Price Discovery Function of Gold Futures Market in China

Yingge Tong, MSc.*
Wiyada Nittayagasetwat, DBA, FRM**

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Abstract

The purpose of this paper is to explore whether the Chinese gold futures market has the price discovery function. The Unit Root test, Cointegration test, Vector Error Correction Model (VECM) test, Granger Causality test and Impulse Response Function are used to examine the lead-lag relationship between gold spot price and gold futures price. The paper selects data for the period starting January 9, 2008 to January 9, 2018. The daily spot price is the daily closing price of Au99.95 from the Shanghai Gold Exchange and the daily gold futures price used in this research is the daily settlement price of the gold futures continuous contract. The Unit Root test shows that gold spot and futures prices are stationary at first order difference. Cointegration test reports a long-term equilibrium relationship between gold spot prices and gold futures prices. The short-term dynamic relationship between the gold futures price and the spot price is proved by the VECM test. The results of the Granger Causality test and the Impulse Response Function confirm that the gold spot price leads the gold futures price, but not vice versa. The conclusion demonstrates that China's gold futures market does not have price discovery function.

Keywords: Unit Root, Cointegration, Vector Error Correction, Granger Causality, Impulse Response Functions

* The Martin De Tours School of Management and Economics, Assumption University, Bangkok, Thailand., Email: yingge.tong@qq.com.
** The Martin De Tours School of Management and Economics, Assumption University, Bangkok, Thailand., Email: wiyadantt@msme.au.edu.

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การคาดการณ์ราคาทองคำในอนาคตของ ตลาดสัญญาซื้อขายล่วงหน้าทองคำของประเทศจีน

ยิงเกอ ทง, วทม.*
วิยะดา นิตยาเกษตรวัฒน์, บธ.ด., FRM**

บทคัดย่อ

วัตถุประสงค์ของงานวิจัยชิ้นนี้เพื่อศึกษาว่า ตลาดสัญญาซื้อขายล่วงหน้าของประเทศจีนสามารถทำหน้าที่ช่วยคาดการณ์ราคาทองคำในอนาคตได้หรือไม่ การทดสอบใช้วิธีการทดสอบความนิ่งของข้อมูล (Unit Root Test), วิธีการทดสอบหาความสัมพันธ์ระยะยาวของตัวแปร (Cointegration Test), วิธีการทดสอบการปรับตัวในระยะสั้น (Vector Error Correction Model, VECM), วิธี Granger Causality และวิธี Impulse Response Function เพื่อศึกษาความสัมพันธ์นำและตามของราคาทองคำที่ซื้อขายทันทีหรือราคาสปอตและราคาที่ผู้ซื้อผู้ขายตกลงกันในสัญญาซื้อขายล่วงหน้าหรือราคาฟิวเจอร์ส ช่วงเวลาที่ใช้ในการศึกษาคือ 9 มกราคม 2551 ถึง 9 มกราคม 2561 การศึกษาครั้งนี้เลือกใช้ราคาปิดของทองคำประเภท Au99.95 ในตลาดซื้อขายทองคำเซี่ยงไฮ้เป็นตัวแทนราคาสปอต และใช้ราคาที่ใช้ชำระราคารายวันเป็นตัวแทนราคาฟิวเจอร์ส วิธีการทดสอบ Unit Root แสดงให้เห็นว่าราคาทองคำสปอตและราคาฟิวเจอร์สมีความนิ่งที่ระดับความต่างที่หนึ่ง วิธี Cointegration รายงานความสัมพันธ์เชิงดุลยภาพระยะยาวระหว่างราคาทองคำสปอตและราคาฟิวเจอร์ส ส่วนความสัมพันธ์ระยะสั้นสามารถพิสูจน์ได้จากวิธีการทดสอบ VECM ผลการทดสอบวิธี Granger Causality และวิธี Impulse Response Function ยืนยันผลการศึกษาว่าราคาทองคำสปอตช่วยชี้นำราคาฟิวเจอร์ส แต่ไม่พบว่าราคาฟิวเจอร์สช่วยชี้นำราคาสปอต จึงสรุปผลในช่วงเวลาการศึกษาว่าตลาดสัญญาซื้อขายล่วงหน้าทองคำของจีนไม่สามารถทำหน้าที่ช่วยคาดการณ์ราคาทองคำในอนาคตได้

