≫ 論 説 ≪

The Price Linkage of Commodity Futures in Japan - Analysis of Tokyo Commodity Exchange and Tokyo Grain Exchange☆

Takayasu Ito*

Summary

The purpose of this paper is to investigate the price linkage of commodity futures contracts on TCE (gold, silver, platinum and rubber) and on TGE (corn, soybean, raw sugar, and red bean) by using non-stationary time series models. As for TCE, I found no cointegration relationship among four contracts. I also found no cointegration relationship for each pair of four contracts. I can conclude that no price linkage among the futures contracts on TCE. I found Granger causality from gold to silver and platinum on TCE. Thus I can assume that gold gave some influences on the prices of silver and platinum, but silver and platinum gave no influences on the price of gold. The metal futures such as gold, silver and platinum gave no impact on rubber and rubber gave no influence on metal futures. As for TGE, I also found no cointegration relationship among four contracts. On the other hand, I found cointegration relationship between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. I can conclude that no price linkage exists among four contracts on TGE, but price linkage exists between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. I found no Granger causality among the contracts on TGE.

Keyword : Price Linkage of Commodity Futures, Cointegration, Granger Causality

JEL Classification : C32, G13

☆ This research was supported by a grant-in- aide from Japan Commodity Futures Industry Association

* Professor of Monetary and Financial Economics, Faculty of Economics, Niigata University 8050, Ikarashi 2-no-cho, Niigata City 950-2181 Japan
Phone / Fax 025-262-6502 e-mail tito@econ.niigata-u.ac.jp

1. Introdcution

The Japanese Commodity Exchange Law was revised in 2004 to improve the credibility of futures market by strengthening the protection of investors. There are six exchanges listing commodity futures in Japan as of November 30,2006. Tokyo Commodity Exchange (TCE) and Tokyo Grain Exchange (TGE) are major exchanges. As for the price movement of commodity futures, some research mention that they are moving independently and others point out that they are moving to together.

Pindyck and Rotemberg (1990) analyzed seven commodities: wheat, cotton, copper, gold, crude oil, lumber and cocoa in US. They concluded that there exists an excess co-movement among seven commodities and this excess co-movement is partially the result of the presence of herding. The approach of this paper is different from Pindyck and Rotemberg (1990). The purpose of this paper is to investigate the price linkage of commodity futures from long run listed on TCE and TGE respectively.

As for the previous studies analyzing the price linkage of commodity futures from long run, Booth and Ciner (2001), Dawson and White (2002), Karbuz and Jumah (1995), Malliaris and Urrutia (1996), Yang (2004) can be cited. Booth and Ciner (2001) concluded that the prices of four commodity futures on the TGE showed no price linkage. They also added that corn and soybean prices are cointegrated. Dawson and White (2002) analyzed the interdependencies between the agricultural futures contracts of barley, cocoa, coffee, sugar, and wheat on the LIFFE. They concluded that there are no interdependencies between any two prices.

Karbuz and Jumah (1995) examined the relationships between futures of cocoa and coffee on the New York CSCE and London Fox. They concluded that in general, the prices tend to move together in the long run. Malliaris and Urrutia (1996) found significant linkages between six agricultural commodities - corn, wheat, oat, soybean, soybean meal and soybean oil- listed on Chicago Board of Trade. Yang (2004) concluded that no cointegration relationship was found among grain futures markets (corn, soybean, wheat and oat) on Chicago Board of Trade.

In view of previous studies, the results of price linkages are different depending on the exchanges, commodities and periods. Booth and Ciner (2001) is considered to be the only work analyzing the Japanese market (TGE). No other works focused on TCE. As for the TGE ,the sample period in this paper is 5 years longer than Booth and Ciner (2001).

2. Data

I use gold, silver, platinum and rubber on TCE and corn, soybean, raw sugar, and red bean on TGE respectively. I choose these eight contracts since they are traded stably for more than a decade. These daily data cover the period from January 4, 1993 through December 26, 2003. As for the contract month, I use the longest ones which are usually most actively traded in Japan. Figure Ⅰ shows the data of TCE. Figure Ⅱ indicates the data of TGE.

