Proceedings of the 2023 International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/24/20230441

The Influence of Investor Sentiment on Futures Price Volatility: Evidence from the Chinese Crude Oil Market

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Abstract: With the progress of crude oil financialization, crude oil futures has become an important derivative product, and its price discovery function has been widely concerned by investors. The relationship between sentiment and price can be studied by constructing oil market sentiment index. Considering that the investor sentiment of single-market energy futures may not reflect the cross-market impact well, this paper selected OI, PSY, RSI and other commonly used futures trading indicators, and used principal component analysis to construct the investor sentiment indexes of single-market (crude oil) and cross-market (crude oil, fuel oil, coking coal, coke) respectively. VAR, Granger test and linear regression are used to explore the influence of investor sentiment on the volatility of crude oil futures prices. The results show that: (i) There is a Granger causality relationship between single market (crude oil) investor sentiment and crude oil price; (ii) There is no Granger causality relationship between cross-market investor sentiment and crude oil price; (iii) Single market and cross-market investor sentiment have an asymmetric effect on the price fluctuation of crude oil futures market.

Keywords: investor sentiment, energy futures market, cross-market

1. Introduction

Energy futures markets are linked to investor sentiment. The transmission of various information in the market will have an impact on investor sentiment, and then affect the investment direction of market participants, and ultimately affect the price of the investment subject matter. Secondly, compared with the stock market, the trading characteristics of futures market tend to magnify the decision-making gap between rational people and irrational people. Futures trading does not need to pay all capital, and the "leverage effect" caused by the use of margin will amplify market conditions and further affect investors' emotions. Futures are "T+0" trades that allow multiple positions to be closed during the day, and the stock cannot be sold if it moves in an unfavorable direction after the day's trading. Third, there is cross-market risk spillover in the energy futures market. Investor sentiment in energy futures markets may be correlated. For example, crude oil market information can be disseminated to other energy markets [1]. In the years when the novel coronavirus broke out around the world, the collapse of crude oil futures prices created low speculation. This sentiment will also affect the natural gas, gasoline and heating oil markets [2][3].

Based on the above research background, first of all, this paper selects five proxy variables of investor sentiment and their lagging terms, and successfully constructs the investor sentiment index

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of single energy futures market and cross-market through principal component analysis. Secondly, VAR, Granger test and linear regression were used to test the relationship between the two investor sentiment indexes and the volatility of crude oil prices, and the differences between the results were compared to explore the cross-market spillover effect. Finally, the EGARCH model is used to test the difference of the influence of the two indexes on the futures price discovery function. The three hypotheses to be tested are (i) there is an effect between the single market investor sentiment indicator and the price volatility of the main INE oil contract, (ii) there is an effect between cross-market investor sentiment indicators and price fluctuations in the main INE crude oil contracts, and (iii) both the cross-market indicators of investor sentiment and the single-market indicators have asymmetric effects on the price fluctuations of the major INE crude oil contracts.

The innovation points of the article are as follows. First, most energy futures market research is based on data from the single market [4]. Based on the research purpose, this paper constructs a cross-market investor sentiment model to provide more practical empirical results. Secondly, focusing on the investor sentiment of China's energy futures market, the data interval of the selection covers all stages of the growth of China's energy futures market. In other words, its research results have their own uniqueness and universality. In addition, based on previous studies on the influence of cross-market investor sentiment on cross-market energy futures returns, this paper horizontally compares the impact of single market investor sentiment and cross-market investor sentiment on the price of the same energy futures, providing a new idea and theoretical framework for studying the influence of investor sentiment on futures returns and cross-market risk spillovers.

In the following chapters, this paper will first conduct a literature review to form the research hypothesis of this paper, then give the model construction, data and variable selection, and then empirically test the research hypothesis according to the research design, and finally give the main conclusions and suggestions.

