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Study on the Influence of the Stock Index Futures Regulation Policy on the Volatility of Stock Spot Market

A Co-integration Analysis Based on the Structure Mutation of CSI 300

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***Abstract*—Based on CSI 300 index and CSI 300 stock index futures data, this paper analyzes the long-term and short-term equilibrium relationship by using the co-integration theory and the error correction model. Emphasis is placed on the analysis of the impact of regulatory policies on this equilibrium relationship. The empirical results show that: First, there is a long-term equilibrium relationship between China's CSI 300 stock index futures market and the corresponding spot market, and stock index futures have a strong ability to guide the spot market. Secondly, policy regulation has a significant impact on the discovery function and guiding ability of stock index futures price. The regulation not only affects the long-run elasticity of futures market to spot market, but also influences the basis of its price guiding function. Thirdly, policy regulation also has a significant impact on the co-integration mechanism of stock index futures and spot market. In the non-regulated state, stock index futures have a strong ability to guide the spot market, but this kind of guiding force changes stagnantly after the regulation.**

Keywords—stock index futures; structural mutation; policy regulation; volatility

I. INTRODUCTION

On June 15, 2015, in order to curb the stock market bubble, the Chinese authorities began to crack down on off-exchange fund allocation in the stock market. The stock market fell sharply, and stock index futures were believed to be the main culprit of the stock market disaster and were caught in the whirlpool of public opinion. In order to curb excessive speculation and strengthen supervision over abnormal trading, financial regulators have gradually increased their control over stock index futures since August. Up to September 7, the most stringent regulation measures were unveiled: individuals shall open positions with single contract no more than ten times a day; non-hedging trading margin raised to 40%; service charge for closing trades bought on the day increased 100 times. After the implementation of the regulation measures, the turnover and volume transaction of stock index futures have significantly shrunk, liquidity been extremely scarce, and the risk management and hedging functions of stock index futures have been nearly lost. It took a year and a half before the restrictions were finally lifted on February 17, 2017. There was market consensus that this loosening would be good long-term capital into the market, but the stock index futures system had a long way to go. The launch of stock index futures is a milestone event in China's financial market. It officially ends the history of China's securities market without short selling mechanism of 20 years, and has a profound impact on the traditional stock market. Has the stock index futures played an expected role since the launch? Does the steady state structure change during the stock market crash? What effect does stock index futures have on the volatility of the spot market? The research on these problems is of great theoretical and practical significance. This paper uses CSI 300 futures index and stock index to analyze the volatility regularity between them from the perspective of structural mutation.

II. LITERATURE REVIEW

Since the stock index futures market abroad has long been mature, more and more researches on the volatility between futures market and spot market have been made by foreign scholars. Two opposing views have been formed in the existing literature: Some scholars believe that there are a large number of speculators in the emerging stock index futures market, which increases the volatility of stock prices; Another view is that stock index futures reduce the volatility of the stock market through their hedging, arbitrage and other functions, and thus have a stable effect on the stock market.

Harris (1989) and other scholars studied the relationship between stock index futures and spot market earlier. They found that the launch of stock index futures accelerated the flow of information in spot market and enhanced the volatility of stock market. Suchismita & Bose (2007) took Indian stock index and stock index futures index as the research object, analyzed the fluctuation relationship between them, and found that there was a strong correlation between spot and futures market volatility. However, Pericli et al. (1997) analyzed the relationship between stock index

futures index and spot market index by using standard & poor's index, and found that the volatility of spot market index of stock index futures was not obvious. Jian Yang et al. (2012) used high-frequency data of China's capital market to analyze the volatility conductivity study between the stock market and the stock index futures market, and verified the strong mutual conductivity of volatility between the two markets.

