PRICE EQUILIBRIUM AND TRANSMISSION IN A CONTROLLED ECONOMY: A CASE STUDY OF THE METAL EXCHANGE IN CHINA

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INTRODUCTION

Since China began to experiment with its open door policy in 1978, the economy has been gradually transferred from a centrally planned and controlled economy to a dual system in which administrative guidance oversight has not completely given way to market forces. In a centrally planned economy, industrial raw materials and agricultural products are tightly controlled and price and distribution are solely determined by

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the planning agency in the government. As the reform expands, China is liberalizing the distribution and price of raw materials. An increasing percentage of total raw materials is left to market forces to determine the price. As a result, most commodity prices in China are in transition between central planning and a free market. It is estimated that 70% of agriculture products and 50% of manufacturing materials are distributed in the free market [see Tsiang (1992) and Jin (1992)].

To facilitate the market mechanism, China has set up several commodity exchanges in recent years [ssee Nusbaum (1993) and Kaye (1992)]. For agriculture products, China established a grain market in Zhengzhou (Hunan Province),[1] on October 12, 1990, and a hog market in Chendu (Sichuan Province) on October 25, 1991. For industrial materials, metal exchanges have been established in Beijing, Shenzhen, and Shanghai since 1991. For crude oil, two petroleum exchanges were established in Nanjing and Shanghai in 1993.

Quite often, the controlled price and market price diverge. In addition, a tight control of import/export activities and foreign exchange also casts doubt on the interaction between commodity prices in China and in world markets. This article tries to examine the price behavior in a Chinese commodity market and its interaction with an international market. Since copper is traded internationally and is the most liquid commodity traded on Chinese commodity exchanges in cash, forward, and futures markets, this article investigates the international price equilibrium and transmission of copper traded on the Shanghai Metal Exchange. While other relevant researches [see Franses and Kofman (1991) and Ma and Soenen (1988)] suggest that metals prices tend to move together, this article investigates the lead–lag relationship between a Chinese metal exchange and the London Metal Exchange. In the second section, three metal exchanges in China are briefly introduced. A theoretical model to explain the mechanism of international price equilibrium in a controlled economy is applied in the third section; Cointegration and Error Correction Models are explained in the fourth section; and data and empirical results are discussed in the fifth and sixth sections. Major findings are outlined in the last section.

METAL EXCHANGES IN CHINA

In 1990, China produces 2.3 million tons of nonferrous metals. Thirty to forty percent of the domestic production was distributed through a

[1]Chang (1991) describes the background and trading activities in Zhengzhou Grain Wholesale Market.

centrally planned system. Sixty to seventy percent of domestic nonferrous metal production was traded in a free market [see Quan (1991)]. Since 1991, three metal exchanges have been established in China: The Jin Peng Copper Exchange in Beijing;[2] the Shanghai Metal Exchange in Shanghai; and the Shenzhen Metal Exchange in Shenzhen. Both the Jin Peng Copper Exchange and the Shenzhen Metal Exchange are organized by the China National Nonferrous Metals Import and Export Corp. (CNNC), which is the biggest importer of nonferrous metals in China and used to be the exclusive agent.[3] The Shanghai Metal Exchange is organized by the Goods and Materials Ministry and the Shanghai Municipal Government. In terms of trading volume, the Shanghai Metal Exchange is the most active metal exchange in China.[4] Table I summarizes the current status of these three metal exchanges in China.

(1) Jin Peng Copper Exchange: On May 15, 1991, with the approval of the State Planning Commission, the Jin Peng Copper Exchange was the first copper exchange established in China. The business of the Jin Peng Copper Exchange was to facilitate transactions of copper cathode and copper products outside of the State planning mechanism and to organize the trading of forward contacts. Copper was the only metal traded on the Jin Peng Exchange. The trading mechanism was by open outcry among brokers on behalf of members and nonmembers on Friday morning, the only official trading day. The exchange did not take responsibility when the buyer or the seller failed to deliver. In addition, the initial margin was the highest among the three exchanges. Since the trading volume was far behind Shanghai and Shenzhen, the Jin Peng Copper Exchange was closed in 1993.

