Research on the Dynamic Relationship among China's Metal Futures, Spot price and London's Futures price

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Abstract

This paper studies the dynamic relationship among futures price, spot price of Shanghai metal and futures price of London with the co-integration theory, Granger causality tests, residue analysis, impulse responses function, and variance decomposition on the VECM. The study shows the three have the long equilibrium relationship: the copper futures price of Shanghai have internalities to the futures of London; the aluminum futures price have externalities; the three have different price discovery functions.

Keywords: Futures prices, Vector Error Correction (VEC) model, Price discovery functions, Impulse responses function

1. Introduction

London Metal Exchange (LME) is the largest and most influential metal exchange in the world, in which the trend of futures prices reflects the anticipation of international price trend, exerting significant directive effect on world metal production and consumption. Shanghai Futures Exchange (SHFE) is the most normal one in China. Futures contract is the most active and mature transaction in domestic market. It has a nice function of price discovery and begins to exert greater effects on world metal price. Therefore, to study the dynamic relationship among futures price, spot price of China metal and futures price of the world is meaningful to assess the operation efficiency, the price discovery function, and the risk-transfer function of China's futures market at home and abroad, and to perfect futures market's operation mechanism.

Scholars at home and abroad have made lots of researches on the relationship between futures price and spot prices. Lai, K. S. & M. Lai (1991) tested the relationship between futures price and spot price by co-integration theory earlier. Chowdhury (1991) examined the relationship between color metal futures price and spot price. Researches show that futures market has relatively evident advantages over spot market in prices. Spot prices exert relatively strong effects on futures prices. Hasbrouck (1995) studied futures market and spot market's function of price discovery. Haigh (2000), Jian Yang & David A. Bessler & David J Leatham (2001) tested the relationship between futures prices and spot prices by co-integration analysis. Jun Wang and Zongcheng Zhang (2004), and Renhai Hua (2004) made empirical researches on the dynamic relationship between SHFE futures prices and spot prices, concluding that there is a balanced and causality relationship between the two. Renhai Hua and Baizhu Chen (2004) proved there is a long-term equilibrium between futures price at home and that abroad. Jinwen Zhao (2004) showed that there is a co-integration relationship between China's metal futures price and international futures price, thinking that China's futures market is effective basically and formulates a self-restrained price mechanism. Hui Gao (2004, 2005) made empirical researches on the relationship between copper futures price of Shanghai, China and that of London, UK, showing that there is a significant positive correlation between the two markets. Xinmin Tian and Xiaogang Shen (2005) analyzed the causality relationship between the copper futures price of SHFE and that of LME, proving the increasing influences of copper futures price of SHFE on copper futures price in world market. Yunzhong Li (2006) made dynamic quantitative studies on metal futures price of SHFE and that of LME by ADL model. To sum up, present documents focus on the two markets based on the relationship between futures price and spot price at home or the relationship between futures price at home and that abroad. There are no sufficient researches that focus on the short-term mutual-affected relationship between futures markets at home and abroad and spot market, the price discovery function, the effect of exterior information or internal information on the three markets, and the untimely transfer of information in market. Therefore, this paper studies the dynamic relationship among futures price, spot price of SHFE and futures price of LME with the co-integration theory, Granger causality tests, residue analysis, impulse responses function, and variance decomposition on the VECM.

2. Variables and explanation

This paper selects the futures prices data from 7th, January, 2002 to 11th, September, 2006. Choose the closing quotation prices of the dominant futures, March copper and aluminum futures that are most representative in LME market. Select the closing quotation prices of copper and aluminum futures contracts in each trading day. Because every futures contract has a deadline, and every trading day has difference futures prices, we choose the latest futures contracts as samples in order to deal with the discontinuousness of futures prices, the small transactions in settlement month, and the unstable prices. As the latest futures contract enters the settlement month, select next latest futures contract. By this way, we can get a continuous and relatively stable futures contracts sequence. Delete the unmatched data caused by different trading dates in domestic futures market and international futures market. At last, we can get the data of the effective copper futures prices of SHFE and LME, and the aluminum futures prices of SHFE and LME, respectively 1109 and 1106, from different futures exchanges. The data of spot prices are from Shanghai Metal Market. In order to reduce hetero-scedasticity, we make logarithmic transformation on futures prices and spot prices, namely $LNLF_t$, LNF_t, and LNS_t.