Although China's stock index futures market started relatively late, many domestic scholars have studied whether the introduction of stock index futures will cause the fluctuations of the spot market, and come to different conclusions. Before the official launch of stock index futures, there were abundant research results on the relationship between stock index futures and spot market in China. For example, He Chengying et al. (2011) took CSI 300 stock index futures as the research object, explored its relationship with the spot market and the A-share market of China, and concluded that CSI 300 stock index futures slightly increased the volatility of the spot market and that China's A-share market had a great impact on the volatility of CSI 300 stock index futures market. Then after the official launch of CSI 300 index futures, Liu Qing-fu, Hua Ren-hai (2011) studied the fluctuation transfer between futures market and spot market in China by using the high-frequency data of CSI 300 stock index futures and spot in five minutes. The results show that the futures market and spot market volatility has two-way transitivity, and spot has dominant influence on fluctuations in stock index futures. Yuan Chen and Fu Qiang (2017) analyzed the correlation between stock index futures spot index and its hedging effect, and found that the Shanghai 50 spot index and the CSI 300 spot index are more influential indexes in China's securities market, and there is no clear mutual leading relationship between futures and the object spot index. In addition, the dynamic coefficient between stock index futures and spot index shows a positive correlation in most periods, among which the spot index of Shanghai 50 has the highest correlation degree, while the spot index of China 500 has the lowest correlation degree. Hu Yue (2013) compared and analyzed the fluctuations of the spot market before and after the launch of stock index futures with the method of ex ante and ex post research, and found that the launch of stock index futures did not significantly change the volatility of the stock market.

In the existing studies, relevant scholars have drawn different conclusions on the relationship between stock index futures market and stock market volatility from different aspects, yet few studies have been conducted on the drastic impact and changes on the market. In addition, since China's stock index futures market began to operate in 2010, they made macro analysis of the impact of stock index futures launch on the volatility of the spot market, and drew the conclusion that stock index futures launch made the volatility of the spot market increase or decrease. This paper mainly considers the structural changes and adopts the variable structure co-integration model. It establishes error correction models respectively, to analyze the structural changes of stock index futures and spot market volatility during the stock market disaster, so as to have a more microscopic understanding of the stock index futures market and spot market volatility.

III. METHODS, DATA AND DESCRIPTIVE STATISTICS

A. Research Methods

After Engel and Granger put forward the co-integration theory in 1987, the theory has been widely used in analyzing the long-term equilibrium relationship of economic variables due to its intuitive mechanism of variables and clear economic significance. However, the conventional co-integration theory may have shortcomings and fallacies, especially the structural mutation caused by the obvious impact on the external mechanism, which leads to the bias of parameter estimation. Co-integration refers to the long-term stable equilibrium relationship between economic variables. If there is structural change in the long term, the relationship between economic variables may change with the change of mechanism. For China in the transition period, institutional reform and adjustment are the ordinary state. Therefore, the co-integration theory considering the possibility of structural mutation is more in line with China's national conditions. Gregory & Hansen (1996) expanded the residual-based co-integration test method and proposed the co-integration analysis method considering the possibility of endogenous structural mutation, including three co-integration models of structural mutation, namely intercept term mutation, time trend term and intercept mutation, and intercept term and slope term mutation. Monte Carlo simulation was used to construct ADF statistic and Z statistic to test threshold values. In this paper, the co-integration model with variable Intercept is selected for comparative analysis, as follows:

$$y_t = \alpha + \beta * D + \gamma^T x_t + \mu_t \quad (1)$$

In Equation (1), there is a co-integration relationship between y_t, x_t of the sequence and $y_t \sim I(d)$, x_t are n-dimensional vectors which also satisfy $x_t \sim I(d)$; μ_t is a random disturbance term which satisfies $\mu_t \sim I(0)$; D represents a dummy variable of a structural mutation.