คำสำคัญ: วิธีการทดสอบความนิ่งของข้อมูล, วิธีการทดสอบหาความสัมพันธ์ระยะยาวของตัวแปร, วิธีการทดสอบการปรับตัวในระยะสั้น (VECM), วิธี Granger Causality และวิธี Impulse Response Function

* คณะบริหารธุรกิจและเศรษฐศาสตร์ มหาวิทยาลัยอัสสัมชัญ กรุงเทพฯ ประเทศไทย, Email: yingge.tong@qq.com.
** คณะบริหารธุรกิจและเศรษฐศาสตร์ มหาวิทยาลัยอัสสัมชัญ กรุงเทพฯ ประเทศไทย, Email: wiyadantt@msme.au.edu.

1. Introduction

Compared with forward contract traded in the over-the-counter market, futures contract is standardized and traded on the exchange. Futures market has two basic economic functions: price discovery and hedging. The price discovery function means that the futures market can respond to new information faster, and more accurately reflect current and future supply and demand, thus guiding spot price change, which in turn can make the market achieve equilibrium. Examining the price discovery function of the futures market not only helps in evaluating the quality and the effectiveness of futures market, but also helps in understanding the price information transmission mechanism between the futures market and the spot market, thus enabling the formulation of corresponding hedging strategies.

Gold has the multiple functions of currency circulation, keeping and increasing value and avoiding risks. In recent years, influenced by the global money market credit crisis, the hedging role of gold in the financial sector has widely been recognized, and has become an important tool for investment.

On October 30, 2002, the Shanghai Gold Exchange was formally established. The current trading varieties are Au99.95, Au99.99, Au100g, Au (T+D), Au (T+N1) and others. Among them, Au99.95 is the mainstream trading product. At the Shanghai Gold Exchange, the gold spot market is mostly open quoted and supplemented by inquiry transactions. In the Shanghai Gold Exchange, the cumulative trading volume of all gold varieties in the first half of 2017 was 24,100 tons, a decrease of 4.56% from 2016, with a turnover of 6.66 trillion yuan, an increase of 2.31% from 2016.

Since January 9, 2008, gold futures contract has been listed on the Shanghai Futures Exchange. The launch of gold futures is conducive to improving China's gold price formation mechanism and the gold market system. Gold futures contracts traded on the Shanghai Futures Exchange traded at 1 kilogram/lot, quoted in (RMB) Yuan/gram, the smallest unit of change was 0.05 Yuan/gram, contracts delivered each month, the gold content of the delivery gold cannot be less than 99.95% gold bullion. In the first half of 2017, the total volume of gold futures contracts on the Shanghai Futures Exchange totaled 21,500 tons with a turnover of 6.00 trillion yuan. The emergence of gold futures can make gold mining, gold enterprises, commercial banks and other related industries effectively avoidrisks.

Compared with the gold futures market in developed countries, Chinese gold futures market is relatively new, and has only been developed for 10 years. There are still many issues that need to be analyzed. Among these issues, the relation between futures and spot prices should be first analyzed. Knowing whether the futures market can realize the price finding function may help gold-related industries to effectively use the futures market to achieve hedging. The price discovery function is also an important basis for investors to use futures trading to conduct their investment.

The aim of this paper is to test the price discovery function of gold futures market by analyzing the lead-lag relationship between gold futures and gold spot markets in the context of China.

2. Review of Related Literature and Studies

This section reviews theories and empirical studies related to the price discovery function of the futures market.