(2) Shenzhen Metal Exchange: The Shenzhen Metal Exchange was established on June 10, 1991 [see MBM LME Supplement (1991)]. The Exchange was organized by CNNC and approved by the Shenzhen Municipal Government. The metals traded in the exchange are copper, aluminum, lead, zinc, tin, nickel, magnesium, and antimony. The trading hours are from 9:00 am to 11:00 am Monday through Friday. All physical and forward transactions are allowed to trade on the Exchange as are

[2]The Jin Peng Copper Exchange was closed in 1993.

[3]It is interesting to note that CNNC established two exchanges as it lost its exclusive nonferrous metal importer status. Through the exchange function, CNNC keeps its strong influence in Chinese metal markets.

[4]Up to October, the total contract values traded at the Shanghai Metal Exchange, Shanghai Grain and Oil Exchange, and Shanghai Energy Exchange in 1993 was 3300 billion Reminbi, 18 billion Reminbi, and 15 billion Reminbi, respectively. Copper contracts accounted for over 90% of the total volume at the Shanghai Metal Exchange [see Zhen (1993)].

TABLE I
Comparison among Jin Peng Copper Exchange, Shanghai Metla Exchange, and Shenzhen Metal Exchange.

	Jin Peng	*Shanghai*	*Shenzhen*
Commodities	copper only	copper, aluminum, lead, zinc, tin, nickel.	copper, aluminum, lead, zinc tin, nickel, magnesium, antimony.
Trading hours	Friday only	Monday through Friday	Monday through Friday
Organization	memebership	membership	membership
Organizers	CNNC	Goods and Materials Ministry & Shanghai Municipal Government	CNNC
Initial margin	5%	Futures: 5% for hedger; 10% for speculator. Forwards: 0–5m 5% 5m–10m 3% over 10m 1%	3%
Default risk	client	Exchange is responsible for futures contract, cleints are responsible for cash and forwards.	exchange

futures which started in 1993. Compared with other metal exchanges, the margin requirement is the lowest. The exchange takes the default risk of either side of a transaction. Generally speaking, the Shenzhen Metal Exchange, like the Shenzhen Stock Exchange, is greatly influenced by practices followed at the Hong Kong exchanges.[5]

(3) Shanghai Metal Exchange: Founded on May 28, 1992, the Shanghai Metal Exchange is the latecomer among the three exchanges.

[5]Generally speaking, aluminum trading is more active at the Shenzhen Metal Exchange and copper trading is more active at the Shanghai Metal Exchange.

However, it is the most liquid metal exchange in China due to the industrial base and the human capital of the financial industry in Shanghai.[6] The Shanghai Metal Exchange is organized by the Goods and Materials Ministry and the Shanghai Municipal Government. Copper, aluminum, zinc, lead, tin, and nickel are traded on the Shanghai Metal Exchange Monday through Friday. The terms and specifications of standard contracts are stipulated by the Exchange in spot market trading. Nonstandard forward contracts can be offset and transferred on the Exchange as well. The general membership of the Exchange has the right to accept customers' orders, and to buy and sell or to transfer contracts for the customers. As for the transactions which result in physical delivery, the Exchange is responsible for organizing the delivery. The Shanghai Metal Exchange launched the standardized copper contract in May, 1993.