B. Data Selection and Descriptive Statistics

This paper selects the closing prices of CSI 300 index and CSI 300 index futures index from April 16, 2010 to September 1, 2017 as the sample interval. Excluding the part that the CSI 300 stock index futures do not coincide with the spot sequence, there are 1,796 data in total, which are from the national tai'an database. Here, and $index_t$ are $findex_t$ the closing price of the CSI 300 index and CSI 300 index futures index on day t, and the logarithmic sequence of closing price $lindex_t = \ln(lindex_t)$ and $lfindex_t = \ln(lfindex_t)$, the yield sequence $rp_t = \ln(index_{it}) - \ln(index_{t-1})$ and $rf_t = \ln(findex_t) - \ln(findex_{t-1})$ of CSI 300 index and CSI 300 futures index are defined. According to the sample data, we get the trend chart ("Fig. 1") of logarithm of closing price

of CSI 300 index and futures index and the fluctuation chart of corresponding yield index (As can be seen in "Fig. 2"). From "Fig. 1", we can see that the closing price trend of CSI 300 index and futures index is basically the same, the fluctuation of both has sharp peak and flat tail, meaning that the fluctuation is fierce at the peak and mild at the end. From "Fig. 2", we can find that the fluctuation of rate of return sequence is also basically consistent. However, from September 7, 2015 (the 1310th day) to February 17, 2017 (the 1661st day), the volatility was significantly more severe, indicating that the period of stock index futures regulation had a more obvious impact on the stock market and futures market volatility. It was also found that the fluctuation of the spot market precedes that of the futures market.

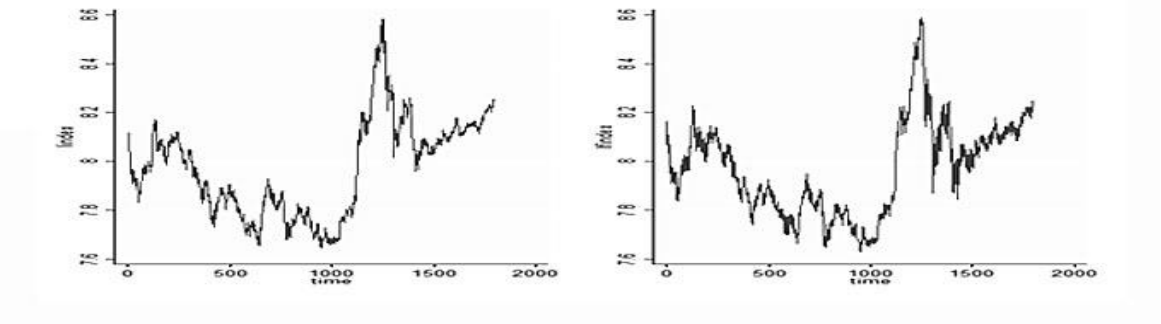

Fig. 1. Logarithmic trend of daily closing price of CSI 300 stock index (left) and CSI 300 stock index futures index (right).

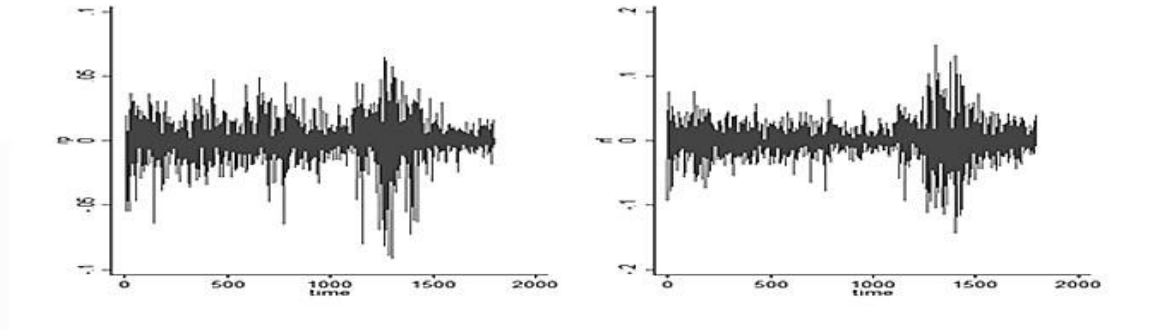

Fig. 2. Daily return trend of CSI 300 index (left) and CSI 300 index futures index (right).

