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Study on the Linkage of Stock Index Futures and Spot Price under Random Impact

-Based on example of csi300

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Abstract: Based on the high Frequency time series data of 5 minutes stock index futures and spot, this paper makes use of Granger causal test, pulse effect method of structural vector autoregressive model, Johansen cointegration test and Inforatio function, respectively, to carry out the cause and effect, impact and The demonstration of cointegration relationship and the calculation of tracking error. Taking the June 2015 "stock disaster" as the background, under the condition that the stock market is down sharply after the uplink, the difference between futures and spot in three time periods is analyzed by variance test, which helps to help the relevant departments to predict the market accurately under the condition of large market change.

Keywords: Stock index futures; Linkage; Tracking error; Cointegration relationship; Random impact

1. Introduction

Stock index futures is not only an important investment tool in the financial market, but its price, volatility and changing trend are important indicators reflecting the market investor confidence, the development of the real economy and the improvement of the financial market. It has the functions of price discovery, avoiding investment risks, and arbitrage. Therefore, the linkage analysis of stock index futures and spot market will help to regulate and forecast financial markets.

The research on the linkage between the stock index futures market and the spot market is mainly focused on the following aspects: first, the empirical analysis of the price discovery function of futures, and second, the interaction between futures prices and spot prices, fluctuations and returns. The third is whether the dynamic relationship between the two markets presents a balanced correlation and whether there is an arbitrage opportunity.

Xie Dongsheng (2011) used the multivariate stochastic volatility model to study the relationship between stock index futures and spot [1], extracted common factors and common fluctuation components, but ignored the further exploration of the interference between the two relations, neglecting The size of the error in the process of time series data fluctuations; Yang Ruijie (2016) explores the linkage between stock index futures and spot from the perspective of price and volatility preemptiveness and no arbitrage, and obtains the precedent and no arbitrage when the futures corresponding target is the large-cap stock. Sex is more significant than the target for small and medium-cap stocks [2]. Considering the important feature of no-arbitrage and paying attention to the different impacts of different targets, but not paying attention to the changes in the market economy background in the time dimension; Wang Mingtao (2018) analyzed the stock index futures synchronization and extended trading hours based on logit and regression models. The impact of price jumps on stock index jumps and the differences in conclusions under different market conditions [3]. It pays attention to the two periods of future trading in advance trading period and period spot trading. The impact of futures' beating effect on spot is that the impact of stock index futures trading session jump on spot opening time index jump mainly comes from the top 5 after opening. Minutes, with the conclusion that the effect is decreasing.

In summary, at present, China's linkage analysis of stock index futures and spot market mainly has the following shortcomings: First, it ignores the change of linkage effect before and after the market changes, most scholars only consider the futures price in the short term. The significant difference in the effect is found. Second, the tracking error of futures based on spot changes is not concerned, and the law of error in linkage is ignored. Therefore, the risk research in futures price changes is not comprehensive enough.

In view of the above deficiencies, this paper selects the high-frequency time series data of non-rule 5-minute stock index futures and spot from April to October 2015, and studies the linkage between futures and spot under the condition that the stock market suddenly changes sharply in June 2015. Sexual size, price lead, tracking error changes and differences.

2. Research Ideas

The research focus of this paper focuses on the impact of large-scale changes in the market on the linkage effect between stock index futures and the spot market.

In June 2015, the stock market experienced an extremely rare “several households’ suspension”. The stock market has undergone tremendous changes, which has had a great impact on the stock market and the futures market. In this context, the stock index futures market and the spot market are related. Conducive to the prevention and control of the next market changes. Therefore, this paper selects the 5-minute stock index futures and spot high-frequency discontinuous time series data from April to October 2015 for empirical analysis.