2.1 Related Theories and Concepts

2.1.1 Cost of Carry

The concept of cost of carry theory was originally proposed by Working in 1933. On the basis of cost of carry theory, Kaldor (1939) introduced the concept of convenience yield. Cornell and French (1983) constructed the cost of carry model under the assumption of perfect market and applied it to research on stock index futures. For gold, warehousing, transportation and insurance costs may be relatively small (Fama & French, 1988). The cost of gold accrues mainly from financing costs.

The cost of carry theory states that futures prices should be equal to spot prices plus holding costs. The holding cost is the cost of holding the spot to the expiration date of the futures contract. Holding costs include warehousing costs, transportation costs, insurance premiums, interest, etc.

The theory of cost of carry assumes that the production of goods is seasonal, but the average demand is distributed throughout the year, and the storage cost will occur in the storage process. Under this assumption, in the static market of supply and demand equilibrium, the cost of carry theory can be expressed as:

$$F = S + C_t \quad (1)$$

where F stands for the futures price of the commodity, S is the spot price of the commodity, and C_t is the cost of the holding.

$$S = F - C_t \quad (2)$$

Equation (2) indicates that the futures price and the holding cost are the main factors affecting the spot price. Due to the existence of arbitrageurs, when the difference between the futures price and the spot price is greater than the cost of the holding, $F\text{-}S > C_t$, the arbitrageur can short the futures contract while long the commodity. On the expiration date of the futures contract, the arbitrager will deliver the spot commodity and earn the difference. As a result, the futures prices will fall and spot prices will rise until the basis and holding costs are equal, until the equilibrium state of $F\text{-}S = C_t$ is reached.

The entire arbitrage process is also the trader's process of transferring futures market information to the spot market. As the whole process has been complete, the spot price finally reflects the information that the futures market has collected. In this sense, futures markets play a role of price discovery.

2.1.2 Rational Expectation Hypothesis

The idea of rational expectation was first proposed by an American economist John F. Muth in 1961. Rational expectations assume that each economic participant's expectation of future events is rational. Consumers take the maximum utility of consumption, while the producer's goal is profit maximization. People's rational expectations, based on the valid information, can guide their economic behavior, and the more accurate their expectations, the greater the benefits that are obtained.

Rational expectations do not mean that people's subjective prediction must be completely consistent with objective reality. The rational expectation school assumes that there are many uncertain factors existing in the real economy, and does not deny that the random change of these uncertain factors could cause people's expected value to deviate from the actual value of the predicted variable. However, under rational expectations, once people realize their mistakes, they will react immediately and adjust their expectations to levels consistent with actual values. Rational expectation theory can also explain the function of discovering the price of futures market. Futures market can continue to provide traders with information such as market price and volume. Traders can use the information to make decisions, and through technical analysis, to predict the future spot prices. When the new information does not match the actual situation, the trader will change his expectations accordingly, resulting in price change as well. Thus, under the normal market operation mechanism, the futures prices can more accurately predict spot prices. Therefore, according to the rational expectations theory, the futures market will have an effective price discovery function.

2.1.3 Efficient Market Hypothesis

The Efficient Market Hypothesis was put forward by Eugene Fama in 1970. The theory holds that if the market price fully reflects the available information, then the market is efficient. The Efficient Market Hypothesis divides the market into the weak-form market efficiency, the semi-strong form market efficiency and the strong-form market efficiency.

According to the hypothesis, if the market is weak-form efficient, the market price has fully reflected the price information of all past history. Technical analysis, in this case, does not work and investors can use fundamental analysis to get excess returns. In the semi-strong form efficient market, in addition to fully reflecting historical price information, prices can also contain all public information associated with the company. At this time, technical and fundamental analysis are unable to help obtain excess returns. In a strong-form efficient market, prices have adequately reflected all the past public and private information and there will be no way to obtain excess profits. Therefore, in an efficient market, futures prices may be unbiased predictors of the future spot prices.