According to this feature, two dummy variables D1 and D2 were introduced at the two endpoints of the stock index futures regulation policy, and the observation interval was divided into three segments, namely, before, during and after the deregulation. The impact of the regulation policy on the spot market and futures market was investigated by the division of the three sub-intervals. Accordingly, suppose index_{it} and findex_{it} are the closing price of the i-th (I =1, 2, 3) interval of CSI 300 index and CSI 300 index futures index, define the logarithmic sequence of closing prices as $lindex_{it} = \ln(lindex_{it})$ and $lfindex_{it} = \ln(lfindex_{it})$, and the return series for CSI 300 index and CSI 300 futures index as $rp_{it} = \ln(index_{it}) - \ln(index_{it-1})$ and $\text{rf}_{\text{it}} = \ln(findex_{it}) - \ln(findex_{it-1})$.

From the descriptive analysis according to the division of the sample data in "Table I", it can be seen that the fluctuation of CSI 300's closing sequence and yield sequence is basically biased distribution which is sharp at peak and flat at end. During the period of stock index futures regulation, the standard deviation of the return sequence is significantly larger, and the kurtosis of the spot market is steeper, which further confirms the characteristics of the return during the period of regulation shown in "Fig. 1" and "Fig. 2".

TABLE I. DESCRIPTIVE STATISTICS OF CSI 300 INDEX, STOCK INDEX FUTURES INDEX AND YIELD

Sample interval 1: stock index futures before the regulation, trading days: 1309						
variable	***mean value***	***standard deviation***	***maximum value***	***minimum value***	***skewness***	***kurtosis***
lindex	7.91532	.2000799	7.643468	8.585552	1.114423	3.916967
lfindex	7.921851	.2005817	7.628226	8.588583	1.028903	3.762499
rp	2.16e-06	.0161623	-.0915442	.0649881	-.6462885	7.29961
rf	-.0001682	.0227417	-.1121721	.1495528	-.0810551	6.785277
Sample interval 2: stock index futures regulation period, trading days: 352						
variable	***mean value***	***standard deviation***	***maximum value***	***minimum value***	***skewness***	***kurtosis***
lindex	8.104852	.0621375	7.956393	8.262748	.483814	3.057582
lfindex	8.067191	.0712753	7.842122	8.247744	-.1276066	3.365471
rp	.0000466	.0146834	-.0727921	.0486116	-1.112398	8.699192
rf	.0004843	.0390086	-.1444759	.1332574	-.0879493	4.736703
Sample interval 3: After the deregulation of stock index futures , trading days: 135						
variable	***mean value***	***standard deviation***	***maximum value***	***minimum value***	***skewness***	***kurtosis***
lindex	8.176837	.0370017	8.113037	8.253933	.3833231	1.822982
lfindex	8.161681	.0420488	8.083699	8.252655	.1504529	1.961884
rp	.0008366	.0062639	-.0186253	.0177984	.2135179	3.454749
rf	.0010242	.0166991	-.0435143	.0395079	-.0370285	2.910329

IV. EMPIRICAL RESULTS AND ANALYSIS

In order to test and estimate the model, we need to test the existence of non-linearity under the condition of non-stationary data, and then determine the form of the transformation function, based on which the model is tested and estimated through co-integration.

A. Stability Test

In order to ensure the accuracy of the conclusion, ADF and PP tests were used to analyze the stability of the lindex_{it} and lfindex_{it} respectively. The null hypothesis of the two tests, H_0: The sequence is I (1) i.e., if the null hypothesis is not rejected, it indicates that the tested variable is a unit root process. The detailed test results are shown in "Table II" below.