3. Empirical analysis on the dynamic relationship between metal futures prices and spot prices at home and abroad

3.1 Co-integration analysis on futures price and spot price

Before the co-integration analysis we make stability test on futures price and spot price. ADF and PP tests prove that the futures prices and spot prices of copper and aluminum are one-order unit integer sequence, what is an acceptable fact. Get the best lagged order by making LR statistics, AIC information principles, and SC rules become the smallest at the same time. Tests show that the best way is to choose the lagged second period to construct VAR model, adopting the Johansen-Juselius co-integration test under multiple variable VAR model to test whether there is co-integration relationship among futures prices LNF_t, $LNLF_t$, and LNS_t. The test result is in table 1.

According to data in table 1, there is a co-integration relationship between aluminum and copper's futures prices and spot prices in China. Engle & Granger (1987) prove that under the condition of co-integration relation among variables there is an error correction formula:

$$\Delta y_t = \alpha \; ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t$$

The estimation result is in table 2.

According to co-integration vectors, there is a long-term equilibrium among metal futures prices at home or abroad and spot prices. But exterior information has different effect on the three markets during a long period. According to the data of correction coefficients, as the correction coefficient statistics is significant and in accord with error correction mechanism, futures prices and spots prices would repair the non-equilibrium state and the system strays away from the equilibrium state. As the correction coefficient statistics is insignificant, futures prices and spot prices are affected by price changes in the lagged period. Comparing these correction coefficients, the LME futures prices' correction coefficient is less than that of SHFE, Shanghai copper's near to London copper's, and London aluminum's far less than London copper's. It indicates that domestic and international futures markets and spot market would regulate the price departure caused by exterior information, realizing the long-term equilibrium relationship of prices in the three markets. However, the price regulation in spot market is more evident than that in SHFE futures market, and that in SHFE futures market more evident than that in LME futures market. Shanghai aluminum futures price has a greater effect on the price regulation of London aluminum futures price than that on Shanghai copper futures price.

3.2 The Granger causality analysis on the relationship of futures price and spot price with VEC model

Although co-integration relationship indicates a causality relation, it does not necessarily distinguish the causality direction among variables. The causality relationship can be tested by long-term co-integration vectors' error correction model (Granger, 1996, 1998). Feldstein and Stock (1994) proved that if there is no co-integration relationship among stable variables, the causality relationship should include the error correction term (ECT). Otherwise, the conclusion may be not correct. Therefore, this paper adopts the new-developed Granger causality test based on VECM, $\mathbf{\Delta Y_t} = \mathbf{\Gamma}_1 \mathbf{\Delta Y}_{t-1} + \mathbf{\Gamma}_2 \mathbf{\Delta Y}_{t-2} + \cdots + \mathbf{\Gamma}_{k-1} \mathbf{\Delta Y}_{t-(k-1)} + \alpha\beta' \mathbf{Y}_{t-1} + \mathbf{u}_t$, to test the variables' externality and causality relationship. According to the AIC and SC principles, select the best lagged order. The test result is in table 3.

The result shows that futures prices at home and abroad have a directive effect on spot price. In China's futures market, for copper futures, there is a mutually-directive relationship between its futures price and spot price. But for aluminum, its futures price has a directive effect on its spot price. In the world futures market, SHFE copper futures price has an increasing effect on world copper price, what causes the price change of LME copper futures. In contrast, it is the international futures market that has a dominant effect on aluminum futures price.

3.3 The dynamic analysis on the relationship of futures price and spot price with VEC model

VAR model determines the dynamic structure of economic system by real economic data instead of economic theories. It is not necessary to put forward pre-assumption in the construction of the model. But as there is a co-integration relationship among variables, we should adopt VEC model to make further analysis. Use the residence analysis in VEC model to find out what factors associate with changes of futures price and spot price. Use impulse response function to test which one has greater and longer effect on futures price and spot price. Use variance decomposition to make sure what factors can effectively predict futures price and spot price.

3.3.1 VEC model's residence analysis

Residences estimated by VEC model stand for parts of variables' changes that can not be explained by the law of three variables in the model (for example, there is a big residence in Shanghai copper futures price, what indicates that the change of Shanghai copper futures price can not explained by its own rules, Shanghai copper spot price, London copper futures price, and short-term error correction term). The positive or negative effect can help to judge the effect correlation (no residence figures in this paper for the sake of proper length). In the aspect of effect degree, there is a stronger correlation between Shanghai copper and aluminum futures prices and spot price, comparing with correlation between the former and London futures price. And London metal futures price and Shanghai futures price have a greater effect degree than that of metal spot price.

