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Association Study of the Fluctuations in Gold Futures and Actuals Markets

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Abstract. Based on daily price data of China's gold futures and actuals from January 4th, 2016 to January 10th, 2018, this study makes an empirical analysis of the relationship between fluctuations of gold futures and actuals after conducting the ADF unit root test, the Johansen co-integration test, the Error Correction Model (ECM) test and the Granger causality test. Research findings show that there exists a long-term equilibrium between gold futures and actuals. Such an equilibrium relationship involves one-way price transmission mechanism, which means that the gold spot price takes a dominant position in affecting and explaining the price of gold futures.

Keywords: Gold Futures, Johansen Co-integration, Granger Causality.

1. Introduction

Gold is a kind of currency with a long history and can be circulated in the market as valuable commodities. Therefore, it plays a significant role in economic development, the status of precious metals, and a nation's monetary policy.

Shanghai Gold Exchange was officially opened for business on October 30th, 2002, signifying that China's gold market had shifted from the stage of the national planned economy to the phase in which gold could circulate as commodities. Later, gold futures were first allowed to be delivered on the Shanghai Futures Exchange on January 9th, 2008, which was a new milestone in China's financial reform. In the following years, thanks to China's enormous economic volume, both China's gold futures and actuals markets entered a period of rapid development, which could be proved by the annual increase in trading volume. What is more noteworthy is that the trading volume of gold futures in Mainland China has ascended to the first place across the world in recent years. Therefore, the study of the relationship between the fluctuations of gold futures and actuals markets is of great significance.

The association study of fluctuations in gold actuals and futures markets is a branch of the research into the correlation between financial spot and forward markets, and many scholars both at home and abroad have participated in this study.

Garbade and Silber (1983) analyzed the relationship between the price fluctuation in the spot market and that in the futures market, while Granger (1987) and Johansen (1988) put forward the main methodology of the co-integration test model. Ghosh (1993) studied the Standard & Poor's 500 (often abbreviated as the S&P 500, or just the S&P) and the relationship between the fluctuation in actuals and futures of the Commodity Research Bureau index (CRB index). He claimed that the spot price of the CRB index had a leading advantage, while the forward price of the Standard & Poor's 500 enjoyed such a leading edge. Gonzala and Granger (1995) put forward the P-T model, with which they could study the contribution of each market to the common factor by calculating and examining the error correction coefficient in the Error Correction Model (ECM). Mattias Nilsson (2008) studied the correlation between price fluctuations in oil futures and actuals traded on the New York Mercantile Exchange from 1986 to 2008. He also proved that the relationship between the prices of oil futures and actuals on the New York Mercantile Exchange didn't conform to the weak-form market efficiency of the efficient-market hypothesis by use of such methodologies as stationary test and co-integration test. Hawati Janor (2013) studied the data of the gold spot and forward markets from 2000 to 2013 from the five countries of the Association of Southeast Asian Nations (including Singapore, Malaysia, Indonesia, Philippines and Thailand), and concluded that Indonesia, Philippines

and Thailand were more suitable to serve as the market for multi-dimensional gold investment strategies which are intended for hedging.

In Chinese mainland, previous research into the relationship between gold futures and actuals is not rare, either. Yu Liang and Zhou Xiaozhou (2008) analyzed the sample data of the gold spot and forward prices in 2008 through positive analysis, including the Granger causality test and the Johansen co-integration test. And they claimed that the price discovery function of gold futures market in mainland China had not been effectively realized. Xie Jiamin (2009) pointed out that there were ineffective factors in the price of domestic gold futures, and that there existed a one-way guiding mechanism in gold forward and spot markets in which the price of gold actuals took the dominant position. Moreover, he also found that the American gold spot market was far more efficient than China's in affecting the gold forward market. By conducting the co-integration test model and the ADL model analyses, Gao Jianyong (2010) studied the sample data from 2008 to 2009, and concluded that China's gold forward and spot prices were consistent in the long-term term despite the large deviation existing in the short run. In other words, there was a higher degree of dependence between volatility sequences of gold forward price and that of spot price in Chinese mainland, thus China's gold futures market had been equipped with the capability of risk aversion to some extent. Lin Yun (2012) also analyzed the price data of China's gold forward and spot markets from 2009 to 2012 by use of the Co-integration test, the Granger causality test and the Error Correction Model (ECM) test, and she came to a conclusion which was almost the same with that of Gao Jianyong (2010), namely, the prices of gold futures and actuals in China conformed to each other in the long run despite the huge deviation in the short run, and China's gold futures market didn't have the price discovery function.

