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Research on the Impact of SSE 50 Index Futures on the Volatility of the Target Stock Market

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Abstract: *To specifically analyze the impact of SSE 50 stock index futures on the volatility of the underlying stock market, the daily closing price of China's SSE 50 index and daily closing price of SSE 50 stock index futures data from 2008-2022 are selected as samples, and the GARCH model, Granger causality test, and DCC-GARCH model are used for empirical analysis in conjunction with the launch time of SSE 50 stock index futures. It is found that: the launch of SSE 50 stock index futures intensifies the volatility of the spot market in the short run, but suppresses the volatility of the spot market in the long run, and suppresses the risk of the stock market to a certain extent; there is a two-way causal relationship between the two, and the two markets have maintained a high positive correlation since the launch of SSE 50 stock index futures, and there is a volatility spillover effect.*

Keywords: *Stock index futures; GARCH; Granger causality test; DCC-GARCH*

1. Introduction

Derivatives trading is an extremely important part of the financial market, and with the opening and continuous development of the economy, derivatives trading is receiving more and more attention from investors and playing a more and more important role in the financial market. The SSE 50 stock index futures were officially listed on April 16, 2015, enriching the variety of China's stock index futures market, and received the attention of investors upon its launch. The underlying asset of stock index futures is the stock index spot, and the price fluctuation of stock market will directly affect the price fluctuation of stock index futures, which in turn will have an impact on the stock market. What exactly is the impact of stock index futures on the spot market? Is there any linkage between the two markets? At present, there are not many or even few types of stock index futures in China, and the construction of stock index futures market is not yet perfect, and the development time is relatively short, which makes the relevant research in China somewhat limited and uncertain. The research results obtained in other countries in related fields may not be fully applicable to our market because of different national policy backgrounds and different degrees of financial market development, so specific research is needed for the actual situation in China.

2. Literature review

Research on the impact of stock index futures on the underlying spot market and the volatility spillover effect has received much attention from various countries, and many studies have been conducted by domestic and foreign scholars, and different conclusions have been reached. Kawaller et al.[1] (1990) conducted an earlier study by conducting a Granger causality test on the price relationship between the S&P 500 index futures market and the spot market. The study found that there was no significant causal relationship between the two. Subsequently, Chan et al.[2] (1991) used the multivariate GARCH model to demonstrate the existence of volatility spillovers and strong bidirectional nature between the S&P 500 index futures and spot markets. In China, research by Zhang Yongzhe [3] and Qian Min (2015) has shown that there is a volatility spillover effect in the Shanghai and Shenzhen 300 stock index futures market. Stock index futures reduce the volatility of the spot market and play a role in risk management to a certain extent. Li Yanjun [4] and Lin Xuerui (2021) found that the emergence of Shanghai and Shenzhen 300 stock index futures has a certain moderating effect on the volatility of the stock market; But in the long run, the inhibitory effect of stock index futures on spot market volatility is gradually weakening. Chun Weide and Zhu Hangcong [5] (2022) found that there is a high dynamic dependence between the Shanghai and Shenzhen 300 stock index futures and spot markets in China, which is influenced by changes in policy rules. Li Fei and Xu Duo [6](2021) measured the extreme risk

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spillover effect between the Shanghai Stock Exchange 50 futures, options, and spot markets, and found that there is a significant two-way risk spillover effect between any two of the three markets.

There are many reasons why scholars hold different views, with differences in research subjects, analysis perspectives, time points, and research methods. Chinese scholars have mainly focused on the impact of stock index futures on the spot market in the CSI 300 stock index futures, while less research has been conducted between the futures and spot of the SSE 50 stock index, so the findings of their research cannot be directly used to determine the relationship between the SSE 50 stock index futures and the SSE 50 index, and the impact of stock index futures on its underlying spot market still needs our further research.

3. Data and Models

3.1. Data selection

The daily closing prices of SSE 50 index from April 16, 2008 to April 15, 2022, and the daily closing prices of SSE 50 stock index futures from April 16, 2015 to April 15, 2022 are selected to study the impact of SSE 50 stock index futures on spot market volatility, and the data are obtained from Wind.