Firstly, the descriptive and correlation analysis is carried out to explore the basic relationship between the stocks of the Shanghai and Shenzhen 300 stocks. Then the ADF unit root test is carried out, and the data is found to be non-stationary. After the first-order difference, the data is stable. Next, using the Granger causality test to determine the Granger causality between the stock index futures and the spot opening price, the highest price, the lowest price, and the closing price, there are 8 types of first-order difference data; secondly, the Johansen cointegration test Based on the vector error correction model, the existence and short-term relationship between the long-term cointegration relationship between stock index futures and spot is judged. Next, using the inforatio function in the matlab financial toolbox, based on the spot of the CSI 300 index, the tracking error of the stock index futures relative to the spot is calculated.

Finally, with the “stock disaster” in June 2015 as the background, in the case of a sharp decline in the stock market from the upside, the market is going up, the market is going down and the market tends to be stable for three time periods. Conduct a T-test to analyze the linkage between the futures and the spot market under different market conditions, the degree of price lead, the change of tracking error and whether there is a significant difference, so as to further propose relevant policy recommendations to help the relevant departments to change in the market. Accurate forecasts for the market in the case.

3. Descriptive Analysis

3.1. Basic analysis

Selecting the closing price data of the futures and spot prices of the Shanghai and Shenzhen 300 Index to draw a line chart, it can be seen that the price basically shows the same direction. When the index climbs all the way, it can be seen that the spot price is higher than the futures price at most points, but when the index rises sharply, the futures price is higher than the index price; while the index falls, the futures price is low most of the time. At the spot price, and when the index declines, the gap between futures and spot prices is larger, reflecting the role of futures price guidance.

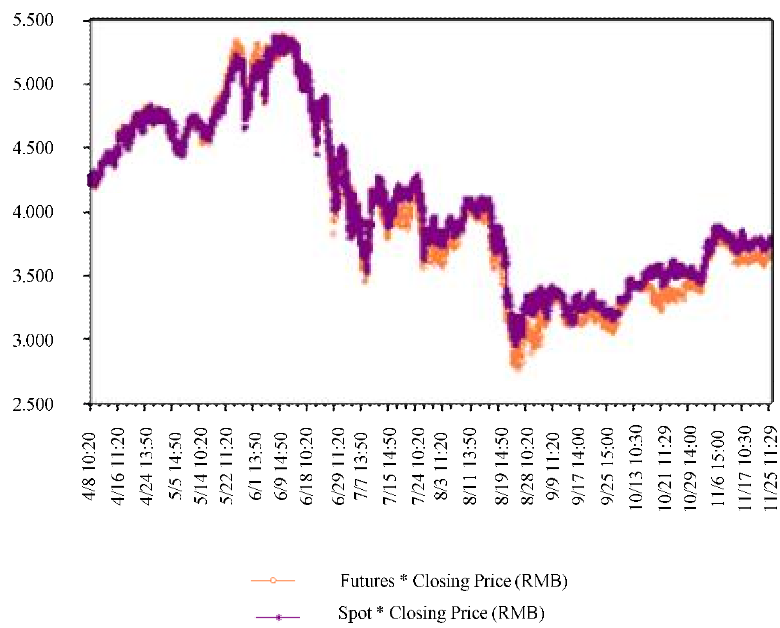

Figure 1.Changes in the spot closing price of the Shanghai and Shenzhen 300 stocks

3.2. Descriptive analysis

3.2.1. Symbol hypothesis

To facilitate empirical analysis, perform symbolic assumptions

Table 1. Symbol hypothesis table

Symbol	Meaning	Symbol	Meaning
X1	Opening Price of Shanghai and Shenzhen 300 Stock Index Futures (RMB)	YI	Spot Opening Price of Shanghai and Shenzhen 300 Stock Index (RMB)
X2	Shanghai and Shenzhen 300 Stock Index Futures Maximum Price (RMB)	Y2	Shanghai and Shenzhen 300 Stock Index Spot Maximum Price (RMB)
X3	Shanghai and Shenzhen 300 Stock Index Futures Minimum Price (RMB)	Y3	Shanghai and Shenzhen 300 Stock Index Spot Minimum Price (RMB)
X4	Closing Price of Shanghai and Shenzhen 300 Stock Index Futures (RMB)	Y4	Spot closing price of Shanghai and Shenzhen 300 stock index (RMB)

The descriptive analysis using spss yields the following results. The variance of futures is significantly larger than that of spot, and the price volatility is greater. Both showed a shape of a right-tailed tail. The overall price of the spot is higher than the futures.