However, those studies either focused on the relationship between the price of the gold futures and the price of the gold actuals in foreign markets such as Singapore, the United States and India, or centered round the relationship between the spot and forward prices of other financial investment products such as the oil market. As for previous research on domestic market, the emphasis was mainly put on the study of the relationship between the market price of gold futures and that of actuals from 2008 to 2012 –a crucial period during which American subprime crisis and European debt crisis broke out. Most of those studied were centered on the capability of risk aversion in China's gold forward and spot markets, findings from which were almost the same, namely, the long-term trend of gold spot and forward prices were consistent despite the huge deviation in the short term, and China's gold futures market didn't have the price discovery function.

However, the period from 2008 to 2012 was just the early stage of gold trading on the Shanghai Futures Exchange. At a time when the Chinese economy enjoys rapid development, such studies have become obsolete. Meanwhile, both international and domestic environments have seen many changes. For example, Russia underwent the Ruble crisis in 2014; and potential or obvious debt problems appeared in Brexit, Wanda Group, Hainan Airlines, Anbang Insurance Group, and Letv Group. Moreover, the Chinese government has also accelerated the implementation of numerous major projects concerning financial reform and opening-up. For instance, China Securities Regulatory Commission (CSRC) recently released the draft of Depository Receipt Management, allowing foreign capital to hold controlling interest in domestic financial institutions. These changes in international and domestic environments, beyond doubt, exert significant influence on the market for gold futures and actuals, and test the capability and value of risk aversion and hedging in domestic gold market as well. Therefore, it is still of practical significance to conduct empirical research on such topics in the latest time.

2. Research Plan

This study is dedicated to studying the following two important questions:

First, was there a long-term equilibrium between the gold futures and actuals markets from January 4th, 2016 to January 10th, 2018, namely, the co-integration relationship?

Second, if there existed a long-term equilibrium between the price of the gold futures market and that of the spot market in China from January 4th, 2016 to January 10th, 2018, then what is the causal relationship between the futures price and the spot price? In other words, is this causal relationship a two-way guidance or one-way? And if it is one-way, whether gold forward price or spot price takes the dominant position?

Based on the above research objectives, this study makes the following plans:

First, it processes the 990 samples which have been selected from the price data of gold actuals of each trading day on the Shanghai Gold Exchange and Au01 Index of each trading day on the Shanghai Futures Exchange during the period from January 4th, 2016 to January 10th, 2018.

Second, it conducts the ADF unit root test (namely the stationary test of time sequence) on the price data of the gold spot and forward markets in Mainland China from January 4th, 2016 to January 10th, 2018. It also applies the first and second difference methods until those data samples become stable because the Johansen co-integration test can only be carried out when the variables of time sequences and periodic volatility are excluded.

Third, the Johansen co-integration test is conducted to determine whether there was a long-term equilibrium between the price data of China's gold actuals and futures markets from January 4th, 2016 to January 10th, 2018. Then by processing those samples with the Error Correction Model (ECM), it can reach the error correction coefficient and thus judge the adjustment intensity and reverse adjustment ability of the whole market for gold futures and actuals when there appears a deviation from the long-term equilibrium between gold spot and forward prices.

Finally, the Granger causality test is conducted to determine whether there was a causal relationship between the prices of gold futures and actuals from January 4th, 2016 to January 10th, 2018 in Chinese mainland, and to judge the price guiding ability and mechanism between the two prices, namely, the significance and direction of such guiding effect.