2. Literature Review

Since Kumer and Lee [5] illustrated that investor sentiment is an significant factor in stock returns, investor sentiment research has become a hot spot in the field of behavioral finance. Compared with investor sentiment in the stock market, there are few researches on investor sentiment in the futures market, but some scholars have conducted relevant researches and achieved good results. Sui Yanxiu and Guo Qiang [6] found through structural breakpoint analysis that there are very obvious speculative activities in the oil futures market, and long-term speculative factors that can reflect investor sentiment have a significant effect on the volatility of oil prices. Liu Song, Liu Hao and Yang Mengyuan [7] adopted the investor sentiment index constructed to quantify investors' real trading behavior and found that investor sentiment is a significant systemic factor influencing the returns of crude oil futures market.

Open interest(OI) is the amount of open interest held by both sides of a trade. To some extent, OI reflects the difference between the two sides of the trade in the price of a certain period. Physiological line (PSY) calculates the proportion of days that prices rise in a certain cycle to predict whether investors will judge the market trend, which is mainly short or long psychology. Momentum index(MTM) reflects the relationship between supply and demand and the price trend by examining the speed of price rise and fall, so it can be used as a proxy variable of investor sentiment [8]. The relative strength index(RSI) is widely used in futures trading to reflect market supply and demand. It predicts future market trends by calculating price fluctuations over time. The relative strength index can judge the strength of the long and short forces [9]. Bull and bearlndex(BBI) is the weighted average of the closing price of different daily limits, which is the reference index of investors' trading. It has both the sensitivity of short-term trading and the robustness of medium - and long-term trading [9].

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3. Data

OI, PSY, RSI, MTM and BBI data for China INE crude oil, SHFE fuel oil, DCE Coke and DCE coking coal from May 2, 2018 to December 5, 2022 were selected. The frequency is daily, and each futures has a total of 1116 sample data. Meanwhile, the daily volatility of main INE crude oil contract price at the same time is selected. The data source is Wind, and the data processing software is SPSS and Eviews.

4. Empirical Results

4.1. Construction of Investor Sentiment Index

It draws on the construction of investor sentiment in the financial market [10][11]. OI, PSY, MTM, RSI, BBI and their lagged terms are selected for principal component analysis. Considering that the reflection of different indicators on investor sentiment may have a advance or lag effect in time, mainstream literature generally selects the source index in the current period and its lag 1 period indicator to jointly construct investor sentiment.

10 proxy variables were selected for principal component analysis, including 5 proxy variables and 5 proxy variables corresponding to lagging period. Firstly, the standardized proxy variables are used for principal component analysis (through Kaiser-Meyer-Olkin, Bartlett spherical test and correlation test). Then the extracted principal components are weighted according to the eigenvalues. Finally, single market investor sentiment St1 and cross-market investor sentiment St2 are formed (the cumulative variance interpretation rate is 85.957% and 78.257% respectively). The results of the cumulative variance contribution of St1 and St2 are reported in Tables 1.

Table 1: Cumulative variance contribution(St1 and St2).

	Extract the sum of squared loads(St1)			Extract the sum of squared loads(St2)		
	Total	Var(%)	Accumulation(%)	Total	Var(%)	Accumulation(%)
OI	4.700	47.128	47.128	4.728	47.249	47.249
PSY	2.677	26.838	73.966	3.102	31.003	78.252
MTM	1.196	11.991	85.957			

Figure1 shows that there is significant correlation and synchronization between single market and cross-market investor sentiment index. It can be inferred that the crude oil market and the overall energy market mood swings are highly correlated. Within the statistical range, both the oil market and cross-market investor sentiment are volatile and largely quarterly. Moreover, sentiment is more volatile across markets than in the single market.