2.1.4 Price Discovery Function

Hoffman (1933) argues that the essence of the price discovery function of the futures market depends on whether the new information is first reflected in the price of the futures market or the price of the spot market. When new information is transmitted in the market, if the futures price first responds to it, then the futures market has the function of price discovery. Working (1948) proposed that price discovery refers to the ability of the futures market to price spot market transactions. Schroeder and Ward (2000) pointed out that price discovery refers to the process by which buyers and sellers reach a price for a particular transaction.

The price discovery function is based on the premise that the futures price can fully reflect relevant information. Since the transaction cost of the futures market is much lower than the spot market, the futures price is more sensitive to information than the spot price. As a result, when some new information appears, futures prices can often respond before spot prices. Therefore, futures market has the function of price discovery.

2.2 Empirical Evidences on the Relationship between Futures Price and Spot Price

The closer the time to maturity date, the more the futures price converges to the spot price; otherwise, arbitrage opportunities will arise. If one of the markets performs more fully and rapidly in response to information, then this market will certainly be stronger in price discovery than in another market. In order to examine whether a market has price discovery function, and which market has an advantage in price discovery, the lead-lag relationship can be tested. Testing the lead-lag relationship of price means that if futures price leads spot price, the future spot price can be predicted by using the futures price. This demonstrates that the futures market plays the role of price discovery.

Due to the difference in economic development levels, the lead–lag relationship between futures prices and spot prices can, therefore, be different in different markets. Some researchers believe that futures price leads spot price while others think that spot price leads futures. Bidirectional relationship was reported as well.

Campbell and Hendry (2007) analyzed the futures and spot prices of Canadian government bonds and discovered that futures prices play a crucial role in price discovery. Similarly, in the context of the United States, Oellermann, Brorsen and Farris (1989) tested the feeder cattle market, while Goodwin and Schroeder (1991) tested the live hog market. The results demonstrated that futures prices lead spot prices. Chan (1992) tested the relation among returns of Major Market Index futures and Major Market cash index and the S&P 500 futures. His findings showed that futures price leads the major market cash index. However, the result of cash index leading the futures is not obvious. The price discovery function of the Mexico stock index futures market was tested by Zhong, Darrat and Otero (2004). In Korea, Min and Najand (1999) examined the volatility and lead and lag relationship in returns between the futures market of the 500 index and the spot market of the underlying assets. They used intraday data and concluded that the futures market is ahead of the spot market by 30 minutes. Similarly, in the context of India, the study by Mahalik, Acharya and Babu (2014) revealed that the futures commodity markets play a leading role and effectively provides price discovery for the spot market, while there is no reverse causality relations. Shihabudheen and Padhi (2010) also found the same results in the Indian commodity futures market. That is, the commodity futures market is ahead of the spot market. Using Granger causality and impulse response, Feng, Liu, Lai and Deng (2007) investigated the price in the futures market and the spot market in the Nordic electricity market. A one-way causal relation between the electricity price and the electricity futures price is discovered, and the price finding function is dominated by the futures market, which means that the electricity futures market achieves excellent efficiency in terms of price finding.

On the contrary, some researchers believe that the changes of spot price are ahead of the futures market. The study by Yang, Yang and Zhou (2012) revealed that the price of the spot market has the ability to reflect the expected futures price. In the similar context of the Chinese market, using the Error Correction Model, Wang, Jiang and Wu (2001) studied the connection between copper futures prices and copper spot prices. They discovered that the leading role of copper futures on copper spot is not obvious but the copper spot price leads the copper futures price. Pradhan (2017) also found similar results in the Indian market using the Nifty spot Index and Nifty futures Index. Spot prices are able to detect new information much faster than futures prices. Hence, the futures market of Nifty Index is led by the spot market. Qin and Heo (2017) used the daily data of the Korean market from 2014 to 2017 to test the link between the VKOSPI futures and the VKOSPI index. The unidirectional relationship from the VKOSPI index spot market to the VKOSPI index futures market is examined using Granger Causality, Variance Decomposition analysis and Impulse Response function.