3. Modeling

In order to test the linkage of transmission mechanism between gold spot and forward prices, and to ensure that this linkage is real and effective, this study must be based on the stability of time sequences. Otherwise, the regression is likely to be a spurious regression, and the Johansen co-integration test can't be carried out, either.

Therefore, this study adopts the ADF unit root test proposed by Dickey and Fuller (1981) to test the stability of the time sequences of the gold spot price R_α and the gold forward price R_β. It is particularly noteworthy that this test method is applicable to the original sequence, the first difference sequence, and the second difference sequence. If the original sequence is not stable, it can be adjusted to the first difference, or even the second difference sequence until it's become so. The test model is as follows:

$$\Delta R_\alpha = \gamma R_{\alpha-1} + \varepsilon_1 \Delta R_{\alpha-1} + \cdots + \varepsilon_{p-1} \Delta R_{\alpha-(p-1)} + \varepsilon_t \tag{1}$$

$$\Delta R_\beta = \gamma R_{\beta-1} + \varepsilon_1 \Delta R_{\beta-1} + \cdots + \varepsilon_{p-1} \Delta R_{\beta-(p-1)} + \varepsilon_t \tag{2}$$

Meanwhile, the null hypothesis H_0 of this model is that the time sequences of R_α and R_β are not stationary.

The alternative hypothesis H_1 is that the time sequences of R_α and R_β are stationary.

After this, it judges whether the time sequences of R_α and R_β lag behind the zero-order ADF unit root test value by less 5%, the threshold of an evident level.

If the answer is positive, it then accepts the null hypothesis H_0, believing that the time sequences of R_α and R_β are not stationary. However, if the time sequences of R_α and R_β lag behind the zero-order ADF unit root test value by less 5%, then the null hypothesis H_0 is excluded. In this case, the time sequences of R_α and R_β are deemed to be stationary and the co-integration test can be started.

It is particularly noteworthy that if time sequences of R_α and R_β are identified as unstable after the ADF unit root test, this paper will continue to carry out the first difference and even the second difference methods on unstable time sequences until they become stationary.

If the time sequences of R_α and R_β are stable after the first difference, it is called the integrated of order 1. Similarly, if time sequences of R_α and R_β are stable after the second difference, it is called the integrated of order 2.

3.1 Johansen Co-integration Test

The author employs the co-integration test method proposed by Johansen to examine and study the validity of gold spot and forward prices.

The definition $\{G_\alpha\}$ represents variables of gold spot prices from January 4th, 2016 to January 10th, 2018, while $\{G_\beta\}$ refers to variables of gold futures prices from January 4th, 2016 to January 10th, 2018.

Then, according to the Johansen co-integration test, the long-term equilibrium between $\{G_\alpha\}$ and $\{G_\beta\}$ can be expressed as follows:

$$G_\beta = \beta' G_\alpha + \mu_t \tag{3}$$

Meanwhile, the null hypothesis H_0 has the following two conditions:

In other words, the equation $\mathrm{r} = 0$ represents that there is no long-term equilibrium between gold actuals and futures markets, while the equation $\mathrm{r} \leq 1$ means that there does exist such a long-term equilibrium, namely, a co-integrated relationship.

After the ADF unit root test, a set of stable price data of gold actuals and futures can be obtained. At this time, this study will carry out the Johansen co-integration test on those data to determine whether the price of gold actuals and that of gold futures have consistent or common trend. In other words, whether there is an equilibrium in the linear combination of a set of price data of gold actuals and futures?

It is noteworthy that such equilibrium is lasting and stable if the prices of gold actuals and futures are co-integrated.

3.2 Error Correction Model Test

After the co-integrated sequences, namely, $\{G_\alpha\}$ and $\{G_\beta\}$ are obtained, it can designate ∇G_α as the sequence of the first difference and ∇G_β as the sequence of the second difference.