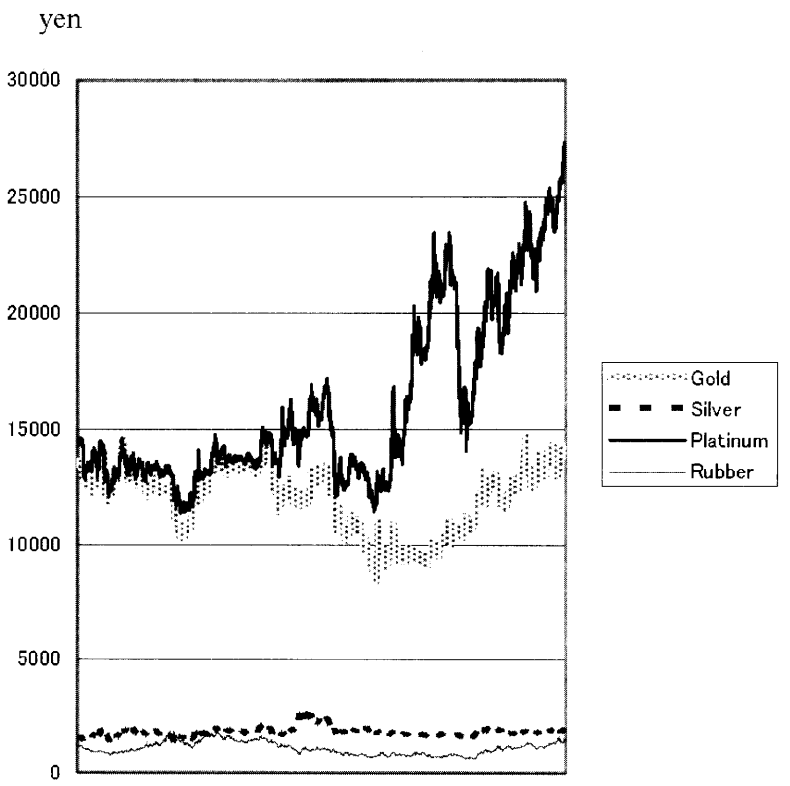

Figure Ⅰ Data for TCE

Sample period is from January 4, 1993 through Decenber 26, 2003.

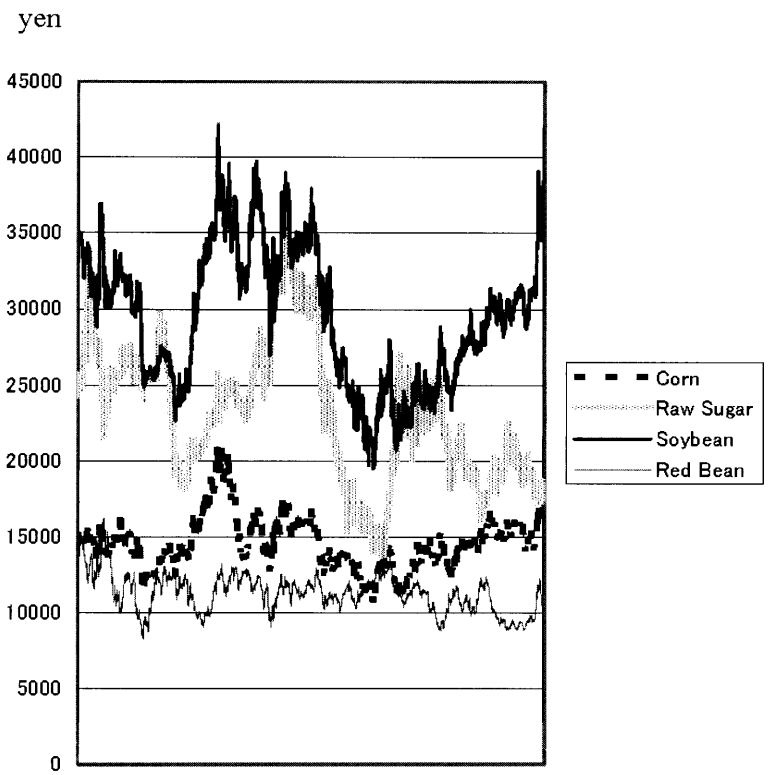

Figure II Data for TGE

Sample period is from January 4, 1993 through Decenber 26, 2003.

