研究ノート

The Efficiency Test of Gold Future Market in Japan

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ABSTRUCT

This paper examines the market efficiency of gold future market in Japan. According to Fama (1970), there are three forms of market efficiency tests. They are weak form, semi-strong form and strong form. This paper investigates weak form of market efficiency. Cointegration test is conducted to avoid a problem of spurious regression caused by a non-stationarity of future prices and spot prices. Gold future prices and spot prices are in the long run equilibrium, but they are not in a relationship of one to one. From the results of empirical analysis, the conclusion can be made that gold future market is not efficient in Japan.

Keywords : Market Efficiency, Gold Future, Cointegration
JEL Classification : G14, C32

1. INTRODUCTION

This paper examines the market efficiency of gold future market in Japan. A problem in testing market efficiency is that the prices of future and spot are usually non-stationary. 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 mistaken results since the coefficient of determination and *t*-statistics don't follow a simple distribution.

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

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The use of cointegration test gives a solution to a problem mentioned above. The test of market efficiency by cointegration test was initially started by Hakkio and Rush (1989) which examine the foreign exchange market in U.K and Germany. Chowdhury (1991) tests the market efficiency of non-ferrous metal futures on London Metal Exchange(LME).

Aulton et al.(1997), Beck(1994), and Crowder and Hamed(1993) are cited as previous studies analyzing the market efficiency of commodity future market. The results as for market efficiency test are different, depending upon the market and sample period. As for the previous study of gold future in Japan, no other previous works examined the market efficiency of gold future in Japan using daily data as this paper.

2. DATA

As for the spot market, closing prices of gold in Tokyo market are used. As for the futures market, settlement prices of gold listed on Tokyo Commodity Exchange (TCE) are used. These daily data cover the period from January 4, 1993 through August 31, 2006. As for the contract month, I use the longest one which is usually most actively traded in Japan.[1] The movement of gold future is shown in Figure 1.

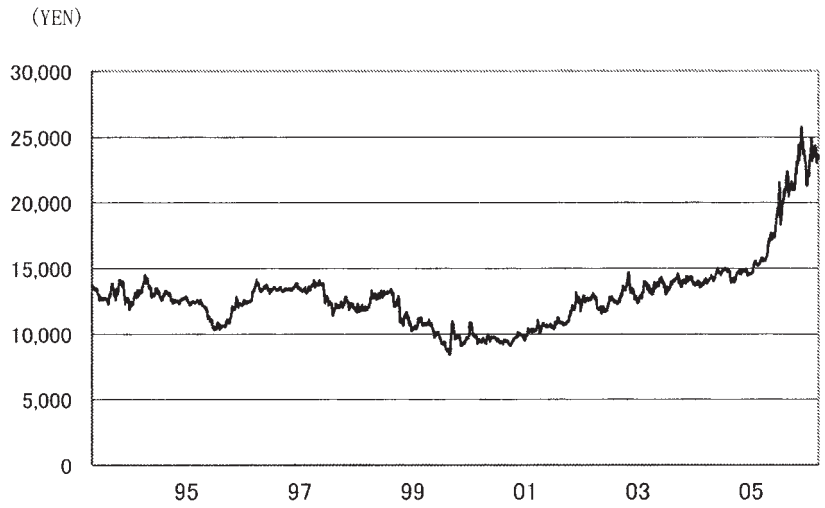

Figure 1 The Settlemet Price of Gold Future
Daily Data from January 4,1993 through August 31,2006 are shown.

[1] The trading volumes of contract month other than longest one are usually small. Thus the longest contract month is suitable for the test of market efficiency.

3. FRAMEWORK OF ANAYSIS AND RESULT

Efficient Market Hypothesis and Cointegration

According to Fama (1970), a market in which prices always fully reflect available information is called efficient. When this definition is applied to commodity future market, equation (1) can be drawn.

$$F_t = E[S_{t+1}|I_t] \qquad (1)$$

Where F_t is the future price at time t, E is the expectations operator, S_{t+1} is spot price at time $t+1$, I is the information at time t. Fama (1970) also points out three forms of market efficiency test. They are weak form, semi-strong form and strong form. This paper investigates weak form of market efficiency in which the information subset is history of past prices.