3.2. Model Setting

3.2.1. GARCH

The conditional variance equation of the general GARCH (p,q) model can be expressed as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2$$

This study adopts the approach of Wang Zhuoqiong [7], introducing the dummy variable d into the conditional variance equation for analysis, and setting the listing time of SSE 50 stock index futures as a node. d=0 represents before the public listing and trading of SSE 50 stock index futures, and d=1 represents after the public listing and trading. Therefore, the conditional variance equation in the above equation becomes:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \lambda D$$

Among them, (q, p) represents the q order GARCH term and p order ARCH term of the GARCH (q, p) model, respectively. And through the coefficient of virtual variable D λ. The significance and numerical value of the SSE 50 stock index futures can determine whether the launch has had an impact on the volatility of the target market, as well as the direction and degree of the impact.

3.2.2. DCC-GARCH

The DCC-GARCH model can achieve dynamic correlation fluctuation analysis between sequences, that is, the fluctuation between sequences is a coefficient that changes over time. The parameter estimation of the DCC-GARCH model requires two steps: estimating the univariate GARCH model; Estimate the dynamic conditional correlation coefficient between variables.

Under binary DCC-GARCH, the covariance matrix H_t can be expressed as:

$$H_t = D_t^{1/2} R_t D_t^{1/2}$$

The dynamic process is determined by the following two equations:

$$r_t = \mu_t + \varepsilon_t$$

$$R_t = diag\left(H_t\right)^{-1} H_t diag\left(H_t\right)^{-1/2}$$

$$H_t = \left(1 - \varphi - \omega\right) R + \varphi \eta_{t-1} \eta_{t-1}' + \omega H_{t-1}$$

The parameters φ、ω are all nonnegative and $0 \le \varphi + \omega < 1$. Therefore, φ、ω determines the dynamic evolution process of the dynamic conditional correlation coefficient.

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4. Empirical analysis and estimation results

4.1. The impact of stock index futures on the volatility of the underlying spot market

4.1.1. Descriptive statistical analysis

Perform logarithmic differential processing on the data, where the daily closing price=P, yield=R, and time=t. Multiply the differential value by 100 to obtain the yield R of the SSE 50 Index. Divide the sample into two sub samples: 1-year (short-term) before and after the listing of SSE 50 stock index futures, and 7-year (long-term) before and after the listing of SSE 50 stock index futures, to study the impact of the launch of SSE 50 stock index futures on the spot market at different times.

Table 1: Statistical characteristics of the daily returns of the SSE 50 Index

	1-year (short-term)	7-year (long-term)
mean	0.073356	0.002902
Maximum	7.547103	9.233181
minimum	-9.852132	-9.852132
standard deviation	2.153722	1.639105
skewness	-0.723541	-0.238618
kurtosis	6.733121	7.503496
JB test	327.2841***	2908.892***

Table 1 describes the relevant information on the daily returns of the SSE 50 Index over two periods. The skewness values of the daily return rate series in both periods are less than 0, and the kurtosis coefficient values are greater than 3, indicating that the two series are both left skewed, peaked, and fat tailed, showing the statistical characteristics of nonnormal distribution. Moreover, the JB normal test rejected the original hypothesis at a confidence level of 1%, which also verified the above conclusion.

4.1.2. GARCH model estimation

First, perform ADF and ARCH effect tests on the sequences, According to the results in Table 2 and Table 3, both sequences passed the test. Use GARCH (1,1) to construct the model, and add dummy variable d to the conditional variance equation based on the analysis above. The results are shown in the table below.

