Study on VECM-DCC-VARMA-GARCH Method Based on United Test of Dynamic Correlation and Spillover Effect --Analysis on the Linkage of CSI 300 Index Futures and Spot Stock

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Keywords: CSI 300 Stock Futures; Stock Spot Market; Price Linkage Effect; VECM-DCC-VARMA-GARCH Model

Abstract: This paper discusses the Co-movement between CSI 300 stock futures and spot stock market, the dynamic relationship and spillover effects between the two market prices, on the establishment of VECM-DCC-VARMA-GARCH model. There are only one-way mean spillover and two-way volatility spillover effects existing in the field from the stock futures market to the stock market. Furthermore, the effect of the market on stock futures is much intense than the effect of stock futures on the stock market. In China, the stock IFs market has a good function in price discovery. Stock IFs did not lead to increased inconstancy of the stock market. On the contrary, it actually plays a stable foundation part in the stock market.

Introduction
Stock IF is a financial derivative product, which is characterized by a price index, and the price at maturity is an index based on maturity. Therefore, changes between markets affect each other, and some degree of non-exogeneity between the two market prices is caused by non-external non-independence. This index can more importantly reflect the non-microeconomic situation at home and abroad. Institutional investors and pension funds around the world basically use this product as an extremely critical tool for them. This method is to match wealth. Investors can obtain methods from IF stocks. This method is to try to not to face risks, including speculation and arbitrage. We also found through data that futures are also a very important means of price discovery. Therefore, stock IF has become a futures commodity that is valued by everyone, and has shown non-slow growth in the global market. In April 2010, the People's Republic of China announced a product, which was the first first financial futures product, namely the Shanghai and Shenzhen 300 Stock IF. In the process of rapid development of the domestic financial market, this product will definitely become an important tool for investors, allowing them to avoid some risks. The study of the non-independent effects between these two markets will tell us one result, which is the relationship between the transfer of information and the up and down jump between the markets.

We further studied these two markets, mainly from two aspects, one is the mean spillover effect and the up and down jump spillover effect. The initial check is from the first moment of the stock return, and an answer can be given to the context between the two market prices. The up-and-down jump spillover effect starts from this point, that is, the second-order moment of returns, and gives the answer to the relationship between the up-and-down jump of the two markets. Among the tools for studying the relationship between two markets, in China, the BEKK-GARCH model is mainly used to understand the up-and-down jump spillovers between several markets. However, it should be pointed out that this model also has a weakness, which is about parameter identification. This model has barriers to the cause analysis of the coefficient matrix, so the explanation given is a bit vague and complex.

Indeed, this model will run into some mathematical barriers. This model will be more concise, but also has another distinctive feature, that is, it has better arithmetic characteristics. The role of this model is to judge the correlation coefficient matrix of non-small patterns. In recent years, this
model has been widely used in the research field, especially in the field of non-static correlation of financial markets. However, the use of this model also has certain limitations and cannot be used to specifically analyze the up-and-down jump spillover effects between different types of markets. In order to solve the problems in the above research, we tried to construct a sexual model, that is, the DCC-VARMA-GARCH model. Using this model, we can explain the non-static relationship between the stock IF and the stock market, as well as the upper and lower levels. The spillover effect of the jump, and several important indicators can be analyzed together, so that we can more accurately understand the non-static relationship between the two markets and the system of information transfer.

**Research methods and model construction**

From the above analysis, we can draw a conclusion that there is a certain cointegration relationship between the stock index and the related futures price. For this reason, the two indexes can be unified under the definition of a non-invalid market Responding to equivalent information on the market. In addition, the relationship between the two markets is very strong, so the conditional mean equation can be expressed by a vector error correction model (VECM), which can test the non-short-term relationship between the two markets. The average spillover effects of these two markets can be adjusted for detection in turn. However, the research results of many researchers have shown that the variance and covariance matrices of these two markets are changing, and they have a temporal change and an up-and-down jump aggregation, and the relationship between the two markets will also change over time. Changed. The article adopts the DCC-VARMA-GARCH model, the purpose of which is to study and analyze the non-static correlation and the up-and-down jump spillover effect between the two markets in China.