Here the framework of analysis is presented. First, unit root tests are conducted to confirm that the prices of gold future and spot are non-stationary $I(1)$.[2] The ADF (Augmented Dickey and Fuller) test and the PP (Phillips and Perron) test are used. Next, cointegration test is conducted to analyze the relationship between gold future prices and spot prices. Non-stationary time series wander widely with their own short-run dynamics, but a linear combination of the series can sometimes be stationary so that they show co-movement with long-run dynamics. This is called as cointegration by Engle and Granger (1987). In the test of cointegration, equation (2) is estimated by OLS to find if residual contains unit root.

$$S_{t+1} = \alpha + \beta F_t + \varepsilon_t \qquad (2)$$

When series S_{t+1} and F_t are both non-stationary $I(1)$, they are called to be in a relationship of cointegration if their linear combination is stationary $I(0)$. The cointegration relationship between S_{t+1} and F_t implies that gold future prices and gold spot prices move together in the long run equilibrium. In addition to testing if S_{t+1} and F_t are in a relationship of cointegration, cointegration vector, β in equation (2), must be confirmed to be one to conclude that the future market of gold is efficient. Equation (3) is used to test if $\beta = 1$ can be rejected with the method of dynamic OLS by Stock and Watson (1993). $\Delta F_{(t-j)}$ is lead and lag variables of gold future.[3]

$$S_{t+1} = \alpha + \beta F_t + \sum_{i=-p}^{p} b_i \Delta F_{t-j} + u_t \qquad (3)$$

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[2] See Dickey and Fuller (1979), Dickey and Fuller (1981). See Phillips and Perron (1988).

[3] As for the number of lead and lag terms, 12 is used. In the case of 6 and 9, the results are the same.

Result

The results of ADF and PP tests show that original data are non-stationary and the data with first difference are stationary. Accordingly the future prices and spot prices of gold are confirmed to be $I(1)$. Thus it's proper to use cointegration test which is supposed to use non-stationary $I(1)$ data directly. Table 1 reports the result of unit root tests.

Table 1 Result of Unit Root Test

Variable		Without Trend	With Trend
Original Data			
Gold Future	ADF	0.948	−0.044
	PP	1.070	0.023
Gold Spot	ADF	1.091	0.070
	PP	0.754	−0.238
Data with First Difference			
Gold Future	ADF	−20.744*	−20.882*
	PP	−58.360*	−58.463*
Gold Spot	ADF	−16.842*	−17.028*
	PP	−64.537*	−64.636*

* indicates significance at 5 % level.

5% critical values are -2.86 (Without Trend) and -3.41 (With Trend).

ADF = Augmented Dickey Fuller PP = Phillips Perron.

Gold future prices and gold spot prices are in the relationship of cointegration. Thus these two prices are considered to be moving together in the long run equilibrium. Table 2 reports the result.

Table 2 Result of Cointegration Test

Variable	Test Statistics
Gold Future -Gold Spot	−5.895*

* indicates significance at 1 % level.

1 % critical value is -3.9001 from MacKinnon (1991).

As for the test of cointegration vector, $\beta = 1$ in equation (3) can be rejected. Thus gold future prices and gold spot prices are not in the relationship of one to one. Table 3 reports the result.

Table 3 Result of Test on Cointegration Vector

Variable	β	Modified SE	Modified t Value
Gold Future -Gold Spot	0.970	0.004	7.500

$\beta = 1$ can be rejected since modified t value is larger than critical value (1.96).

4. CONCLUDING REMARKS

The purpose of this paper is to examine the market efficiency of gold future in Japan. According to Fama(1970), there are three forms of market efficiency tests. They are weak form, semi-strong form and strong form. This paper investigates weak form of market efficiency in which the information subset is history of past prices.

Engle and Granger (1987) cointegration test and cointegration vector test are conducted to avoid a problem of spurious regression caused by a non-stationarity of future prices and spot prices. Gold future prices and spot prices are in the long run equilibrium, but they are not in a relationship of one to one. From the results of empirical analysis, the conclusion can be made that the market of gold future is not efficient in Japan.

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