3. Framework of Analysis

3.1 Unit Root Test

Nelson and Plosser (1982) got a conclusion that there is no denying the existence of unit root in the macro economic variables of US. Since the empirical analysis from mid-1980 through mid-1990's show that such data as interest rates, foreign exchange and stocks are non-stationary, it's necessary to check if the data used in this chapter contain unit roots. The KPSS (Kwiatowski/Phillips/Schmidt/ Shin) test is used. KPSS test defines null hypothesis as 'unit roots don't exist' and alternative hypothesis as 'unit roots exist'. The KPSS test is considered to have more statistical power than other unit root tests such as ADF (Augmented Dickey and Fuller) test[1].

[1] For unit root tests, see Dickey and Fuller (1979), Dickey and Fuller (1981) and Kwiatowski, *et al.* (1992).

3.2 Coitegration Test

Generally OLS method is used to analyze the relationships among the variables. However when the non-stationary variables are included, ordinary hypothesis test tends to draw a mistaken results since the coefficient of determination and t-statistics do not follow a simple distribution.

Granger and Newbold (1974) called this problem 'Spurious Regression'. Phillips (1986) pointed out two things as to the analysis of non-stationary data—(1) the coefficient of determination tend not to measure the relationship among variables, (2) the estimated equation with low Durbin-Watson ratio can possibly have a problem of spurious regression.

Non-stationary time series model is necessary to cope with the problems mentioned above. There are mainly two types of cointegration test- (1) Engle and Granger (1987), (2) Johansen (1988). The most difficult part of cointegration analysis starting from VAR model is how to decide the number of cointegration relationship. When 3 variables are analyzed, the number of cointegration relationship may be 1 or 2. Engle and Granger can't cope with this problem, but Johansen is able to decide the number of cointegration relationship and to get a MLE of unknown parameters.

Johansen suggested the analysis with the k order VAR mode. Here VAR model is presented with k order against vector X_t with p variables.

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + \lambda + u_t \tag{1}$$

All the p elements of X_t is considered to be $I(1)$ variables. u_t is an error term with zero mean. λ is a constant term. The equation (1) is expressed by using a first difference.

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi \Delta X_{t-k} + \lambda + u_t \tag{2}$$

Here

$$\Gamma_I = -I + \Pi_1 + \ldots + \Pi_i, \quad (i = 1, \ldots, k-1)$$
$$\Pi = -I + \Pi_1 + \ldots + \Pi_k$$

Under the assumption that all the elements of X_t are $I(1)$, ΠX_{t-1} needs to be $I(0)$. This means the rank of matrix Π satisfies $0 \leq rank(\Pi) < p$. When the elements of X_t are in the relationship of cointegration, $0 < rank(\Pi) < p$ is established. Thus matrix Π can be expressed as $\Pi = \alpha\beta'$ by using the α and β of p x r matrix Π. Finally equation (2) can be expressed as follows.

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} \ldots + \Gamma_{t-k} \Delta X_{t-k+1} + \alpha \beta' \Delta X_{t-k} + \lambda + u_t \quad (3)$$

β' is a cointegration vector and $\beta' X_{t-k}$ is an error correction term. After I confirm the non-stationarity of data, I apply Johansen cointegration test to four contracts gold, silver, platinum, rubber) at TCE and four contracts (corn, soybean, raw sugar, and red bean) at TGE respectively. I also test the data in a pair in each Exchange. I use maximal eigen value test and trace test for the investigation of cointegration tests.