METAL PRICE EQUILIBRIUM IN CHINA

Nonferrous metals are internationally traded industrial materials. Investors can easily buy or sell metal in other international exchanges, e.g., the London Metal Exchange and the Commodity Exchange in New York. If the domestic metal price in China is too high, an investor can sell metal in Shanghai and buy metal in London. Therefore, the upper boundary for domestic metal price can be found without invoking arbitrage activities. If China charges $x\%$ tax on imported metal,[7] the domestic price, P_d, should not be higher than $(1 + x\%)\, P_f$, where P_f is foreign price for metal. One obtains:

$$P_d < (1 + x\%)P_f \tag{1}$$

as the higher boundary for the domestic price. In other words, if the domestic price is higher than $1 + x\%$ of the foreign price, Chinese institutions can import metal from foreign countries and arbitrage the difference. On the other hand, China prohibits metal exporting to other countries without specific government authorization. In theory, this restriction can keep the local metal price substantially lower than the international price because no one is allowed to sell (export) the cheaper domestic metal to the foreign market to arbitrage the difference.

[6]Shanghai used to be the most important financial center in the Far East before 1949. The Shanghai Stock Exchange was established in late 1990. In addition, the Shanghai Foreign Exchange Transaction Center is one of the most liquid foreign exchange transaction centers in China.

[7]Including all relevant tariff and value added tax, $x\%$ was 23.26% in 1992.

Therefore, the lower boundary for domestic metal price can be as low as zero in the short run.

In addition, within the short-term arbitrage boundary, there is a long-term price equilibrium process in a controlled economy. As shown in Figure 1, there are three parts in a conventional supply–demand chart. OQ_d is the total domestic production (capacity) of metal production in China. OQ_c is the quota set by the central planning agency with a control price at P_c. Beyond OQ_c is the quantity of metal imported from the international market. As discussed in the previous section, the cost for imported metal is $(1 + x\%)\, P_f$. As a result, there are three segments in the supply curve:

1. Control segment (from O to Q_c): This segment is controlled by the central planning agency. Since the control price and production quota are set at P_c and Q_c, the supply curve is perfectly elastic up to Q_c. In other words, the supplier produces Q_c under the control price, P_c, to satisfy the planning agency. It is also important to note that if demand is less than the production quota, the government picks up the residuals. It is in this segment that the central planning agency can exercise its authority to change the final equilibrium.

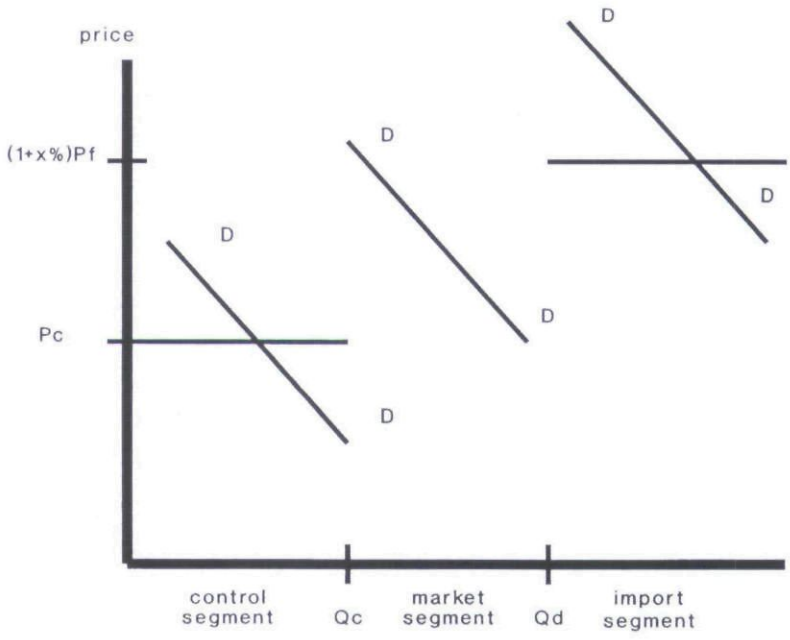

FIGURE 1
Demand and supply in a controlled economy.