Table 2. Descriptive results

Variable	Range	Minimum	Maximum	Average Value	Variance	Skewness	Standard Error	Peak Value	Standard Error
X1	2619	2770	5390	4018.64	468621.888	.326	.028	-1.084	.056
X2	2604	2793	5397	4029.14	470134.436	.324	.028	-1.088	.056
X3	2630	2746	5376	4007.56	466534.097	.327	.028	-1.081	.056
X4	2621	2769	5391	4018.42	468563.591	.326	.028	-1.084	.056
Y1	2413	2967	5379	4081.00	398071.659	.313	.028	-1.053	.056
Y2	2401	2979	5380	4087.80	399010.276	.311	.028	-1.056	.056
Y3	2415	2953	5367	4074.11	396686.945	.314	.028	-1.051	.056
Y4	2406	2968	5374	4081.09	397850.837	.313	.028	-1.053	.056

3.3. Correlation analysis

It can be seen from the results that the four prices of spot and futures all show significant correlation.

Table 3. Correlation results

Pair		Relevance	Saliency	Pair		Relevance	Saliency
Pair 1	X1 & Y1	.996	.000	Pair 3	X3 & Y3	.996	.000
Pair 2	X2 & Y2	.996	.000	Pair 4	X4 & Y4	.996	.000

4. Empirical Research

4.1. ADF unit root stationarity test

A prerequisite for Granger causality testing is that the time series must be stationary, otherwise false regression problems may occur [4]. Therefore, the ADF unit root test is performed before the Granger causality test. According to the test results, there are 8 roots in the actual sequence data of X1-Y4, which are non-stationary.

Therefore, the first-order differential processing is performed, and the unit root test of the eight first-order difference squares $\Delta X1-\Delta Y4$ is passed, and there is no unit root. Therefore, the opening price, closing price, lowest price and closing price of the Shanghai and Shenzhen 300 stocks are all first-order single-order sequences, which are in line with the basic conditions for SVAR model and cointegration test.

4.2 Granger causality test

At the 5% significance level, the first-order differential data of the X1 to Y4 eight sets of data is subjected to a two-or-two Granger causality test. According to the AIC criterion and the SC criterion, the optimal lag order is 2, and finally verified. 56 pairs of Granger relations, most of which are consistent with Granger causality, due to more data, the specific results are shown in Appendix I, some of the data is organized as follows. It can be seen that the first-order difference between the highest price, the lowest price and the closing price of the CSI 300 stock index futures is not the Granger reason for the first-order difference of the highest price of the spot, but the first-order difference of the highest price, the lowest price and the closing price of the spot is the first-order futures. Difference is the Granger reason for the data; for the first-order differential data of the opening price, the Shanghai and Shenzhen 300 stock index futures are the Granger reasons for the spot, and the spot is not the Granger reason for the futures.

Table 4. Granger causality test results

H0 Test	F Test Statistic	P Value
DY1 does not Granger Cause DX1	0.5176	0.596
DX1 does not Granger Cause DY1	136.909	4.00E-59
DX2 does not Granger Cause DY1	1651.49	0
DY2 does not Granger Cause DX2	1.69232	0.1842
DX3 does not Granger Cause DY2	332.265	5.00E-139
DY3 does not Granger Cause DX3	0.26651	0.7661
DX4 does not Granger Cause DY3	969.922	0
DY4 does not Granger Cause DX4	2.27842	0.1025

Next, the data is segmented Granger test, and the data is segmented Granger causality test

4.3. Johansen cointegration test

For the two series of futures and spot closing prices of the Shanghai and Shenzhen 300 Index, the maximum eigenvalue test and the trace test were carried out respectively. The results obtained are shown in Table 5. Both reject the null hypothesis of "0 co-integration vectors" and accept "at least The null hypothesis of 1 cointegration vector, which proves that there is a long-term cointegration equation for the futures and spot of the CSI 300 Index at a significant level of 5%, that is, there is a long-term equilibrium relationship.