TABLE II. ADF AND PP TESTS OF LINDEX_{IT} AND THE SEQUENCES OF LFINDEX_{IT}

variable	**test forms**	**ADF**	**PP**	**conclusion**
lindex1t	(1,0)	-1.456(0.56)	-1.529(0.52)	I(1)
Dlindex1t	(1,0)	-33.847(0.00)	-33.922(0.00)	I(0)
lindex2t	(1,0)	-2.202(0.21)	-2.237(0.23)	I(1)
Dlindex2t	(1,0)	-21.122(0.00)	-21.045(0.00)	I(0)
lindex3t	(1,0)	-0.229(0.93)	-0.147(0.94)	I(1)
Dlindex3t	(1,0)	-11.197(0.00)	-11.227(0.00)	I(0)
lindext	(1,0)	-1.428(0.57)	-1.475(0.55)	I(1)
Dlindext	(1,0)	-41.075(0.00)	-41.066(0.00)	I(0)
lfindex1t	(1,0)	-2.254（0.15）	-1.906（0.33）	I(1)
Dlfindex1t	(1,0)	-45.007（0.00）	-45.236（0.00）	I(0)
lfindex2t	(1,1)	-2.434（0.36）	-5.071（0.00）	I(1)
Dlfindex2t	(1,0)	-28.91(0.00)	-35.297(0.00)	I(0)
lfindex3t	(1,0)	-2.079 (0.25)	-1.228(0.66)	I(1)
Dlfindex3t	(1,0)	-20.108(0.00)	-23.021(0.00)	I(0)
lfindext	(1,0)	-1.743 (0.40)	-2.028(0.26)	I(1)
Dlfindext	(1,0)	-57.68(0.00)	-57.178(0.00)	I(0)

[a.] Note: In the testing form "(c, t)", "c" represents that there is a intercept term, and "t" represents that there is a time trend term; the testing statistics of ADF and PP in the brackets correspond to the ending probability of the Statistical test, which is the p value.

According to "Table II", the lindex_{it} and lfindex_{it} (I =1, 2, 3), except for the instability of lfindex2t, other variables are unit root processes, and the difference is a stationary process.

B. Co-integration Analysis Based on Structural Changes

As can be seen from "Table II", the stock index $lindex_t = \ln(lindex_t)$ and stock index futures $lfindex_t = \ln(lfindex_t)$, as well as the three sub-intervals lindex_{it} and lfindex_{it} (I =1, 2, 3) are all the processes of $I(1)$. Then, do they have a stable relationship of long-term equilibrium? Is this relationship influenced by the regulation and deregulation of stock index futures and thus causes structural changes? The researchers uses the EG two-step method to analyze this, and analyze the influence of short-term fluctuations by establishing error correction models of the two markets.

Due to the definite time point of stock index futures regulation and deregulation, the structural change models of lindext to lfindext in three time periods and lindext to lfindext, D1, D2, lfindext*D1 and lfindext*D2 were constructed respectively. OLS estimation of these models was carried out to obtain "Table III", and the stability test of corresponding regression residuals was conducted to obtain "Table IV".

TABLE III. CO-INTEGRATION TEST BETWEEN LINDEXT AND LFINDEXT

variable	(1) Model 1 lindex	(2) Model 2 lindex	(3) Model 3 lindex	(4) variational structure model lindex
D1				-1.197***
				(0.155)
D2				0.509**
				(0.251)
lfindex	0.992***	0.787***	0.849***	0.849***
	(0.00303)	(0.0246)	(0.0189)	(0.0188)
Lfindex*D1				0.144***
				(0.0190)
Lfindex*D2				-0.0620**
				(0.0309)
Constant	0.0534**	1.759***	1.251***	1.251***
	(0.0237)	(0.199)	(0.155)	(0.154)
Observations	1,309	352	135	1,796
R-squared	0.990	0.814	0.930	0.989

[a.] Note: the brackets in the table refer to the robust standard error of the corresponding coefficient, *** p<0.01, ** p<0.05, * p<0.1, similarly hereinafter.

TABLE IV. UNIT ROOT TEST OF REGRESSION RESIDUAL SEQUENCES BETWEEN LINDEXT AND LFINDEXT

models	ADF statistics for residuals	The critical value of the z-statistic	p value	conclusion
Model 1	-16.695	-2.860	0.0000	I(0)
Model 2	-6.799	-2.860	0.0000	I(0)
Model 3	-9.002	-2.860	0.0000	I(0)
Model 4	-21.189	-2.860	0.0000	I(0)