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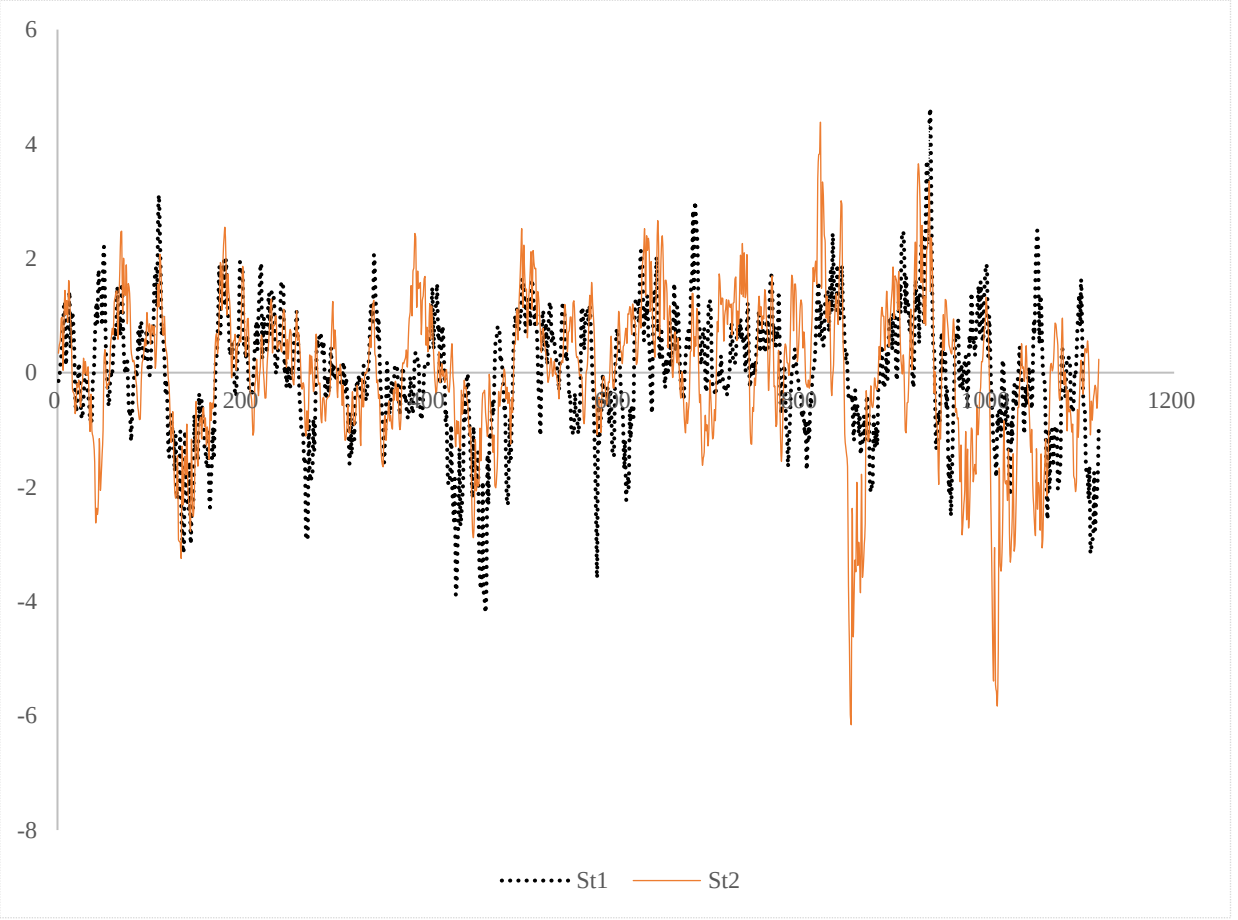

Figure 1: The figure shows the trend of the crude oil market and cross-market investor sentiment indicators over time.

4.2. Granger Causality Test

As shown in Table 2, the Granger causality relationship between investor sentiment St1 in the crude oil market and oil contract price volatility V is one-way. Volatility V is the Granger cause for the change in investor sentiment St1 in the crude oil market. Besides, there is no Granger causality relationship between cross-market investor sentiment St2 and crude oil contract price volatility V.

Table 2: Granger test results(St1 and St2).