Table 5. Cointegration test results

	Maximum Eigenvalue Test			Trace Check		
Null hypothesis	Characteristic root	Maximum eigenvalue	Threshold	Characteristic root	Trace statistics	Threshold
0 cointegration vectors	0.0055	41.7685	14.2646	0.0055	43.0900	15.4947
At least one cointegration vector	0.0002	1.2805	3.8415	0.0002	1.2805	3.8415

4.4. VEC (vector error correction) model

VEC is a VAR model with cointegration constraints (ie, long-term stable relationship). The explanatory variable of the VEC model is the lag term of each factor, which is exactly the same as the VAR structure. The only difference is that VEC is in the VAR model composed of differential variables. Added the error correction term calculated in the first part. It is mostly used for non-stationary time series modeling with cointegration relationship. The ECM error regression term is used as the first-order difference VAR model of regression quantity, which can further explore its short-term relationship.
The error correction term appears as CointEq1, and the cointegration relationship is expressed as the form of the error correction term:

$$\mathrm{CointEq1} = X4(-1) - 1.082279{*}Y4(-1) + 398.4732$$

According to the above formula, when Y4 is unchanged, the change of X4 in the t period($\Delta(X4-1) = X4 - X4(-1)$)can eliminate the 0.2% unbalanced error of the previous period, and the change of Y4 in the t period($\Delta(Y4-1) = X4 - Y4(-1)$) when X4 is unchanged can be increased before A period of 1.2% unbalanced error.
The error correction model for calculating the closing price of the Shanghai and Shenzhen 300 Index futures and the spot is as follows:

$$\Delta Y4 = -0.0126 * Y4(-1) - 0.9240 * X4(-1) - 0.2290\Delta(Y4(-1)) - 0.0379$$
$$*\Delta(Y4(-2)) + 0.1618 * \Delta(X4(-1)) + 0.0513 * \Delta(X4(-2)) - 0.0639$$
$$\Delta X4 = 0.0030 * Y4(-1) - 0.9240 * X4(-1) + 0.0409 * \Delta(Y4(-1)) + 0.0271$$
$$*\Delta(Y4(-2)) - 0.0849 * D(X4(-1)) - 0.0281 * D(X4(-2)) - 0.0741$$

5. Three-stage Empirical Study

The stock market suddenly fell sharply in June 2015, which had a huge impact on financial stability and economic development. According to the price change of the Shanghai and Shenzhen 300 Index, this paper selects three time periods, namely, the market high-speed up-and-down period, the market down period, During the market stabilization period, explore the difference between the price linkage and tracking error of the spot market during the stock index period in different time periods.

Table 6. Time period selection

Period	Time Slot
Market High-speed Upward Period	2015/4/8 10:20:00-2015/6/18 11:30:00
Market High-speed Downward Period	2015/6/18 11:30:00-2015/8/28 10:25:00
Market Stable Period	2015/8/28 10:25:00-2015/11/26 10:00:00

5.1. Piecewise granger test

When the market is moving at a high speed, it can be known that the opening price, the highest price, the lowest price and the closing price of the first-order differential data of the Shanghai and Shenzhen 300 stock index futures are the Granger reasons for the spot price, and vice versa, the opening price of the spot, the highest price, The lowest price and closing price are not the Granger reasons for the futures price. This conclusion is also true during the high-speed downturn of the market. For the stable development period, except for the highest price, the spot prices are Granger's reasons, and the other prices are basically the same. It can be seen that there is a big difference between the segmentation and the Granger test after the Granger test. However, from a more subtle supervision point of view, in the market downturn, the opening and closing prices of the spot price and the lowest price of the Shanghai and Shenzhen 300 stock indexes are significantly lower than the upward and downward periods of the futures opening and closing prices; The highest spot price for futures is significantly higher than the upside and downside, while the spot closing price is significantly lower than the upside and downside.