The mean equation of the model, which combines the two equation, is expressed as:

$$
r_t = u + \sum_{k=1}^{p} \Phi_k r_{t-k} + \Pi Z_{t-1} + \epsilon_t \tag{1}
$$

$r = \begin{pmatrix} r_1 \\ r_2 \end{pmatrix}$ is the rate of return vector (1 for the futures market and 2 for the stock market), $\Phi_k = \begin{pmatrix} \phi_{k,11} & \phi_{k,12} \\ \phi_{k,21} & \phi_{k,22} \end{pmatrix}$ is lag term coefficient matrix, $Z_{t-1} = f_{t-1} - \delta s_{t-1}$ indicates a non-right term that reflects the equilibrium relationship between variables, $\Pi = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix}$ is error correction coefficient vector, $\epsilon = \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \end{pmatrix}$ is residual term vector.

The variance equation part of the model is in the form of DCC-VARMA-GARCH (1,1), The residual vector in equation (1), $H_t = \begin{pmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{pmatrix}$ Conditional covariance matrix for the residual vector, $D_t = diag(h_{11,t}^2, h_{22,t}^2)$ is a diagonal matrix composed of two standard deviations of market returns. The conditional variance is set here in the form of VARMA,

$$
h_{ii,t} = c_{ii} + \sum_j a_{ij} \epsilon_{j,t-1}^2 + \sum_j b_{ij} h_{jj,t-1} \tag{2}
$$

$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$ is ARCH effect term coefficient matrix, $B = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}$ is GARCH effect term coefficient matrix.

In the DCC model proposed by Engle, the structure of $Q_t$ is set as

$$Q_t = (1 - \theta_1 - \theta_2) Q + \theta_1 \xi_{t-1} + \theta_2 Q_{t-1} \tag{3}
$$

$\xi_{t-1} = D_{t-1}^{-1} \epsilon_t$ is normalized residual, $\theta_1, \theta_2$ are parameters and are all greater than zero. In order to guarantee the positive definiteness $H_t$, require $\theta_1 + \theta_2 < 1$. 

-60-
In the mean equation, if all of \( \Phi_{k,21} \) is zero or insignificant. If all \( \Phi_{k,21} \) is zero or not significant, it means that the stock market has no mean overflow in the stock index futures market. The test of the mean spillover effect is essentially the joint significance test of the single equation coefficients. The corresponding statistic is
\[
F = \frac{(SSE_r - SSE_u)/k}{SSE_u/[T - 2(k + 1)]}
\]

In order to more clearly illustrate the volatility spillover effect between markets, the variance equation (2) is expanded as:
\[
h_{1,t} = c_{11} + a_{11}\epsilon_{1,t-1}^2 + a_{12}\epsilon_{2,t-1}^2 + b_{11}h_{1,t-1} + b_{12}h_{2,t-1}
\]
\[
h_{22,t} = c_{22} + a_{22}\epsilon_{1,t-1}^2 + a_{22}\epsilon_{2,t-1}^2 + b_{21}h_{1,t-1} + b_{22}h_{2,t-1}
\]

The variance equation explores the influencing factors of the conditional variance of the yields of the two markets, which are the residual squared of the yields of the two markets lagging one period and the conditional variance of the two markets lagging one period. The parameters, \( a_{11}, b_{11} \) and \( a_{22}, b_{22} \) represent the continuity of the volatility of the two markets, and \( a_{11}, b_{11}, a_{22} \), \( b_{22} \) are either zero or insignificant, indicating that the market itself lags the square of the residual term and the conditional variance of the lagging period has no effect on the conditional variance of the current period. \( a_{12}, b_{12} \) reflect the stock market's ARCH and GARCH type volatility spillover effects on the futures market. If \( a_{12}, b_{12} \) at the same time, they are zero or insignificant, it means that the stock market rate of return is lagging the residual square of the one period, and the lag of the one period is the variance of the futures market conditions no effect. \( a_{21}, b_{21} \) reflect the volatility spillover effect of the futures market on the stock market. This paper uses the likelihood ratio method to test the volatility spillover effects between markets and test statistics
\[
LR = -2(L_r - L_u) \sim \chi^2(n)
\]