Hypothesis	F-Statistic	p-Value
V does not Granger-cause St1	3.304	0.037***
St1 does not Granger-cause V	1.491	0.226
V does not Granger-cause St2	0.667	0.513
St2 does not Granger-cause V	0.926	0.396

4.3. Impulse Response Analysis

Figure 2 shows the reaction of investor sentiment St1 after being impacted by volatility. The first phase was negatively impacted, and the reaction was the largest in the 10th phase, indicating that

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investor sentiment St1 can react quickly to volatility shocks and the short-term response is more obvious than the long-term response.

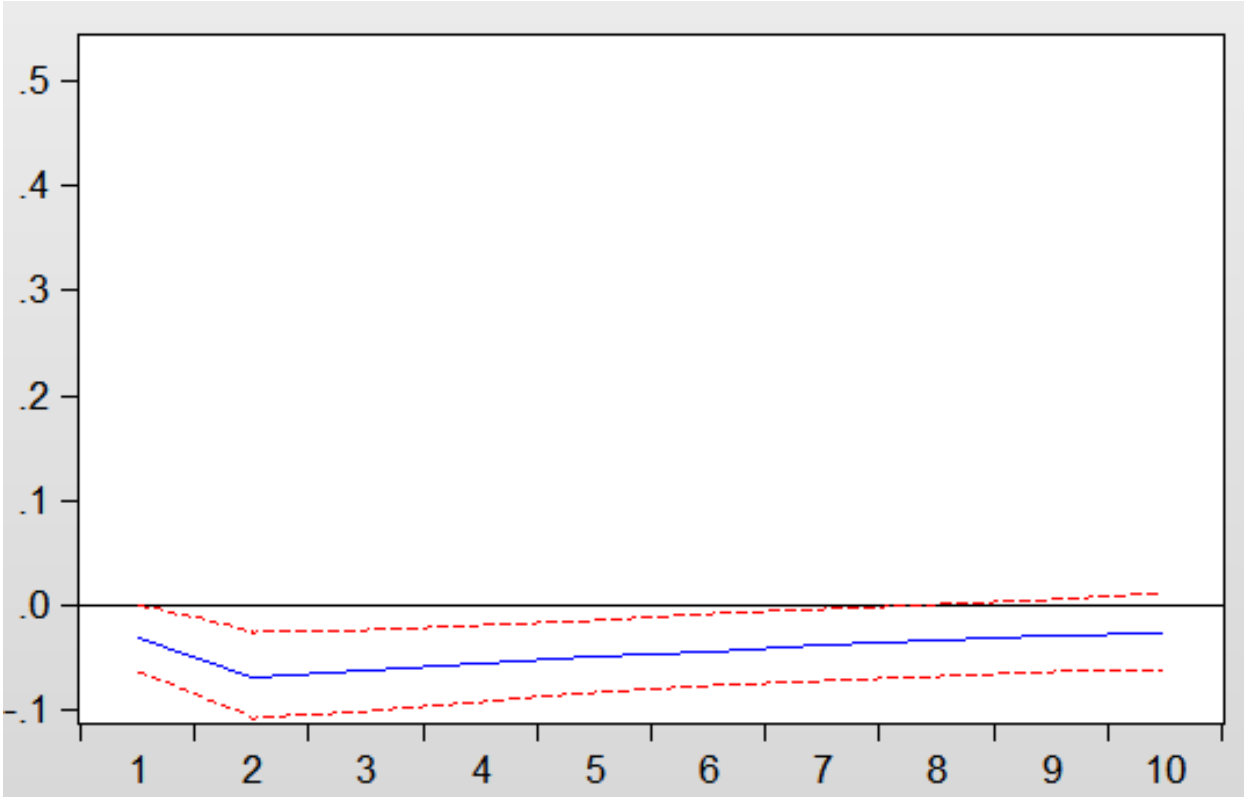

Figure 2: Response of St1 to V.

4.4. Vector Autoregressive Model Estimation

VAR estimation results indicates that in the equation with emotion index St1 as the explained variable, the volatility lag coefficient is significantly not 0. In the equation with volatility as the explained variable, the lag term coefficient of emotion index St1 is also significantly non-0, which indicates that emotion index St1 and volatility can have a bidirectional influence. Similarly, the sentiment index St2 and volatility can have a two-way influence.