2. Market Segment (between Q_c and Q_d): If the demand curve is located in the market segment, Q_cQ_d, the equilibrium depends on the domestic production function and supply curve. The price can be anywhere in the arbitrage channel discussed in the previous section. In the market segment, the government can still affect the equilibrium through its subsidy policy to change either the supply or the demand function. However, the production quota and price control have no impact on the market equilibrium in this segment.
3. Import Segment (Q_d and beyond): As the demand curve shifts further to the import segment of the supply curve, the equilibrium is determined by the international market, $(1 + x\%)\ P_f$. In the import segment, the marginal cost (revenue) for the buyer (seller) is fixed at $(1 + x\%)\ P_f$. On the other hand, Chinese demand might affect the international price. The price movement becomes an interactive process between the China and international market. The causality between these two markets is difficult to determine.[8]

China imports a large percentage of its metal consumption. As long as the demand curve is located in the import segment, the supply curve is horizontal, and the price is determined by the foreign market plus tariff.[9] However, the huge shift in Chinese domestic demand could also affect the level of the supply curve in a reverse causal process. Copper price equilibrium and the transmission process between the London Metal Exchange (LME) and the Shanghai Metal Exchange (SHME) are tested by a cointegration and Granger causality model.

COINTEGRATION AND CAUSALITY

As explained in the previous section, Chinese copper prices are expected to keep pace with the world price adjusted by tariff and transportation costs. A simple cointegration hypothesis is tested to examine if there are any obstacles preventing the market mechanism from reaching the equilibrium. As proposed by Engle and Granger (1987), the following cointegration and causality models are employed.

If Y_t and X_t are cointegrated, then there exists a constant A, such that $\epsilon_t = Y_t - AX_t$ is stationary. As a result, it is estimated that

$$Y_t = a + bX_t + \epsilon_t \tag{2}$$

[8]See Epstein (1993) for an interesting report on how CNNC slammed the international copper prices in January 1993.

[9]Based on a more complicated model, Kalt (1981) draws similar conclusions on U.S. oil price regulation in the post-embargo era.

where Y_t is the price series in the LME and X_t is the price series in the SHME. The augmented Dickey–Fuller (ADF) test is used to test the significance of β in the following regression:

$$\Delta\varepsilon_t = \alpha + \beta\varepsilon_{t-1} + \sum_{i=1}^{n} \phi_i \Delta\varepsilon_{t-i} + v_t \tag{3}$$

where ε_t is the error-term from the cointegration equation and v_t is a stationary random error term.

After a cointegration test, the price transmission causality between the Chinese copper market and the international copper market is investigated. A time series $\{X_t\}$ is said to Granger cause another time series $\{Y_t\}$ if present Y can be predicted better by using past values of X than by not doing so. Other relevant information, including the past values of Y, are used in either case. However, if these two series are cointegrated, an error correction term needs to be added to the causality tests [see Engle and Granger (1987)]. The following error correction model is estimated.

$$\Delta Y_t = \alpha + \sum_{i=1}^{n} \beta_{yi} \Delta Y_{t-i} + \sum_{i=1}^{n} \beta_{xi} \Delta X_{t-i} + \gamma\varepsilon_{t-1} + v_t \tag{4}$$

F-value is used to test the Null Hypothesis: Coefficients for $X_{t-1}, X_{t-2}, \ldots\ldots, X_{t-n}$ are zero.

DATA

Three sets of data are used:

(1) Chinese metal prices: Copper spot and three-month forward prices at the Shanghai Metal Exchange are collected from June 1, 1992, through October 14, 1993.[10] The spot price is the daily weighted average price reported by the Exchange.[11] The three-month forward and futures price are the closing price.[12] All prices quoted in the SHME are in Reminbi. Since copper futures did not start trading until May, 1993, the empirical tests do not include copper futures.

(2) LME metal prices: spot prices and three-month forward metal prices are collected from June 1, 1992, through October 14, 1993.

[10]The authors thank Change Qing for providing the valuable data set collected by Shanghai Oriental Brokers Company.

[11]The Shanghai Metal Exchange was open only on Monday, Wednesday, and Friday before October, 1993. As a result, three daily prices are collected in one week.