3.3 Granger Causality Test

I apply Granger Causality to test causalities among future contracts on each Exchange. The original data are usually transformed into the change ratio to avoid a problem of spurious regression. But using these data is considered to cause an error. Toda and Yamamoto (1995) developed the Granger causality test in which non-stationary data are directly used. According to their method, the null hypothesis is tested by adding trend term t and p + 1 (original lag plus one) are added for the estimation of four equations mentioned below. Four equations are used for the test of four contracts on TCE. Similar equations are used for the test of contracts on TGE. For example, equation (4) checks if silver, platinum, rubber and gold Granger-cause gold.

$$GO_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i SI_{t-i} + \sum_{i=1}^{p+1} \beta_i PL_{t-i} + \sum_{i=1}^{p+1} \chi_i RU_{t-1} + \sum_{i=1}^{p+1} \delta_i GO_{t-1} + u_t \quad (4)$$

$$SI_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i SI_{t-i} + \sum_{i=1}^{p+1} \beta_i PL_{t-i} + \sum_{i=1}^{p+1} \chi_i RU_{t-1} + \sum_{i=1}^{p+1} \delta_i GO_{t-1} + u_t \quad (5)$$

$$CO_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i SI_{t-i} + \sum_{i=1}^{p+1} \beta_i PL_{t-i} + \sum_{i=1}^{p+1} \chi_i RU_{t-1} + \sum_{i=1}^{p+1} \delta_i GO_{t-1} + u_t \quad (6)$$

$$RU_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i SI_{t-i} + \sum_{i=1}^{p+1} \beta_i PL_{t-i} + \sum_{i=1}^{p+1} \chi_i RU_{t-1} + \sum_{i=1}^{p+1} \delta_i GO_{t-1} + u_t \quad (7)$$

4. Result of Analysis

4.1 Unit Root Test

I checked non-stationarity of original data by KPSS test. The null hypothesis 'unit roots don't exist' can be rejected in all the tests of level stationarity and trend stationarity. All the original data are considered to be unit root process. Table I shows the result.

Table I KPSS Test for Original Series

	Lag=4		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
TCE				
Gold	11.02*	5.70*	4.59*	2.22*
Silver	5.51*	4.48*	2.17*	1.76*
Platinum	35.81*	6.65*	13.90*	2.60*
Rubber	11.97*	5.39*	4.64*	2.09*
TGE				
Corn	4.22*	3.18*	1.65*	1.25*
Raw Sugar	15.94*	2.05*	6.19*	0.80*
Soybean	9.17*	3.62*	3.57*	1.41*
Red Bean	11.50*	1.24*	4.56*	0.50*

* indicates significant at 5 % level.
5% critical values are 0.463 (level stationarity) and 0.146(trend stationarity) .
η_μ is level staionarity η_τ is trend stationarity.
TCE is Tokyo Commodity Exchange. TGE is Tokyo Grain Exchange.

I also checked the non-stationarity of data with first difference from original data. The null hypothesis 'unit roots don't exist' can't be rejected in all the tests of level stationarity and trend stationarity. Thus I can judge that all the data are non-stationary $I(1)$. Table II provides the result.

Table II KPSS Test for First Difference

	Lag=4		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
TCE				
Gold	0.15	0.05	0.15	0.05
Silver	0.05	0.03	0.05	0.03
Platinum	0.20	0.03	0.20	0.02
Rubber	0.13	0.09	0.14	0.10
TGE				
Corn	0.05	0.04	0.05	0.04
Raw Sugar	0.06	0.04	0.06	0.04
Soybean	0.10	0.05	0.10	0.05
Red Bean	0.02	0.02	0.02	0.02

* indicates significant at 5 % level.
5% critical values are 0.463 (level stationarity) and 0.146(trend stationarity).
$\eta\mu$ is level staionarity.
TCE is Tokyo Commodity Exchange. TGE is Tokyo Grain Exchange.

4.2 Cointegration Test

After I confirmed that all the data are non-stationary $I(1)$, I conducted cointegration test by Johansen for each Exchange. As for TCE, I found no cointegration relationship among four contracts. I also found no cointegration relationship for each pair of four contracts. I can conclude that no price linkage among the futures contracts on TCE. Table Ⅲ shows the results.