Bidirectional relationship between spot and futures prices was reported by many researchers. Silvapulle and Moosa (1999) studied the causal relationship between futures price of crude oil and crude oil spot price. Nonlinear causality test showed a bilateral causality between crude oil spot price and futures price. Shu and Zhang (2012) tested the function of discovering price of VIX futures contract traded on Chicago Board Options Exchange and its information efficiency and found a bilateral causality between VIX index price and VIX index futures price, indicating that the VIX index and futures price of VIX index respond to new information at the same time. In Turkey, Ersoy and Çıtak (2015) reported that there is a long-run and steady relation between the ISE-30 index and the futures price of ISE-30 index. Bilateral interactions between cash and futures price of the ISE-30 index were found. In the South African market, Floros (2009) tested the relationship between FTSE/JSE Top 40 of stock index futures price and spot price and argued that there is a two-way causality between the futures price and the FTSE/JSE Top 40 stock index price. The two-way causality between AOI index price and AOI index futures price was also verified by Turkington and Walsh (1999) in the Australian market.

3. Research Methodology

This section presents the details about the source and length of data. Various econometric methods including Unit Root Test, Cointegration Test, Vector Error Correction Model Test, Granger Causality Test and Impulse Response Function Test are shown.

3.1 Data Cllection

On January 9, 2008, the first futures contract of gold was listed on the Shanghai Gold Futures Exchange. Therefore, this paper selected data from January 9, 2008 to January 9, 2018. The daily gold futures price used in this research is the daily settlement price of the gold futures continuous contract of the Shanghai Futures Exchange. The continuous contract data are derived from the rolling of the nearest month futures contracts. Because the grade and quality specifications of the underlying assets of the gold futures contract are gold bullion with a fineness of no lower than 99.95%, this paper chose the daily closing price of Au99.95 as the gold spot price. The data used in this paper are gathered from Wind Financial Terminal Database.

3.2 Methodology

3.2.1 Unit Root Tests

Cointegration concept suggests that if non-stationary time series data are used directly for an econometric study, it may lead to “pseudo-regression” phenomena that affects the validity of the results. In order to avoid the occurrence of “pseudo-regression”, the stationarity of time series data should be tested first. In this paper, Augmented Dicky Fuller (ADF) method is used to test whether the time series contains unit root. The form of the Augmented Dicky Fuller test model can be presented as:

$$\Delta S_t = \beta_1 + \beta_2 t + \delta S_{t-1} + \sum_{i=1}^{m} \beta_i \Delta S_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta F_t = \beta_1 + \beta_2 t + \delta F_{t-1} + \sum_{i=1}^{m} \beta_i \Delta F_{t-i} + \varepsilon_t \quad (4)$$

$$H_0: \delta = 0$$

$$H_1: \delta < 0$$

where ΔS_t and ΔF_t represent the gold spot price series and futures price series after the first order differential at time t, respectively. S_{t-1} and F_{t-1} representing the time series lagged one period, ε_t is the error term. The null hypothesis, H_0, indicates that the series has at least one unit root. Alternative hypothesis, H_1, indicates that there is no unit root.

3.2.2 Cointegration Tests

The ADF test is used to investigate whether the variable is a stationary series. If the series is stationary, the Granger causality test can be analyzed directly. If the series is not stationary, one must check whether the first difference term is stationary. If the two series are integrated of the same order, then the next test will be cointegration test.

In the short-run, when an economic variable deviates away from its long-run equilibrium for a period of time, if this deviation is temporary, then the balance mechanism will adjust in the next period to restore it to equilibrium. However, if this deviation is persistent, it can be said that there is no equilibrium relationship between these variables. Cointegration test is used to investigate whether there is a long-term equilibrium relation existing between non-stationary variables. In this paper, the Johansen method is used to verify whether a cointegration relation actually exists between the prices in futures and spot market of gold.

