0104)	(0.0122)	(0.0154)
$Att_{t-1} \times Control_{t-1}$	−0.1482	1.7086	1.2289 **	0.7634	1.5848 **	−0.6397	−1.7063 *
	(0.1254)	(1.6297)	(0.5154)	(0.6186)	(0.7275)	(0.9888)	(0.9116)
Intercept	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
R^2	0.4590	0.4564	0.4779	0.4587	0.4756	0.4547	0.4687
	Sp	**Dow**	**WTI**	**Brent**	**Gold**	**Silver**	**Copper**
V_{t-1}	0.6774 ***	0.6653 ***	0.6703 ***	0.6670 ***	0.6877 ***	0.6850 ***	0.7212 ***
	(0.0731)	(0.0723)	(0.0696)	(0.0696)	(0.0714)	(0.0707)	(0.0711)
Att_{t-1}	0.0062 **	0.0066 **	0.0067 ***	0.0066 ***	0.0056 **	0.0054 **	0.0068 ***
	(0.0026)	(0.0025)	(0.0025)	(0.0025)	(0.0026)	(0.0026)	(0.0024)
$Control_{t-1}$	−0.0207	−0.0238	0.0043	0.0014	0.0243 *	0.0075	−0.0052
	(0.0173)	(0.0189)	(0.0082)	(0.0080)	(0.0129)	(0.0070)	(0.0088)
$Att_{t-1} \times Control_{t-1}$	−1.3345	−1.0100	0.0423	−0.2847	1.6094 *	0.8190	1.2989 *
	(1.1135)	(1.1748)	(0.5716)	(0.5592)	(0.8964)	(0.5658)	(0.6573)
Intercept	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
R^2	0.4598	0.4586	0.4529	0.4538	0.4712	0.4617	0.4869

Note: The tables consist of three parts, which, respectively, report the results of the joint impact of investor attention and other markets on cotton volatility in the short, medium and long term. The value in the bracket means the standard error. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

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