[12]In 1992, the Shanghai Metal Exchange reported only high/low for three-month forward transaction. Therefore, the average of daily high and daily low are used in this study. The SHME reported weighted average spot prices in 1992.

Both prices are the daily LME second ring closing prices reported by Reuters. The LME copper prices were quoted in British pounds before May, 1993. British pounds/U.S. dollar rates are from the MSCI data base to convert all prices before May to U.S. dollars. Since there is no Reminbi/British pound swap rate available and LME reported all copper quotes in U.S. dollars after May, 1993, it seems that the U.S. dollar is a suitable currency to use to standardize the quotes between LME and SHME. (For the period after May, 1993, the pound is not used at all as the transformation currency unit). It is important to note that the LME trading hours are behind the SHME trading hours due to time zone differences.

(3) Reminbi prices: Daily swap Reminbi/U.S. dollar closing prices reported by the Shanghai Foreign Exchange Transaction Center are collected for the sample period. Swap prices are the market rates determined by supply and demand of companies authorized to trade the Reminbi. Those companies that are short of foreign currencies can swap Reminbi with other firms that are short of Reminbi at market price. However, the authorities sometimes restrict the trading activity when the market is volatile. In the sample period, People's Bank, the Chinese central bank, restricted the market activity, resulting in swap rates that were not determined by market forces in April, May, and June, 1993.

EMPIRICAL RESULTS

Figure 2 shows the foreign exchange/tariff adjusted copper spot price in the London Metal Exchange and the Shanghai Metal Exchange during the sample period.[13] For most of the time, the SHME prices are lower than LME prices. This result conforms to previous nonarbitrage conditions. However, the SHME prices are consistently higher than the LME during April and May 1993 due to the foreign exchange trading restriction by People's Bank during the period. In addition, the price discrepancy between the LME and the SHME jumps in June and July mostly because of a volatile foreign exchange market. The same patterns are formed in the three-month forward copper prices at the LME and the SHME.

Before testing two time series for integration, it is important to ensure that they each demonstrate the same order of nonstationarity.

[13]LME spot price is adjusted in Reminbi using swap rate, and 23.26% is used as the tariff rate.