\( L_r, L_u \) are the log-likelihood function values of the constrained model and the unconstrained model respectively, and \( n \) is the number of constrained parameters.

**Data Processing and Model Estimation**

**Data Selection and Processing.** China’s CSI 300 Index futures contract can be traded in four months, which can be traded in the current month, next month and the next two quarters. In general, the actual delivery date of this contract can be determined on the third Friday of the expiration month. Then, after the actual delivery, the transaction of the month is actually changed from the transaction of the previous month. Because the IF spot market will have a non-minimum trading volume and non-weak cash liquidity in the closest delivery month, we can understand that this transaction price can also best represent the price at that time. It follows that why we chose this transaction, that is, the Shanghai and Shenzhen 300 continuous futures trading sequence IFLX0 of the China Financial Futures Exchange for the month as the representative transaction of the futures market, and the Shanghai and Shenzhen 300 stock price index was selected to represent the stock market. The sample we studied is a 15-minute interval of transaction data from April 16, 2015 to June 30, 2019. Due to the different trading hours of the two markets, the stock market has 30 minutes less trading time than the IFs market. But it should be pointed out that we know that in the specific analysis, the selected data is extremely in one-to-one correspondence. Therefore, we chose stock index futures market data and stock trading time as overlapping parts, a total of 15,628 pairs, and the data sources are from the SF stock market analysis system. Our first step is to deal with it by making the two price indices into natural logarithms, and then using the returns of these two markets as natural logarithms.
We can see that Table 1 gives such characteristics, which are these two aspects, one is the CSI 300 stock index futures, and the other is the spot index. The standard deviation and the extreme value of the spot index return rate are smaller than the return rate. As a result, it can be seen that the stock index futures market's up and down jump is not lower than the spot market. So do you want to know the main reason? That's because leverage, because the margin system of the stock index futures market has a non-small leverage. From another perspective, right-handers are reflected in stock index futures, and non-right-handed ones are spot indexes. Non-left-handed people of stock index futures are much smaller than non-right indexes of spot indexes. From another statistical indicator, non-blunt peaks and non-fine tails are the basic characteristics of the production series, and our calculations also show that these two production series follow a non-normal distribution. The non-single result of the non-single mixture test of the rate of return has two correlations, one is autocorrelation and the other is mutual correlation. Therefore, we think it is very important to quickly set up a multivariate model, which is the first moment and the second moment between the two returns. What is the purpose? The purpose is to study the spillover effects between the above two markets.

Table 1. Basic statistical characteristic of Shanghai and Shenzhen 300 stock index futures and spot yields

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
<th>Skew.</th>
<th>Kurt.</th>
<th>JB</th>
<th>Q(5)</th>
<th>Q'(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Futures</td>
<td>-0.006</td>
<td>-2.673</td>
<td>3.086</td>
<td>0.26</td>
<td>0.02</td>
<td>20.02</td>
<td>54460***</td>
<td>532.39***</td>
<td>33.41**</td>
</tr>
<tr>
<td>Spot</td>
<td>-0.005</td>
<td>-2.585</td>
<td>1.570</td>
<td>0.24</td>
<td>-0.75</td>
<td>11.98</td>
<td>19804***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Root Test and Cointegration Test for Each Sequence. We can see such information from the inspection result data in Table 2. Such an assumption has not been rejected, that is, the two income series of stock index futures and spot market prices have the same situation, which is the null hypothesis that there is a unit root. When we performed a non-swaying test on the two indicators, we saw a result that the assumption of non-post is not accepted at the 1% boundary level, and the ranks of non-post prices are represented as I (1) processes.