As for TGE, I also found no cointegration relationship among four contracts. On the other hand, I found cointegration relationship between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. I can conclude that no price linkage among four contracts on TGE, but price linkage exists between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. Table Ⅳ shows the results.

Table III Cointegration Test for TCE

	Maximal Eigen Value Test		Trace Test	
Null Hypothesis	Test Statistics λ max	5% Crical Value	Test Statistics λ trace	5% Crical Value
Gold, Silver, Platinum, Rubber				
r = 0	13.19	28.14	28.3	53.12
r≦1	8.94	22.00	15.11	34.91
r≦2	4.3	15.67	6.18	19.96
r≦3	1.88	9.24	1.88	9.24
Gold, Silver				
r = 0	11.7	15.67	15.24	19.96
r≦1	3.54	9.24	3.54	9.24
Gold, Platinum				
r = 0	5.39	15.67	7.14	19.96
r≦1	1.75	9.24	1.75	9.24
Gold, Rubber				
r = 0	10.65	15.67	13.25	19.96
r≦1	2.59	9.24	2.59	9.24
Silver, Platinum				
r = 0	11.62	15.67	12.67	19.96
r≦1	1.04	9.24	1.04	9.24
Silver, Rubber				
r = 0	12.17	15.67	15.09	19.96
r≦1	2.92	9.24	2.92	9.24
Platinum, Rubber				
r = 0	3.99	15.67	5.36	19.96
r≦1	1.37	9.24	1.37	9.24

* indicates significant at 5 % level.
Critical Values are from Osterwald-Lenum(1992).
TCE is Tokyo Commodity Exchange.

Table Ⅳ Cointegration Test for TGE

	Maximal Eigen Value Test		Trace Test	
Null Hypothesis	Test Statistics λ max	5% Crical Value	Test Statistics λ trace	5% Crical Value
Corn, Raw Sugar, Soyben, Red Bean				
r = 0	20.74	28.14	50.18	53.12
r≦1	18.61	22.00	29.44	34.91
r≦2	7.14	15.67	10.83	19.96
r≦3	3.68	9.24	3.68	9.24
Corn, Raw Sugar				
r = 0	9.19	15.67	12.54	19.96
r≦1	3.35	9.24	3.35	9.24
Corn, Soybean				
r = 0	16.84*	15.67	23.61*	19.96
r≦1	6.76	9.24	6.76	9.24
Corn, Red Bean				
r = 0	17.04*	15.67	24.83*	19.96
r≦1	7.79	9.24	7.79	9.24
Raw Sugar, Soybean				
r = 0	6.29	15.67	10.29	19.96
r≦1	3.76	9.24	7.50	9.24
Raw Sugar, Red Bean				
r = 0	17.71*	15.67	21.20*	19.96
r≦1	3.49	9.24	3.49	9.24
Soybean, Red Bean				
r = 0	17.60*	15.67	24.83*	19.96
r≦1	5.78	9.24	7.50	9.24

* indicates significant at 5 % level.
Critical Values are from Osterwald-Lenum(1992).
TGE is Tokyo Grain Exchange.

4.3 Granger Causality Test

I conducted Granger causality test by using the method by Toda and Yamamoto (1995). I found Granger causality from gold to silver and platinum on TCE. I found no Granger causality among the contracts on TGE. Table Ⅴ shows the results.

Table V Granger Causality Test

Objective Variable	Explanatory Variable			
TCE				
	Gold	Silver	Platinum	Rubber
Gold	-	0.47	1.31	2.04
Silver	11.20*	-	0.96	1.72
Platinum	3.50*	0.96	-	1.08
Rubber	1.92	0.93	0.35	-
TGE				
	Corn	Raw Sugar	Soybean	Red Bean
Corn	-	0.63	1.44	0.43
Raw Sugar	2.04	-	1.49	0.43
Soybean	1.14	1.11	-	0.45
Red Bean	1.77	0.94	1.47	-

* indicates significant at 5 % level. Test Statistics are F values.
Method by Toda and Yamamoto (1995) is used.
TCE is Tokyo Commodity Exchange. TGE is Tokyo Grain Exchange.