According to the theory proposed by Davidson, Hendry, Srba and Yeo in 1978, the Error Correction Model (ECM) should be employed to analyze those sequences, and the mathematical expression is as follows:

$$\nabla G_\beta = \gamma + \delta_1 \nabla G_\alpha + \delta_2 ECM \tag{4}$$

Among which,

$$\mathrm{ECM} = G_{\beta-1} - \delta G_{\alpha-1} - \gamma \tag{5}$$

Here, γ and δ are estimated parameters of the equation $\mathrm{G_\beta = \gamma + \beta G_\alpha + \varepsilon_t}$.

The method used in this study is to reach a long-term balanced parameter by use of the co-integration model, and then calculate the corresponding error correction coefficient by adding the residual error obtained from the first step into the Error Correction Model (ECM) as an unbalanced error term. This helps to judge whether the price of the gold futures in Mainland China and the error correction term can explain the gold spot price. It can also determine the adjustment effect and intensity of the market exerting on the gold spot and forward markets when their prices deviate from the long-term equilibrium.

3.3 Granger Causality Test

After analyzing whether there is a long-term equilibrium between the gold futures market and the gold spot market in Chinese mainland, this study will also apply the Granger causality test model to process the price data of domestic gold futures and actuals markets for the following three purposes:

First is to judge whether there is a guiding relationship between the gold futures market and the gold spot market in Chinese mainland. Second is to figure out whether the guiding relationship is one-way or two-way if it does exist. The third is to determine whether gold futures or actuals take the dominant position when there only exists a one-way guiding relationship.

By following the previous research plan, namely, designating M_t as the price sequence of the gold spot market and N_t as that of the gold futures market, it is easy to figure out the Granger causality test model:

$$M_t = \sum_{i=1}^{n} \varphi_{1i} M_{t-i} + \sum_{j=1}^{n} \omega_{1j} N_{t-j} + \varepsilon_{1t} \quad (6)$$

$$N_t = \sum_{i=1}^{n} \varphi_{2i} M_{t-i} + \sum_{j=1}^{n} \omega_{2j} N_{t-j} + \varepsilon_{2t} \quad (7)$$

If $\omega_{1j} \neq 0$, it can be considered that there exists a one-way guiding relationship between the gold futures market and the gold spot market, and it is N_t that guides M_t. If $\omega_{1j} \neq 0$ and $\varphi_{2i} \neq 0$, there is a two-way guiding Granger causality between the gold forward market and the gold spot market, meaning than M_t and N_t guide each other.

4. Empirical Analysis

4.1 Source of Sample Data and Description of Features

This study selects the Au01 Index provided by the database of Wind to represent the price of Shanghai gold futures because its gold futures contracts are very active and representative. Besides, the author chooses the price of Au9995 provided by the Shanghai Gold Exchange to represent the gold spot price for the same reason that Au9995 is the most important gold spot trading category in China and its price takes the dominant position. Moreover, the delivery of Au9995 has the deferred nature of "T+D", so it can match the price data of the Au01 Index for data processing and relevant analysis.

The author chooses the data of each trading day from January 4th, 2016 to January 10th, 2018, which is the settlement price of futures for each trading day, because it can better reflect the actual price in the trading of gold futures. Moreover, many other domestic scholars have been keen to study the relationship between the price fluctuation of gold actuals and gold futures during such periods as the United States subprime mortgage crisis and the European debt crisis broke out and come to almost the same conclusion. Therefore, the data of this study features strong timeliness. As China's gold forward and spot markets enjoy rapid development and the Chinese economy develops at a middle-to-high speed, such research featuring timeliness can reflect the real situation of the current gold actuals and futures markets in China, and help judge whether gold actuals and futures can play an effective role of risk aversion in actual delivery.

To sum up, the time span of the 990-transaction data analyzed in this study is from January 4th, 2016 to January 10th, 2018. After eliminating abnormal and invalid data samples, it employs the EViews 10 software to carry out empirical research and co-integration test on the rest samples.

4.2 Stationary Test

The following table can be obtained after the analysis done with EViews 10.