Table 2. Root test results of each sequence unit

<table>
<thead>
<tr>
<th>Sequence</th>
<th>S</th>
<th>F</th>
<th>ΔS</th>
<th>ΔF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% Critical value</td>
<td>-3.96</td>
<td>-3.96</td>
<td>-3.43</td>
<td>-3.43</td>
</tr>
<tr>
<td>ADF Statistics</td>
<td>-1.68</td>
<td>-1.87</td>
<td>-57.80***</td>
<td>-59.41***</td>
</tr>
</tbody>
</table>

Parameter Estimation and Testing. We can see the empirical estimates from the results shown in Table 3. According to the SC information rule, the optimal non-advance order of the VECM model is 2. Which model will this article diagnose first? Of course, non-single detection is performed on binary standardized residuals, and we will further apply binary statistics Ljung-Box. Therefore, we can see that the model's standardized residuals have no significant serial correlation or conditional heteroscedasticity. The results show a point that the fitted model can completely describe the conditional mean and the up-down jump rate.

In the mean equation, none of the parameters $\phi_{k,1j}$ is significant, indicating that there is no autocorrelation in stock index futures returns, and it is not affected by the cross-effects of previous returns on stock market returns. The parameters $\phi_{k,2j}$ are significant, indicating that the stock index returns have an autocorrelation, and are also affected by the cross-effects of previous futures returns. This shows that there are no spot leading futures, but only one-way causality of stock index futures leading the spot, and the price discovery function of the CSI 300 stock index futures is strong.
Table 3. Parameter estimation results of VECM-DCC-VARMA-GARCH model

\[ r_t = u + \sum_{k=1}^{\beta} \Phi_k r_{t-k} + \Pi z_{t-1} + \varepsilon_t \]

\[
\Phi_1 = \begin{pmatrix}
-0.026 & -0.042 \\
(1.00) & (1.61) \\
0.383^{***} & -0.338^{***} \\
(18.48) & (-13.24)
\end{pmatrix}
\]

\[
\Phi_2 = \begin{pmatrix}
0.027 & -0.039 \\
(1.01) & (1.60) \\
0.151^{***} & -0.099^{***} \\
(6.26) & (-4.15)
\end{pmatrix}
\]

\[
u = \begin{pmatrix}
-0.004 \\
(-0.92) \\
0.000 \\
(0.11)
\end{pmatrix}
\]

\[
\beta = \begin{pmatrix}
-0.014^{**} \\
(-1.94) \\
0.019^{**} \\
(2.70)
\end{pmatrix}
\]

Variance equation

\[ h_{jt} = c_e + \sum_{j} a_{e} e_{j,t-1}^2 + \sum_{j} b_{e} h_{j,t-1} \]

\[
C = \begin{pmatrix}
-0.000 \\
(-1.12) \\
0.000^{**} \\
(2.35)
\end{pmatrix}
\]

\[
A = \begin{pmatrix}
0.084^{***} & -0.071^{***} \\
(8.75) & (8.01) \\
0.004 & 0.016^{***} \\
(0.74) & (3.12)
\end{pmatrix}
\]

\[
B = \begin{pmatrix}
0.816^{***} & 0.222^{***} \\
(34.85) & (6.27) \\
-0.020^{**} & 0.981^{***} \\
(-2.34) & (119.81)
\end{pmatrix}
\]

Dynamic correlation equation

\[ Q_t = (1 - \theta_1 - \theta_2) \bar{Q} + \theta_1 \xi_{t-1} \xi_{t-1} + \theta_2 Q_{t-1} \]

\[ \theta_1 = 0.009^{**} (2.54) \quad \theta_2 = 0.983^{***} (114.98) \]

The error correction term coefficients \( \beta_1, \beta_2 \) are significantly negative and positive at significance levels of 5% and 1% respectively, indicating that when the futures and spot are out of the long-term equilibrium relationship, they will all approach the long-term equilibrium. The absolute value of the error correction term coefficient of the stock index futures market is 0.014, which is smaller than the absolute value of the error correction term coefficient of the spot market, which is 0.019. Stock index spot price changes have played a more important role.