Table 2: Stability Test Results of Daily Return on the SSE 50 Index

	1-year (short-term)	7-year (long-term)
Prob	0.0000	0.0001

Table 3: ARCH-LM test for residual sequences

	1-year (short-term)	7-year (long-term)
Prob. F	0.0000	0.0000
Prob. Chi-Square	0.0000	0.0000

Table 4: Regression Results of GARCH (1,1) Model

	1-year (short-term)	7-year (long-term)
α_0	0.039760***	0.034498***
α_1	0.101759***	0.068269***
β_1	0.884806***	0.923239***
λ	0.112995**	-0.017932***

From Table 4, it can be seen that all parameters in the conditional variance equation have passed the significance test, and all parameters have practical significance. The construction of the GARCH model is correct. Mainly analyze the coefficient of dummy variable D in regression results λ, From coefficient of virtual variable λ From the perspective of numerical values and symbols, in the period of 1 year before and after, the coefficient λ Positive, indicating that in the short term after the official introduction of the SSE 50 stock index futures, there is a slight increase in the volatility of the spot market due to the listing of stock index futures. And the coefficient of the dummy variable D in the previous and subsequent 7-year periods λ Negative, indicating that in the long run, the impact of SSE 50 stock index futures on the volatility of the stock market is generally inhibitory, which to some extent suppresses the risk of the stock market.

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The ARCH effect test was conducted on the above model, as shown in Table 5. The residual no longer has the ARCH effect, and the model fitting effect is good.

Table 5: ARCH-LM test for residual sequences of GARCH (1, 1)

	1-year (short-term)	7-year (long-term)
Prob. F	0.1033	0.2166
Prob. Chi-Square	0.1034	0.2164

4.2. Analysis of the Linkage between Stock Index Futures and Spot Markets

4.2.1. Descriptive statistical analysis

Select the data from April 15, 2015 to April 15, 2022 for model construction. The data preprocessing still uses logarithmic differentiation to obtain the SSE 50 day return series. RS represents the return series of the SSE 50 Index, and RF represents the return series of the SSE 50 Index Futures.

Table 6: Statistical characteristics of daily returns

	SSE 50 Index	SSE 50 Index Futures
mean	-0.004864	-0.006590
Maximum	7.547103	10.60053
minimum	-9.852132	-13.75131
standard deviation	1.451332	1.588176
skewness	-0.684333	-0.604805
kurtosis	9.492192	13.86124
JB test	3125.548***	8479.514***

From the results of descriptive statistical analysis in Table 6, it can be seen that the average daily return of the SSE 50 stock index futures is lower than the average daily return of the SSE 50 index, and both are less than 0, indicating that the market has been in a downward state for more time and the stock index futures market has experienced more losses. From the standard deviation, it can be seen that the fluctuation range of the daily yield of SSE 50 stock index futures is slightly larger, indicating that the price fluctuation of SSE 50 stock index futures is more intense. In addition, from the skewness, kurtosis and other values of the two return rate series, the two return rate series do not obey the standard normal distribution. The JB test P-values also reject the original hypothesis at a 1% confidence level, which also proves this conclusion.

4.2.2. Granger causality test

Perform ADF test on the yield series of SSE 50 stock index futures and SSE 50 index, From Table 7, it can be seen that the sequence is stationary, and then conduct Granger causality test to preliminarily verify the relationship between the two markets

Table 7: Stability Test Results of Daily Return on the SSE 50 Index

	SSE 50 Index	SSE 50 Index Futures
Prob	0.0000	0.0000

Table 8: Granger causality test results

Original Assumption	Sample Size	F Statistics	P-Value
RS does not Granger Cause RF	1702	5.83033	0.0030
RF does not Granger Cause RS		8.48990	0.0002

The Granger causality test results are shown in Table 8. The original assumptions were "RS do not Granger Cause RF" and "RF do not Granger Cause RS", and both returns rejected the original hypothesis at a confidence level of 1%. It can be considered that the two are mutually causal, indicating a bidirectional relationship between the SSE 50 stock index futures and the SSE 50 index.

4.2.3. DCC-GARCH model estimation results

The model estimation results are shown in Table 9. The ARCH coefficient and GARCH coefficient of the two time series are generally significant. Firstly, in the residual equation of the univariate GARCH model, the α 1 value of SSE 50 stock index futures is higher, indicating that SSE 50 stock index futures are more susceptible to external shocks. Secondly, the relationship between the two markets β The 1 value is significantly higher than α 1, indicating that the volatility of both markets is more susceptible to

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the influence of their own memory β 1 is larger, indicating that the SSE 50 Index is more susceptible to the influence of one's own memory. Two markets α 1+ β All values tend to trend towards 1, indicating that the market will continue to fluctuate, but α 1+ β 1<1 indicates that the impact of market news on stock index futures and spot volatility is limited, and the impact of market information on future markets will gradually weaken.