Table 1. Results of the ADF Unit Root Test

Category	ADF Test Value	Threshold Value			P Value
		1% Level	5% Level	10% Level	
R_α	-3.8054	-3.4443	-2.8676	-2.5701	0.0031
R_β	-3.9002	-3.4443	-2.8676	-2.5701	0.0022

It is obvious that the ADF test value of R_α and R_β are negative 3.805 and negative 3.900 respectively, both of while less than the threshold value of the 1% Level, 5% Level and 10% Level. Moreover, the P value of R_α and R_β are 0.003 and 0.002, both of which are less than 0.05. Therefore, it is safe to say that the null hypothesis H_0 should be excluded and the alternative hypothesis should be taken. In other words, the time sequences of R_α and R_β are stationary.

The above results also lay the foundation for the following Johansen co-integration test.

4.3 Johansen Co-integration Test

The following results of the Johansen co-integration test can be obtained after processing effective data samples collected in this paper.

Table 2. Results of the Johansen Co-integration Test

H_0	Eigenvalue	Statistical Quantity	Threshold Value(0.05)	P Value
r=0	0.07489	45.5595	25.8721	0.0001
$r \leq 1$	0.02204	10.1392	12.5178	0.1210

It is not difficult to reach the following conclusion with those results.

When H_0 holds that r=0, the P value is 0.001 and the statistical quantity is 45.556, both of which are less than the threshold value. Therefore, this null hypothesis is rejected.

When H_0 holds that $r \leq 1$, the P value is 0.121 and the statistical quantity is 10.139, both of which are greater than the threshold value. Therefore, this null hypothesis is accepted.

Obviously, such results demonstrate that there does exist a long-term, stable equilibrium between the price of gold futures and the price of actuals in domestic market.

4.4 Error Correction Model

The following results can be obtained after data processing.

Table 3. ADF Unit Root Test Results of Residual Error

Residual Error	ADF Test Value	Threshold Value			P Value
		1% Level	5% Level	10% Level	
	-21.1637	-3.4444	-2.8676	-2.5701	0.0000

It is evident that the ADF test value of the residual error is less than the threshold value and the P value is zero. Therefore, the residual error can scientifically exclude the null hypothesis, which means that the residual error is the data featuring stable time sequence.

After this step, the residual error is added into the Error Correction Model as an unbalanced error term to calculate the corresponding coefficient. The results are as follows.

When gold actuals are the dependent variables, their error correction coefficient is 7.189 and the P value is 0.000. When gold futures are the dependent variables, the coefficient is negative 2.727 and the P value is 0.106, greater than 0.05.

Therefore, it can be considered that gold spot price guides the price of gold futures, which means that gold actuals and their error correction term exerts reverse adjustment on the changes in gold forward price, and the intensity of such adjustment mechanism is significant. On the contrary, the price of gold futures can hardly explain that of gold actuals.

4.5 Granger Causality Test

The following results can be obtained after data processing.

Table 4. Results of the Granger Causality Test

H_0	Lagging Order	F Statistical Quantity	P Value
Gold actuals aren't the Granger causality of gold futures	2	24.9169	5×10^{-11}
Gold futures aren't the Granger causality of gold actuals	2	0.5703	0.5657

Therefore, it can be considered that the null hypothesis H_0 which holds that gold actuals aren't the Granger causality of gold futures should be excluded because the P-value is 5×10^{-11}, less than the threshold value of 0.05, which means that the gold spot price in Mainland China exerts a significant guiding effect on the price of gold futures. While the null hypothesis which holds that gold, futures aren't the Granger causality of gold actuals should be taken because the P-value is 0.566, greater than 0.05, which means the price of gold futures in Mainland China do not guide old spot price.

To sum up, it can be considered that there is a one-way guiding effect between gold futures and actuals markets in Chinese mainland. And it is the gold spot price M_t that guides the price of gold futures N_t.

4.6 Empirical Results

By conducting an association study of fluctuations in prices of gold actuals and futures, this paper can reach the following conclusions.