In the estimation of the dynamic correlation coefficient equation, \( \theta_1 + \theta_2 = 0.992 \), indicating that the changes in the correlation coefficients of the two markets have strong continuity, but \( \theta_1 \ll \theta_2 \) shows that the correlation coefficients are mainly affected by the correlation coefficients in the previous period, but not affected by the unexpected information shocks in the previous period.

Table 4. Test of stock index futures market and stock market spillover effect

<table>
<thead>
<tr>
<th>Mean spillover test</th>
<th>Volatility spillover test</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 )</td>
<td>( F )</td>
</tr>
<tr>
<td>( \phi_{i,12} = \phi_{2,12} = 0 )</td>
<td>107.36***</td>
</tr>
<tr>
<td>( \phi_{i,21} = \phi_{2,21} = 0 )</td>
<td>171.57***</td>
</tr>
<tr>
<td>( \phi_{i,21} = \phi_{2,21} = 0 )</td>
<td>1.98</td>
</tr>
</tbody>
</table>

In the test in Table 4, we can see the response of the up and down jump spillover effect in the two markets. This can be seen from the non-fuzziness of the LR statistics. When the non-fuzzy level is 1%, the two markets there is no up and down jump result. Moreover, two hypotheses were
rejected, one was the up-and-down jump effect of the stock index futures market on the stock market, and the other was the null hypothesis of the up-and-down jump effect from the stock market to the stock index futures market. From this result, we can draw the view that China's stock index futures market and the stock market have two up and down jump effects.

Conclusion

We hope to build the above model for empirical analysis. This empirical analysis studies the non-static correlation between the stock IFs market and the stock market to elicit non-advanced relationships and regarding volatility effects. Our conclusions are as follows:

Is there an independent relationship between Chinese stock index futures and stock index? The movement of the stock IF to equilibrium is slower than that of the stock price index, which is a situation that occurs in the process of adjusting its non-short-term equilibrium price relationship. Although, China's stock index futures market is still in its infancy. From the perspective of the structure of traders, the proportion of individual investors is still high. The number of participants in the spot stock market is far greater than the number of participants in the futures market, which has led to an important result, namely the adjustment of long-term equilibrium prices. In this process, of course, the market must play a more important role than government policy.

Through analysis, we conclude that there is a non-uniform spillover relationship, which is about the relationship between China's stock IF market and the stock market. The stock market obtained this information from the stock IF market. The price discovery function is a very good feature developed from the stock IF. Speculators are important participants in the stock IF market, which is mainly because of the relatively strong speculative atmosphere in the stock IF market.

China's stock index futures and stock markets have been affected significantly by the current period. This impact includes two aspects, namely, abnormal shocks and accumulation of information. The futures market cannot change the predictable impact at a relatively fast rate as the conditional variance, and the stock market fluctuations will continue to be strengthened by receiving external information shocks.

The non-unilateral jump up and down spillover effect is a distinctive feature of China's stock IF market and stock market. Moreover, the spillover effect of the stock market on IF is significantly stronger than the spillover effect of IF on stocks. In the non-long term, many unpredictable effects will increase the ups and downs of the stock IF market and the unforeseen effects of the stock IF market will have a very small impact on the up and down jumps of the stock index futures market. From a non-short-term perspective, the previous ups and downs of the stock market will cause such consequences, and the consequences are obvious, that is, the current ups and downs of the stock index futures market, and the current up and downs of the stock market will be slowed. This slowdown is caused by the ups and downs of the IFs market.

References