4.5. The Impact of Investor Sentiment on the Volatility of Crude Oil Futures Prices

A linear regression equation between investor sentiment and crude oil price volatility was established to research the influence of sentiment on price volatility [10][12][13].

Table 3: Results of the regression of St1 and St2.

Variable	St1- α	St1-C	α	C
Coefficient	-1.72***	33.892***	-1.354***	33.892***

Table 3 results show that at the 1% level, the coefficient of single market investor sentiment and that of cross-market investor sentiment are both negative and significant, indicating that both single market investor sentiment and cross-market investor sentiment are significantly negatively correlated with crude oil price volatility.

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4.6. The Influence of Investor Sentiment on the Volatility of Crude Oil Futures Prices Volatility

In this paper, Eviews software is used for EGARCH modeling, and the model is as follows:

$$log(\sigma 2t) = \omega + \sum_{j=1}^{q} \beta_j log(\sigma^2{}_{t-j}) + \sum_{i=1}^{p} \alpha_i \left|\frac{\epsilon_{t-i}}{\sigma_{t-i}}\right| + \sum_{k=1}^{r} \gamma_k \frac{\epsilon_{t-k}}{\sigma_{t-k}} \quad (1)$$

The estimated results of crude oil price volatility and investor sentiment analyzed in this paper are shown in Table 4. By estimating results of yield rate and investor sentiment, the volatility equation are obtained:

$$log(GARCH) = C(4) + C(5) \times \left|\frac{resid(-1)}{\sqrt{GARCH(-1)}}\right| + C(6) \times \left|\frac{resid(-2)}{\sqrt{GARCH(-2)}}\right| + C(7) \times \left|\frac{resid(-3)}{\sqrt{GARCH(-3)}}\right| + C(8) \times \frac{resid(-1)}{\sqrt{GARCH(-1)}} + C(9) \times log\, GARCH(-1) + C(10) \times St1 \quad (2)$$

Select $C(8) \times \frac{\mathrm{resid}(-1)}{\sqrt{\mathrm{GARCH}(-1)}}$ as the validation index of leverage effect. The P value of St1 and St2 is extremely significant, which reflects the asymmetric effect of single market investor sentiment and cross-market investor sentiment on crude oil contract price fluctuations. This verifies hypothesis three.

Table 4: EGARCH results(St1 and St2).

Variable	Coefficient	Std.Error	z-Statistic	Prob.
C(8)(St1)	-0.229052	0.022045	-10.39027	0.0000
C(8)(St2)	-0.265830	0.022275	-11.93424	0.0000

5. Conclusion

First, VAR demonstrates the effect between single market investor sentiment and the price volatility of the main INE crude contract. The change of investor sentiment in the crude oil market is the Granger cause of the price fluctuation of the INE crude oil contract. It can be seen from the pulse response results that investor sentiment responds quickly to the impact of crude oil price volatility, and the short-term response is more obvious than the long-term response. Linear regression results show that investor sentiment in a single market has a significant negative correlation with the volatility of crude oil prices, indicating that when investor sentiment is high, the volatility of crude oil prices will increase, while when investor sentiment is low, the volatility of crude oil prices is relatively flat, so the volatility of crude oil prices is more sensitive to optimistic investment sentiment. Second, the cross-market sentiment and crude oil market sentiment are highly correlated and synchronized, and st2 fluctuates more, indicating that the cross-market portfolio has emotional spillover effect on crude oil investment. There is a significant negative correlation between cross-market investor sentiment and crude oil price volatility, indicating that the comprehensive investor sentiment has the same impact on the sensitivity of crude oil price volatility as the crude oil market sentiment. Third, both the cross-market indicators of investor sentiment and the single-market indicators have asymmetric effects on the price fluctuations of the major INE crude oil contracts.

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