As can be seen from "Table III"and "Table IV", all residual sequences are stable sequences, so the co-integration relationship between stock index futures market index and spot market index is very significant no matter before or during the regulation, or after the deregulation of stock index futures policy. The stock index futures management policy also has a significant impact on the co-integration relationship. It not only has a significant impact on the intercept term, but also significantly changes the slope, that is, the stock index futures management policy has caused structural changes in the long-term equilibrium relationship between the futures market and the spot market. Specifically, the co-integration model relationship of such structural changes is as follows:

$$lindex_t = 1.251 - 1.197D_1 + 0.509D_2 + 0.894lfindex_t + 0.144lfindex_t * D_1 - 0.062lfindex_t * D_2 \quad (2)$$

According to the model expression, before the introduction of stock index futures regulation policy, the long-term elasticity of spot market price to futures market price was 0.894 on average. On September 7, 2015, securities regulatory authorities strictly controlled stock index futures, and the long-term elasticity of futures market price to spot market price was 1.038 on average. And after the policy was loosened, the long-term elasticity dropped to 0.832 on average.

Then, the short-term relationship between the spot market and the futures market is analyzed. Suppose $ECM_t = e_t$, and the residual sequence is taken as the error correction term. The error correction models of the two markets were constructed and estimated as follows:

Before the regulation, $dlindex_t = 0.000093 + 0.1601ECM_t + 0.5695dlindex_t$ (3)

(0.748) (0.000) (0.000)

R2=0.5741

During the regulation, $dlindex_t = -0.0000361 + 0.0785ECM_t + 0.1706dlindex_t$ (4)

(0.96) (0.005) (0.000)

R2=0.1588

After the deregulation, $dlindex_t = 0.000556 + 0.223ECM_t + 0.2643dlindex_t$ (5)

(0.96) (0.005) (0.000)

R2=0.3428

In the above equation, R2=0.5741 before the regulation reflects the high degree of sample fitting; the coefficient of ECMt is 0.1601, which reflects that the fluctuation of CSI 300 index deviates from the long-term average in the short term and is returning to the long-term level at a rate of 16%. During the regulation, R2=0.1588 reflects the poor fitting degree of samples; the coefficient of ECMt is 0.0785, which reflects that in the short term the fluctuation of CSI 300 index deviates from the long-term average and drops to 7.85%, in which speed it reverts to the long-term level. After the deregulation, R2=0.3428 reflects the poor fitting degree of samples; the coefficient of ECMt is 0.223, which reflects that in the short term the fluctuation of CSI 300 index deviates from the long-term average and rises to 22.3%, back to the long-term level. Here it shows that the futures regulation policy has seriously affected the discovery function of stock index futures price.

V. CONCLUSIONS AND SUGGESTIONS

Based on the CSI 300 index and the CSI 300 index futures daily closing price as the original data, according to the theory of co-integration and error correction model, this paper analyzes the short-term and long-term equilibrium relationship of China stock index futures and spot markets, and focus on analyzing the impact of the stock index futures regulation policy that securities regulatory authorities adopted during the 2015 crash on the equilibrium relationship. The empirical results show the following conclusions:

First, from the perspective of co-integration relationship, there is a long-term equilibrium relationship between China's CSI 300 futures index market and the corresponding spot market, and stock index futures have a strong ability to guide the spot market.

Second, from the perspective of policy regulation, regulation has a significant impact on the price discovery function and guiding ability of stock index futures. In the long run, regulation not only affects the long-term elasticity of futures market to spot market, but also influences the basis of price guiding function.

Third, from the perspective of the consequences of structural mutation, policy regulation has a significant impact on the co-integration mechanism of stock index futures and spot market. In the non-regulated state, stock index futures have a strong ability to guide the spot market, but this kind of guiding force changes slowly after the regulation.

Although the launch time of stock index futures in China is relatively short, the conclusion of empirical research still has a good reference and guiding role. By discussing the price discovery function and long-term relationship between CSI 300 index futures and spot market, it is not only helpful for investors to grasp the change law of relevant asset prices, but also to formulate more reasonable hedging and arbitrage strategies and construct corresponding risk management strategies by using the relationship; it also provides theoretical support for management to formulate more efficient regulatory policies and regulations.

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