Impulse response function is to describe an internal variable's response toward error. In specific, as we exert an effect that is near to the standard deviation on random error, impulse response function can describe the influences on internal variable's current value and future value. Impulse response function can reflect the prices' mutual effects, relations, and the degree of effects (time and depth) in the three markets. In order to overcome the shortcoming of Cholesky decomposition in co-variance matrix, we adopt Generalised Impulse Responses (GIR) advanced by Pesaran and Shin (1998) to make analysis. The analysis result is in figure 1 and figure 2.

For the metal copper, as current price is affected by SHFE futures price's standard variance information, copper futures price is affected strongly by its information currently. The price increases by 1.16% firstly and then rises slowly. On the third trading day, the price reaches the top. The influence sustains a long period. As the market transfers the information to LME, the London copper futures price increases 0.58% on the day. Then, the price increases stably at 0.82%. On the day, the copper spot price increases by 0.72%, then rises at a lower speed. On the sixth trading day, the price reaches the top increase, 1.14%, exerting a stable driving effect. In current, the positive effect on LME futures price: London copper futures price increases 1.64% on the day and then reduces slowly on the second and the third trading days. Finally, it tends to exert a stable driving effect. SHFE futures price reaches the top increase, 1.25%, on the third trading day. Spot price reaches the top increase, 1.20%, on the second trading day. Both fluctuate during later four trading days, and then exert a sustainable effect. After a positive effect from copper spot price, Shanghai copper futures price begins to increase on the first trading day and finally generates 1.0% sustainable effect. London futures price is not affected severely.

For the metal aluminum, as current price is affected by domestic futures price, copper futures price is affected strongly by its effect currently. On the third trading day, the price reaches the top, increasing 0.85%. Then there is a stable sustainable effect. LME futures price confronts a direct effect. Because the effect is small, the price sustains stable at 0.32%. Spot price rapidly increases 0.89% as current price increases 0.48%, exerting a sustainable effect. As LME futures price is affected by standard variance information, the price changes severely. On the first trading day, the price reaches the top, 1.28%, and then decreases to 1.11% slowly and tends to be stable. SHFE futures price and spot price reach their tops, 0.42% and 0.38% respectively on the second trading day and the fourth trading day. Afterwards, both decrease slowly and exert stable driving effect. As the effect of spot price's standard variance is over, its effect on London and Shanghai' aluminum futures prices.

3.3.3 VEC model's variance decomposition analysis

Variance decomposition is to analyze the contribution degree of every structural effect on internal variables' changes. It can help to further evaluate the importance of different structural effects. Because the changes of futures price and spot price reflect the three markets' responses to new information, the market that possesses amounts of information absorbs more market information, and can exert greater effect in its price discovery function. The three markets' variance decomposition result is in table 4 and table 5.

For the metal copper's SHFE futures price changing variance, in the first lagged period, the total variance is coming from the futures market thoroughly and decreases along with the rise of variance in the lagged period. Finally it is near to 55.74%. LME futures price tends to increase fast. At last it rises to 39.28%. Spot price increases slowly and finally tends to be close to 4.98%. For LME futures price changing variance, SHFE futures price variance rises fast and finally is close to 30.11%. London futures price decreases gradually and finally is near to 69.02%. There is no other effect if spot market lags behind one period. The final percent is merely 0.87%. For spot market price changing variance, as the lagged period is one, 53.65% is from self. Then it begins to decrease fast from the second lagged period. Finally it is close to 12.64%. SHFE futures market generates 45.90% effects in the first lagged period. Then the effect increases to 58.50% slowly. LME futures price generates relatively small effect in the first lagged period. It increases fast in the second lagged period and finally is close to 28.86%.

Table 5.

For the metal aluminum's SHFE futures price changing variance, in the first lagged period, the total variance is coming from the futures market thoroughly and decreases slowly during following lagged periods. Finally it is near to 83.15%. LME spot price tends to increase. Finally they are near to 16.62% and 0.23% respectively. For LME futures price's variance, SHFE futures price variance rises slowly and finally is close to 8.64%. London futures price decreases gradually and finally is near to 91.33%. The proportion of spot market is merely 0.03%. For spot market price changing variance, as the lagged period is one, 52.59% is from self. Then it begins to decrease fast and finally it is close to 1.85%. SHFE futures market generates 47.38% effects in the first lagged period. Then the effect increases to 82.63% rapidly. LME futures price finally increases to 15.52%.

4. Conclusion

Because SHFE adopts a physical delivery policy, futures price is evidently close to spot price nearing the settlement day. Numerous trans-market arbitrageurs make SHFE futures price be close to LME futures price. Therefore, prices in the three markets tend to be equal. That is rightly the result of co-integration analysis. SHFE, LME metal futures prices and spot price stay in a long-term equilibrium. Short-term fluctuation will be consumed by the three markets' inner regulation mechanism. It indicates that China's futures market has a self-restrained price mechanism. But the three markets response differently toward exterior information.