Table 7. Granger causality test result of market high speed upward period

H0 Test	F Test Statistic	P Value
DY1 does not Granger Cause DX1	2.52505	8.03E-02
DX1 does not Granger Cause DY1	122.239	3.00E-51
DY2 does not Granger Cause DX2	0.16525	8.48E-01
DX2 does not Granger Cause DY2	94.171	4.00E-40
DY3 does not Granger Cause DX3	0.59091	5.54E-01
DX3 does not Granger Cause DY3	63.2684	2.00E-27
DY4 does not Granger Cause DX4	0.94517	3.89E-01
DX4 does not Granger Cause DY4	70.8947	1.00E-30

Table 8. The granger causality test results in the high-speed downward period of the market

H0 Test	F Test Statistic	P Value
DY1 does not Granger Cause DX1	0.16058	0.8517
DX1 does not Granger Cause DY1	31.7234	3.00E-14
DY2 does not Granger Cause DX2	1.20485	0.2999
DX2 does not Granger Cause DY2	31.0072	5.00E-14
DY3 does not Granger Cause DX3	0.07316	0.9295
DX3 does not Granger Cause DY3	71.0758	1.00E-30
DY4 does not Granger Cause DX4	2.75633	0.0637
DX4 does not Granger Cause DY4	11.2997	1.00E-05

Table 9. Granger causality test results for market stationary period

H0 Test	F Test Statistic	P Value
DY1 does not Granger Cause DX1	2.65912	0.0702
DX1 does not Granger Cause DY1	22.2827	3.00E-10
DY2 does not Granger Cause DX2	4.52998	0.0109
DX2 does not Granger Cause DY2	17.5616	3.00E-08
DY3 does not Granger Cause DX3	0.47374	0.6227
DX3 does not Granger Cause DY3	54.7097	5.00E-24
DY4 does not Granger Cause DX4	0.12157	0.8855
DX4 does not Granger Cause DY4	15.1052	3.00E-07

5.2. Segmental tracking error calculation and significance test

It can be seen that the tracking error is higher in the downturn period than in the upstream period and the stationary period, and the tracking error in the upstream period is the smallest. Then SPSS is used for t-test. There are significant differences in tracking errors at different stages.

Table 10. Calculations of segmental tracking errors

Period	Opening Price	Highest Price	Minimum Price	Closing Price
Market high-speed upward period	0.0022	0.0017	0.002	0.0021
Market high-speed downward period	0.0046	0.0039	0.0043	0.0132
Market stable period	0.0028	0.0027	0.0028	0.003