First, with the ADF unit root test, it is not difficult to find that the ADF test value of domestic gold spot price R_α and domestic gold forward price R_β are negative 3.805 and negative 3.900 respectively, both of which are less than their threshold value of 1% Level, 5% Level, and 10% Level. Furthermore, the P value of R_α and R_β are 0.003 and 0.002 respectively, both of which are far less than 0.05. Therefore, it can be considered that the time sequences of R_α and R_β are very stable.

Second, through the Johansen co-integration test, this paper discovers that when the null hypothesis holds that r=0, which means there is no long-term equilibrium between gold spot and forward prices, the P value is 0.000, the statistical quantity is 45.560, and the threshold value (5%) is 25.872. Because this P value is less than 0.05 and the statistical quantity is less than 25.872, the null hypothesis H_0 should be excluded. Therefore, it can be said that there is a long-term equilibrium between gold futures and actuals price, namely, a co-integrated relationship.

When the null hypothesis holds that r $\leq$ 1, which means there is a long-term equilibrium between gold futures and actuals prices, the P value is 0.121, the statistical quantity is 10.139, and the threshold value (5%) is 12.51798. Because this P value is greater than 0.05 and the statistical quantity is greater than 12.518, the null hypothesis H_0 should be accepted. In other words, there is a long-term equilibrium between gold futures and actuals price, namely, the co-integrated relationship.

Through such a two-way test mechanism, it is easy to find that there is a long-term stable equilibrium between the fluctuation in domestic gold spot price and that in forward price. In other words, gold spot and forward prices keep a common trend of movement in the long term.

Third, by use of the Error Correction Model (ECM), two sets of data are obtained. When the gold spot price is the dependent variable, the error correction coefficient (ECC_1) equals 7.198 and the P

value (P_1) is 0.000. When the price of gold futures is the dependent variable, the error correction coefficient (ECC_2) is negative 2.727 and the P value (P_2) equals 0.106.

The fact that $P_1 = 0.000 < 0.05$, $P_2 = 0.106 > 0.05$demonstrates that gold spot price guides and explains the price of gold futures, and that the gold spot price and its error correction term exert evident reverse adjustment on the changes in the price of gold futures. In addition, it can also be considered that the price of gold futures can hardly explain gold spot price, which means the price of gold futures and its error correction term have no reverse adjustment effect on gold spot price.

Forth, through the Granger causality test, this study finds that for the hypothesis that gold spot price isn't the Granger causality of the futures price and the hypothesis that gold futures price is not Granger causality of gold spot price, both of their deferred orders are 2, their F statistical quantity are 24.917 and 0.570 respectively and their P-values are P_1 0.000 and P_2 0.566.

The fact that$P_1 = 0.000 < 0.05$,$P_2 = 0.566 > 0.05$ demonstrates that domestic gold spot price exerts an evident guiding effect on the price of gold futures, while the latter does not have such a guiding effect on the former. Furthermore, the linkage mechanism between the fluctuations in gold spot and forward prices in Mainland China is one-way, and the spot price occupies the dominant position. Besides, the spot price defers two orders, meaning that the price of the gold futures is also subject to the changes in the first two stages of the spot price.

5. Major Findings

By calculating the volatility of the markets for gold actuals and futures, this study concludes that the volatility of gold spot and forward prices are relatively stable. And through the correlation test, it concludes that there is an evident positive correlation between the price of gold actuals and that of gold futures.

Subsequently, this study concludes that there is a long-term equilibrium between the fluctuation in the price of domestic gold futures and that in the spot price by constructing the ADF unit root test model, the Johansen co-integration model, the Error Correction model, and the Granger causality test model. Besides, such equilibrium refers to a one-way guiding relationship in which gold actuals significantly guides the price of gold futures and the former exerts an evident effect of reverse adjustment on the changes in the latter. On the contrary, the price of domestic gold futures can hardly explain that of gold actuals, which means that it's hard to believe the domestic market for gold futures is equipped with the price discovery function.

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