According to the result of VECM causality test, for the metal copper, there is a mutual directive effect between SHFE futures price and spot price, and LME futures price exerts a unilateral directive effect on spot price. There is a bilateral directive relationship between LME futures price and SHFE futures price. Shanghai copper futures price possesses a long-term internality effect, in contrast with London copper futures price. For the metal aluminum, spot price does not exert a directive effect on futures price. There is a unilateral directive effect. LME futures price has a unilateral effect on spot price and SHFE futures price. Shanghai aluminum futures price has an externality, in contrast with London aluminum futures price.

According to VECM impulse response function, LME futures price, SHFE futures price, and spot price response strongly toward self new information. Shanghai copper futures price information and London copper futures price information can generate similar sustainable effect on each other. London copper futures price information has a greater effect on spot price, slightly higher than the effect of Shanghai copper futures price information on spot price, what reflects London copper and Shanghai copper's market dominant effect. London aluminum futures price information has a relatively higher effect on Shanghai aluminum price. The effect of Shanghai aluminum futures price standard variance information on spot price is higher than the effect of London aluminum futures price on spot price, showing the dominant effect of London aluminum futures market on Shanghai aluminum market. In China, Shanghai aluminum has a dominant effect on spot market.

According to variance decomposition, in the aspect of SHFE and LME copper futures markets' price discovery function, the two markets possess similar dominant positions. In the aspect of spot market's price discovery function, SHFE futures market holds the dominant position. For the metal aluminum's price discovery function, futures prices exert decisive effect on each other. But London aluminum futures price has a stronger effect on Shanghai aluminum futures price. In the aspect of aluminum spot market's price discovery function, SHFE futures market stays in a dominant position.

In a word, SHFE metal futures market is effective in the field of resource allocation. It has better price discovery function and risk-transform function. Copper has already held a position in world metal pricing system. Since China consumes and imports amounts of copper from other countries, it is an inevitable trend for China's copper futures market affecting international copper price more and more. Speculators who participate in copper futures market and arbitrators must notice both London futures market and China's copper futures market in order to escape from risks. Participators in copper spot market should notice the price changes in Shanghai copper futures market. In contrast, aluminum futures' market has a weak ability in international pricing system, what indicates that China's aluminum futures market needs for further perfection. At present, participators in Shanghai aluminum futures market should notice London futures market closely in order to escape from risks caused by price changes. However, participators in aluminum spot market should notice Shanghai aluminum futures market all the time.

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Table 1. Johansen-Juselius co-integration test result

Type	Zero assumption	Eigen-value	Maximum SR	5% critical value	Trace statistics	5% critical value
Copper	r = 0	0.060	68.64	21.13	80.29	29.80
	r 1	0.009	10.08	14.26	11.64	15.49
Aluminum	r = 0	0.022	24.24	21.13	34.34	29.80
	r 1	0.009	10.03	14.26	10.1	15.49

Table 2. The estimation result of co-integration vector and regulation coefficient

Copper	Co-integration vector (β)	Regulation coefficient (α)	Aluminum	Co-integration vector (β)	Regulation coefficient (α)
LNF_t	1.000	-0.168(-5.22)	LNF_t	1.000	-0.007(0.32)
$LNLF_t$	-0.259(-9.50))	0.092(2.03)	$LNLF_t$	-0.011(-0.33)	0.003(0.08)
LNS_t	-0.723(-25.37)	0.014(0.47)	LNS_t	-0.979(-18.81)	0.074(-3.79)

Notice: ( ) means test value t .

Table 3. The result of VECM-based Granger causality relationship test

Copper	ΔLNF_t	$\Delta LNLF_t$	ΔLNS_t	Aluminum	ΔLNF_t	$\Delta LNLF_t$	ΔLNS_t
ΔLNF_t	-	13.84	22.02	ΔLNF_t	-	6.44	81.85
$\Delta LNLF_t$	422.85	-	676.64	$\Delta LNLF_t$	317.82	-	319.97
ΔLNS_t	9.92	4.87	-	ΔLNS_t	8.84	4.15	-

Notice: the number is χ^2 (Wald) statistics value (free degree 4), the critical value of $\chi^2_{0.05}$ is 9.448.

Table 4. Copper predicted variance decomposition result.