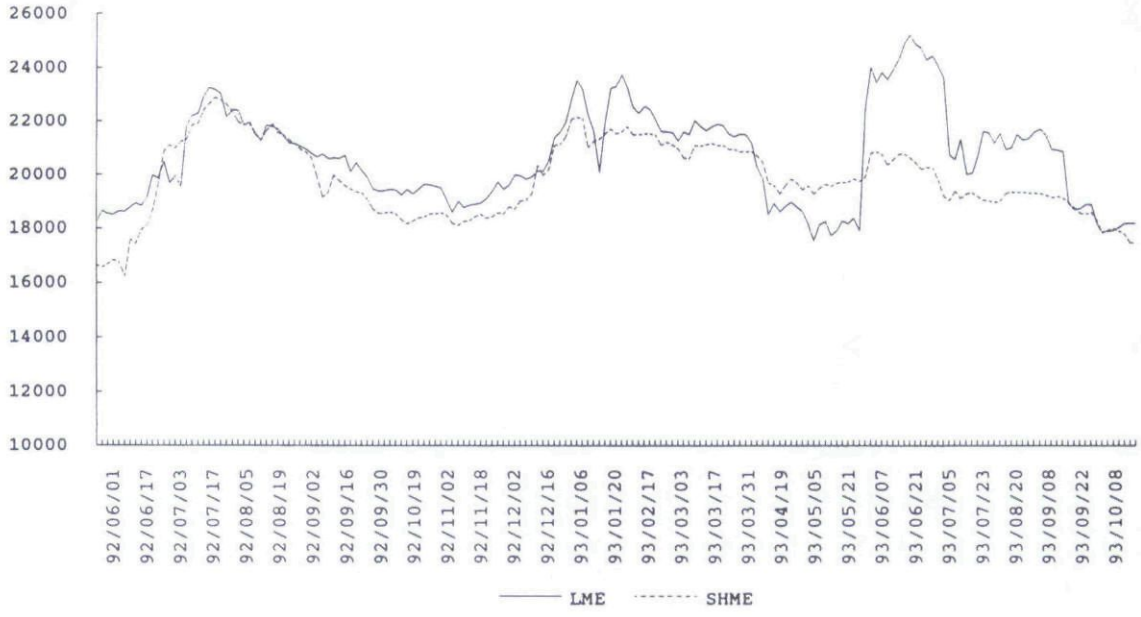

FIGURE 2
Copper spot prices in LME and SHME (June 1992–October 1993).

The ADF test is employed to test the non-stationary hypothesis for both the spot and the three-month forward price series in the LME and the SHME.[14] Table II shows that all four series cannot reject the non-stationary hypothesis at the 0.01 level.[15] However, by taking the difference of the price level, all four series reject the non-stationary hypothesis at the 0.01 level.[16] Therefore, it is determined that the price difference series are stationary, not the price level. After the stationary test, the cointegration relationship is tested between the copper price at the LME and at the SHME. The estimation of the OLS cointegration regression yields the following results:

(1) Spot market:

$$\begin{aligned} \mathrm{LME}_t &= 1.3385 + 0.8476\ \mathrm{SHME}_t + e_t \\ &\quad (2.19) \qquad (13.73) \\ R^2 &= 0.5048 \end{aligned} \tag{5}$$

[14]All ADF tests and Causality tests use one period lag to investigate the impact of the latest price movement.

[15]All price series are measured in natural logarithms.

[16]See Table 8.5.2 in Fuller (1976).

TABLE II

A. Results of ADF Tests on Copper Spot Price in LME and SHME

	Level: $\Delta Yt = \alpha + \beta_1 Y_{t-1} + \beta_2 \Delta Y_{t-1} + \beta_3 T + e_t$				
Y	α	β_1	β_2	β_3	R^2
LME	0.6685	−0.0684	0.1149	−0.00003	0.0308
	(2.59)	(−2.57)	(1.54)	(−0.75)	
SHME	0.4211	−0.0420	0.1393	−0.00005	0.0665
	(2.58)	(−2.55)	(1.91)	(−2.41)	

	First Difference: $\Delta^2 Y_t = \alpha + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta^2 Y_{t-1} + \beta_3 T + e_t$				
Y	α	β_1	β_2	β_3	R^2
LME	0.0037	−0.9471	0.0308	−0.00004	0.4508
	(0.79)	(−9.32)	(0.41)	(−0.92)	
SHME	0.0044	−0.8238	−0.0541	−0.00004	0.4275
	(1.79)	(−8.33)	(−0.72)	(−1.95)	

B. Results of ADF Stationary Tests on Copper 3-Month Forward Price in LME and SHME

	Level: $\Delta Yt = \alpha + \beta_1 Y_{t-1} + \beta_2 \Delta Y_{t-1} + \beta_3 T + e_t$				
Y	α	β_1	β_2	β_3	R^2
LME	0.7543	−0.0770	0.1586	−0.00004	0.0460
	(2.87)	(−2.86)	(2.15)	(−1.18)	
SHME	0.3694	−0.368	0.2451	−0.00004	0.0796
	(2.20)	(−2.18)	(3.40)	(−2.09)	

	First Difference: $\Delta^2 Y_t = \alpha + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta^2 Y_{t-1} + \beta_3 T + e_t$				
Y	α	β_1	β_2	β_3	R^2
LME	0.0028	−0.9306	0.0566	−0.00003	0.4328
	(0.63)	(−9.39)	(0.75)	(−0.80)	
SHME	0.0026	−0.7789	−0.0114	−0.00003	0.3750
	(1.13)	(−8.38)	(−0.15)	(−1.43)	