Table 9: Regression Results of DCC-GARCH Model

		SSE 50 Index	SSE 50 Index Futures
GARCH	α_0	0.019727***	0.024626***
	α_1	0.093384***	0.111683***
	β_1	0.901497***	0.887814***
DCC-GARCH		Theta1	0.064565***
		Theta2	0.913786***

The estimation results of the DCC-GARCH model show that the two parameters are significantly non zero, and theta1+theta2<1, meeting the constraint conditions, indicating a significant dynamic correlation between the SSE 50 stock index futures and the spot market during the sample period. Based on the obtained theta1 and theta2, plot the time-varying correlation coefficient between the returns of the SSE 50 stock index futures and the SSE 50 index, as shown in Figure 1:

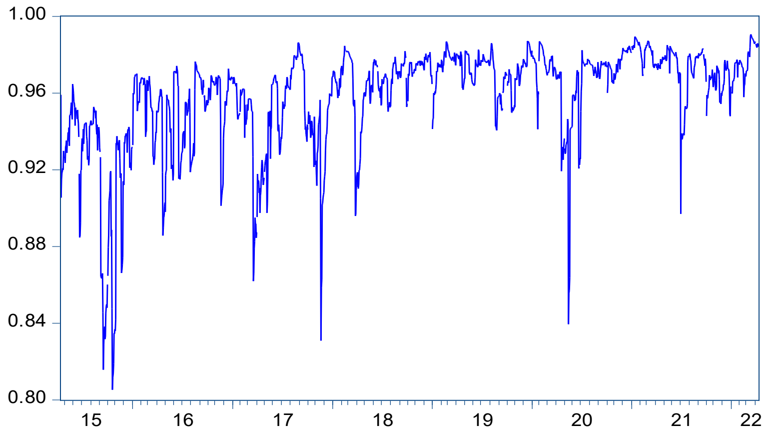

Figure 1: The time-varying correlation between the SSE 50 Index and the SSE 50 Index Futures Yield

From the Figure 1, it can be seen that the dynamic correlation coefficient between the SSE 50 stock index futures and the SSE 50 index has remained above 0.8, indicating that the SSE 50 spot market has shown a high positive correlation for a long time and there is a volatility spillover effect. During 2015, the dynamic correlation coefficient between the two markets showed significant fluctuations, and in October 2015, the dynamic correlation coefficient dropped to its lowest value; During the subsequent trade war between China and the United States from 2017 to 2018, the dynamic correlation coefficient between the two markets showed significant fluctuations; The outbreak of the epidemic in 2020 has had an impact on the stock market due to the emergence of extreme risk events, which has affected the linkage between the futures and spot markets. The correlation coefficients between the two markets have fluctuated sharply, but under active epidemic control, the fluctuation range of the correlation coefficients between the markets has gradually slowed down and returned to normal volatility levels.

5. Conclusions

Through the study of the impact of SSE 50 stock index futures on the volatility of the target stock market, it was found that:

First, by constructing a GARCH model that introduces dummy variables, it was found that in the short term, the listing of SSE 50 stock index futures has a certain degree of increase in the volatility of the target securities market, but the impact is very weak. In the long run, the coefficient of dummy variable D is negative, indicating that the SSE 50 stock index futures have a certain inhibitory effect on the volatility of the underlying securities. However, due to the small absolute value of the numerical value, the inhibitory effect is also negligible.

Second, The Granger causality test indicates a bidirectional relationship between the two. The DCC-

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GARCH model estimation results show that the dynamic correlation coefficient between the Shanghai 50 stock index futures and the SSE 50 index has remained above 0.8, indicating that since the launch of the SSE 50 stock index futures, the two markets have maintained a high positive correlation and there is a volatility spillover effect.

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