Variance	LNF_t is from			$LNLF_t$ is from			LNS_t is from		
0	LNF_t	$LNLF_t$	LNS_t	LNF_t	$LNLF_t$	LNS_t	LNF_t	$LNLF_t$	LNS_t
1	100.00	0.000	0.000	12.374	87.626	0.000	45.904	0.451	53.645
2	80.422	19.236	0.342	16.554	83.359	0.087	47.571	24.053	28.376
3	75.190	24.373	0.437	19.275	80.649	0.076	52.096	26.461	21.443
4	74.120	25.277	0.603	20.432	79.487	0.081	53.666	26.617	19.717
5	72.413	26.789	0.798	21.464	78.425	0.111	54.166	27.526	18.308
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N	55.739	39.284	4.977	30.106	69.022	0.872	58.503	28.860	12.637

Table 5. Aluminum predicted variance decomposition result.

Variance	LNF_t is from			$LNLF_t$ is from			LNS_t is from		
0	LNF_t	$LNLF_t$	LNS_t	LNF_t	$LNLF_t$	LNS_t	LNF_t	$LNLF_t$	LNS_t
1	100.00	0.000	0.000	5.255	94.745	0.000	47.378	0.032	52.590
2	88.870	10.990	0.140	6.586	93.409	0.005	62.147	7.868	29.985
3	86.207	13.637	0.156	6.869	93.061	0.070	67.145	9.283	23.572
4	85.509	14.313	0.178	7.294	92.627	0.078	68.623	10.463	20.914
5	85.033	14.791	0.176	7.558	92.364	0.078	69.909	11.078	19.013
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N	83.150	16.617	0.233	8.637	91.331	0.032	82.633	15.514	1.853

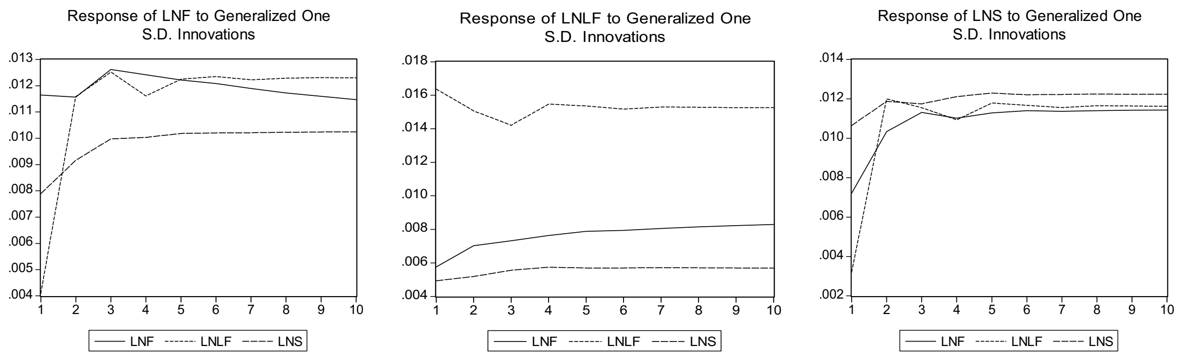

Figure 1. The Impulse Response Figure for Shanghai and London Copper Futures Prices and Spot Price.

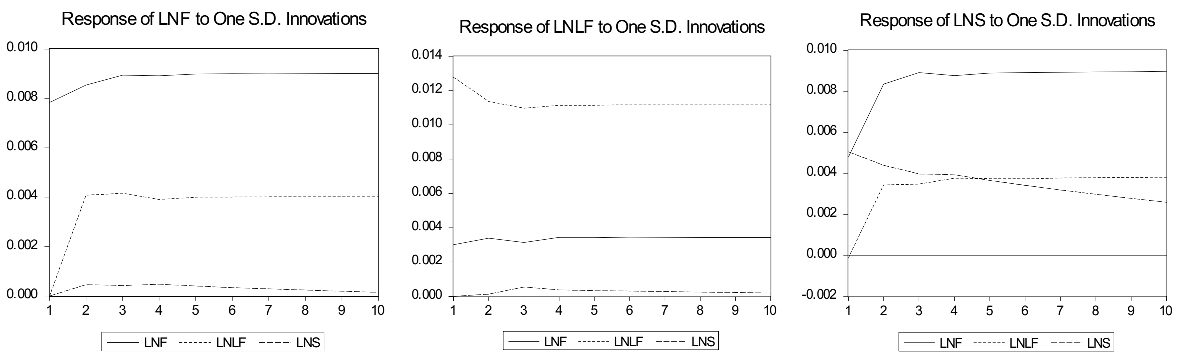

Figure 2. The Impulse Response Figure for Shanghai and London's Aluminum Futures Prices and Spot Price.