(2) Forward market:

$$\mathrm{LME}_t = 1.2279 + 0.859\ \mathrm{SHME}_t + e_t$$
$$(2.11) \qquad (14.66)$$
$$R^2 = 0.5363 \qquad (6)$$

LME_t is the daily copper price at the LME and SHME_t is the daily copper price at the SHME. Residuals from eq. (5) and (6) above are put

into eq. (3). The ADF test on β coefficients in eq. (3) for both spot and forward markets are -3.39 (spot market) and -3.55 (forward market). Since the statistics exceed the critical value of 5% level, the results of the ADF test confirm the presence of cointegration between the LME and the SHME.[17] These findings support the previous argument that Chinese copper prices should coincide with international prices regardless of its controlled nature. Since a cointegration relationship exists between the LME and the SHME, an error correction model is required to test the causality relationship. Table III shows the testing results of the error correction model. In the copper spot market, it is found that the LME Granger causes the SHME at the 0.05 level. On the other hand, there is no significant evidence that the SHME Granger causes the LME. In the three-month forward market, at the 10% significance level, unidirectional causality leading from the LME to the SHME is found.

CONCLUSIONS AND COMMENTS

While there are still many obstacles, e.g., foreign exchange and import/export controls, for a completely free market mechanism to operate, the findings of this study suggest that the short-term non-arbitrage conditions and long-term international price equilibrium prevail in the Shanghai Metal Exchange. In addition, the Granger causality test shows that there exists unidirectional causality leading from the international spot market to the domestic spot market. However, the causality relationship between the LME and the SHME in the forward market is less significant than in the spot market. Since the Chinese metal market is relatively young and the sample period of this study is short, the empirical results probably raise more questions than answers. Further research is needed in the suggested as following areas:

1 As more data on copper futures become available, an investigation on the price relationship between Chinese futures prices and world futures prices will be more feasible. After all, futures contracts without delivery are more suitable for arbitrage and inter-market spread speculation.

2 Since China abandoned its dual currency system on January 1, 1994, Reminbi is now subjected to more market forces. It will be interesting

[17] A dummy variable is used also to adjust the abnormal period during April, May, and June, 1993. The results are similar and t-values for β improve slightly.

to see whether the reform on the foreign exchange market will increase the efficiency in the metal market.

3 Because of the difficulty of data collection, study of the price pattern traded at the Shenzhen Metal Exchange was not undertaken. However, it will be interesting for future research to investigate the lead–lag relationship within China between Shenzhen and Shanghai.

4 As discussed in Brenner and Kroner (1992), if two series are cointegrated, usually the driving fundamental force is assumed not to have a stochastic trend. This study's testing was done after correcting for tariffs. When transportation data are available, it would be interesting to test whether transportation cost contains a stochastic trend.

TABLE III

A. OLS Regressions for Granger Causality Tests on Copper Spot Price

SHME GC LME			*LME GC SHME*		
β_y	0.1147	(1.48)	β_y	0.1051	(1.38)
β_x	0.1341	(0.93)	β_x	0.1057	(2.62)[c]
γ	−0.1263	(3.39)[c]	γ	−0.0323	(−1.38)

B. OLS Regressions for Granger Causality Tests on Copper 3-Month Forward Price

SHME GC LME			*LME GC SHME*		
β_y	0.1453	(1.85)[a]	β_y	0.1947	(2.49)[b]
β_x	0.1575	(1.08)	β_x	0.0793	(1.93)[a]
γ	−0.1394	(3.60)[c]	γ	−0.0174	(−0.72)

Parameter estimates for a lagged independent variable (ΔX), a lagged dependent variable (ΔY), and an error term (RES).

$$\Delta Y_t = \alpha + \beta_y \Delta Y_{t-1} + \beta_x \Delta X_{t-1} + \gamma \mathrm{RES}_{t-1}$$

T-statistics are in parentheses. *t*-value for ΔX is used to test Null Hypothesis: Coefficients for ΔX_{t-1} are zero.
[a]Significant at the 0.10 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.01 level.

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