5. Conclusion

The purpose of this paper is to investigate the price linkage of commodity future contracts on TCE (gold, silver, platinum and rubber) and on TGE (corn, soybean, raw sugar, and red bean) by using non-stationary time series. As for TCE, I found no cointegration relationship among four contracts. I also found no cointegration relationship for each pair of four contracts. I can conclude that no price linkage among the futures contracts on TCE.

I found Granger causality from gold to silver and platinum on TCE. Thus I can assume that gold gave some influences on the prices of silver and platinum, but silver and platinum gave no influences on the price of gold. The metal futures such as gold, silver and platinum gave no impact on rubber and rubber gave no influence on metal futures.

As for TGE, I also found no cointegration relationship contracts among four contracts. On the other hand, I found cointegration relationship between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. I can conclude that no price linkage among four contracts on TGE, but price linkage exists between corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean. I found no Granger causality among the contracts

on TGE.

The fact that four combinations (corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean) out of six combinations in four contracts on TGE are cointegrated suggests that there is a common trend in each combination. On the other hand, no mutual influence worked in the formulation of futures prices on TGE.

The finding on TGE suggests that cross hedging opportunities become possible between two contracts (corn and soybean, corn and red bean, red bean and raw sugar, red bean and soybean) in the relationship of cointegration.

References

Booth,G.G. and C.Ciner (2001), "Linkages among Agricultural Commodity Futures Prices: Evidence from Tokyo," *Applied Economics Letters*,8,pp.311-313.

Dawson,P.J. and B.White (2002), "Interdependencies between Agricultural Commodity Futures Prices on the LIFFE," *Journal of Futures Markets*,22, pp.269-280.

Dickey,D.A. and W.Fuller (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root,"*Journal of the American Statistical Association*,74, pp.427-431.

Dickey,D.A. and W.Fuller (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with A Unit Root,"*Econometrica*,49,pp.107-1072.

Engle,R.F. and C.W.J.Granger(1987), "Co-Integration and Error Correction: Representation, and Testing, "*Econometrica*,55,pp.251-276.

Granger,C.W.J. and P.Newbold (1974), "Spurious Regressions in Econometrics," Journal of *Econometrics*,2,pp.111-120.

Johansen,S. (1988) "Statistical Analysis of Cointegrated Vectors," *Journal of Economic Dynamics and Control*,12,pp231-254.

Karbuz,S. and A.Jumah (1995), "Cointegration and Commodity Arbitrage," *Agribusiness*,11, pp.235-243.

Kwiatkowski,D., P.C.B.Phillips, P.Schmidt and Y.Shin (1992), "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root," *Journal of Econometrics*,54,pp.159-178.

Malliaris,A.G. and J.L.Urrutia (1996), "Linkages between Agricultural Commodity Futures Contracts," *Journal of Futures Markets*,16,pp.595-609.

Osterwald-Lenum,M. (1992) "Practitioners' Corner A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," *Oxford Bulletin of Economics and Statistics*,54,3,pp169-210.

Phillips,P.C.B. (1986), "Understanding Spurious Regressions in Econometrics," *Journal of Econometrics*, 33,pp.311-340.

Pindyck,R.S. and J.J.Rotemberg (1990), "The Co-movement of Commodity Prices," *Economic Journal*,100,pp.1173-1189.

Toda,H.Y .and T.Yamamoto (1995), "Statistical Inference in Vector Autoregressions with Possibly Integrated Processes," *Journal of Econometrics*,66,pp.225-250.

Yang,J (2004), "Government Policy and Price Comovements in Commodity Futures Markets," *American Business Review*, January,pp.1-10.

Zhang,H. (1993) "Treasury Yield Curves and Cointegration," *Applied Economics*,25, pp361-367.