Table 11. Conclusion

Null Hypothesis:	F-Statistic	Prob.
DX2 does not Granger Cause DX1	2828.33	0
DX1 does not Granger Cause DX2	41.9258	8.00E-19
DX3 does not Granger Cause DX1	3152.48	0
DX1 does not Granger Cause DX3	59.7524	2.00E-26
DX4 does not Granger Cause DX1	9810.41	0
DX1 does not Granger Cause DX4	0.34753	0.7064
DY1 does not Granger Cause DX1	0.5176	0.596
DX1 does not Granger Cause DY1	136.909	4.00E-59
DY2 does not Granger Cause DX1	825.41	0
DX1 does not Granger Cause DY2	20.3296	2.00E-09
DY3 does not Granger Cause DX1	724.507	2.00E-288
DX1 does not Granger Cause DY3	6.69131	0.0012
DY4 does not Granger Cause DX1	3000.35	0
DX1 does not Granger Cause DY4	0.56496	0.5684
DX3 does not Granger Cause DX2	302.162	6.00E-127
DX2 does not Granger Cause DX3	325.373	3.00E-136
DX4 does not Granger Cause DX2	1173.67	0
DX2 does not Granger Cause DX4	2.69155	0.0678
DY1 does not Granger Cause DX2	10.7519	2.00E-05
DX2 does not Granger Cause DY1	1651.49	0
DY2 does not Granger Cause DX2	1.69232	0.1842
DX2 does not Granger Cause DY2	113.638	2.00E-49
DY3 does not Granger Cause DX2	83.6621	1.00E-36
DX2 does not Granger Cause DY3	355.571	3.00E-148
DY4 does not Granger Cause DX2	339.36	8.00E-142
DX2 does not Granger Cause DY4	9.18532	0.0001
DX4 does not Granger Cause DX3	1313.88	0
DX3 does not Granger Cause DX4	1.13655	0.321
DY1 does not Granger Cause DX3	16.2001	1.00E-07
DX3 does not Granger Cause DY1	1951.91	0
DY2 does not Granger Cause DX3	106.156	3.00E-46
DX3 does not Granger Cause DY2	332.265	5.00E-139
DY3 does not Granger Cause DX3	0.26651	0.7661
DX3 does not Granger Cause DY3	203.495	9.00E-87
DY4 does not Granger Cause DX3	371.799	1.00E-154
DX3 does not Granger Cause DY4	2.14956	0.1166
DY1 does not Granger Cause DX4	0.79382	0.4522
DX4 does not Granger Cause DY1	2867.74	0
DY2 does not Granger Cause DX4	3.59982	0.0274
DX4 does not Granger Cause DY2	858.42	0
DY3 does not Granger Cause DX4	1.83857	0.1591
DX4 does not Granger Cause DY3	969.922	0
DY4 does not Granger Cause DX4	2.27842	0.1025
DX4 does not Granger Cause DY4	61.5661	3.00E-27
DY2 does not Granger Cause DY1	2859.68	0
DY1 does not Granger Cause DY2	98.5406	6.00E-43
DY3 does not Granger Cause DY1	2859.41	0
DY1 does not Granger Cause DY3	102.196	2.00E-44
DY4 does not Granger Cause DY1	8443.86	0
DY1 does not Granger Cause DY4	0.03937	0.9614
DY3 does not Granger Cause DY2	306.791	8.00E-129
DY2 does not Granger Cause DY3	333.637	1.00E-139
DY4 does not Granger Cause DY2	1291.63	0
DY2 does not Granger Cause DY4	7.83577	0.0004
DY4 does not Granger Cause DY3	1398.13	0
DY3 does not Granger Cause DY4	1.15821	0.3141

6. Conclusion

Firstly, according to descriptive analysis, correlation analysis and unit root test, it is concluded that the Shanghai and Shenzhen 300 stock index futures and spot prices are non-stationary, but the first-order difference is stable, so the data is first-order stable; secondly, the gran Genesis test. Next, according to the Johansen cointegration test, the spot data has a long-term cointegration relationship. Then VEC is used to explore its short-term relationship. Then, the difference between Granger and tracking error is analyzed in stages, and the market down period is obtained. The tracking error is higher than the conclusion of the up-and-down period.

It can be seen that under the random impact of "stock disaster", not only will the spot and futures prices of stock index futures change significantly, but also the linkage between the spot market and the futures tracking error will change greatly. This change is rapidly declining in the index, which is more obvious when the market is in a high-speed downturn. Therefore, in the market downturn, the government needs to actively rescue the market in order to maintain market stability.

References

[1] Xie Dongsheng, Li Dezhi. Research on the Relationship between Stock Index Futures and Spot Based on Multivariate Stochastic Volatility Model Method - Taking Financial Markets in Five Asian Regions as an Example. Shanghai Finance. 2011, (06), 79-85.

[2] Yang Ruijie. An Empirical Study on the Linkage of Stock Index Futures and Stock Index Spots in China. Xinjiang University of Finance and Economics. 2016.

[3] Wang Mingtao,Sun Ximing,Chen Yun.Study on the Impact of China's Stock Index Futures Jumping on the Stock Jump of Stock Index - Based on the Perspective of Synchronization and Extended Trading. Journal of Management Sciences. 2018, 21(08), 64-82.

[4] Chen Wei, Li Ping, Liu Tao. Study on the Interaction and Guidance Relationship between Stock Index Futures and Spot Market Price - An Empirical Analysis Based on Shanghai and Shenzhen 300 Stock Index Futures. Journal of Central University of Finance and Economics. 2013, (02), 25-30.