The Johansen method is based on the relation between matrix rank and characteristic root. According to the Johansen cointegration test method, the model is expressed as:

$$\Delta x_t = A_0 + \pi x_{t-1} + \pi_1 \Delta x_{t-1} + \varepsilon_t \quad (5)$$

where x_t represents the vector $[S_t, F_t]$, and ε_t represents the error term.

The trace test is used to test the amount of cointegration vectors by Johansen (1988, 1991).

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_i) \quad (6)$$

$$H_{r0} : \lambda_{r+1} = 0$$

$$H_{r1} : \lambda_{r+1} > 0,\ r = 0, 1, \ldots, k\text{-}1$$

where r stands for the amount of cointegration vectors and $\hat{\lambda}_i$ represents the amount of the characteristic roots that are estimated. T is the number of observations that can be applied.

3.2.3 Vector Error Correction Model (VECM) Tests

The Vector Error Correction mechanism was proposed by Engle and Granger in 1987. Even if the relation between two variables that are non-stationary is long-term equilibrium, it may be imbalanced in the short run. The imbalance of a period can be corrected in the next period with the Error Correction Mechanism. Based on the Granger's theorem, the Error Correction Model can be used to further analyze any variables that have cointegration relationships. The Vector Error Correction Model applied in this paper can be presented as:

$$\Delta S_t = a_0 + \varphi_s Z_{t-1} + \sum a_{1j} \Delta S_{t-j} + \sum a_{2j} \Delta F_{t-j} + \varepsilon_{st} \quad (8)$$

$$\Delta F_t = b_0 + \varphi_f Z_{t-1} + \sum b_{1j} \Delta S_{t-j} + \sum b_{2j} \Delta F_{t-j} + \varepsilon_{ft} \quad (9)$$

where $Z_{t-1} = S_{t-1} - \beta_1 - \beta_2 F_{t-1}$ represents the error correction term. ΔS_t represents the gold spot price series after the first-order difference at time t, and ΔF_t represents the first difference of the gold futures price series, ε_t represents the error term. Z_{t-1} is an error correction term that represents the long-run equilibrium relationship between S_{t-1} and F_{t-1}. The coefficients φ_s and φ_f reflect the adjustment speed to adjust to the equilibrium state when the long-run equilibrium relation deviates from the equilibrium. a_{1j}, b_{1j}, a_{2j} and b_{2j} are short-term adjustment coefficients.

3.2.4 Granger Causality Test

Granger Causality test is a procedure applied to test whether A Granger-Causes B. The main point is to check the extent of the current B to be explained by the past A. If the correlation coefficient between A and B is statistically significant, it can be concluded that "A Granger-Causes B". The following regression will be estimated:

$$\Delta S_t = \sum_{i-1}^{m} \alpha_i \, \Delta S_{t-i} + \sum_{j=1}^{m} \beta_j \Delta F_{t-j} + \lambda_1 \, t + u_{1t} \quad (10)$$

$$\Delta F_t = \sum_{i-1}^{m} \gamma_i \, \Delta F_{t-i} + \sum_{j=1}^{m} \delta_j \Delta S_{t-j} + \lambda_2 \, t + u_{2t} \quad (11)$$

The null hypothesis of the two formulas above are: $\beta_1 = \beta_2 = \ldots = \beta_m = 0$ and $\delta_1 = \delta_2 = \ldots = \delta_m = 0$ F-test will be calculated for these two equations. If the null hypothesis cannot be rejected at the same time, there is no Granger causality between the variable A and the variable B. If both null hypotheses are rejected at the same time, then there is Granger causality between the variable A and the variable B.

3.2.5 Impulse Response Function

Granger Causality test only examines the directional relation between spot price and futures price; however, it is interesting to know the length of time that spot prices affect futures prices and the length of time that futures prices have an impact on spot prices. This paper uses the Impulse Response Function to analyze the short-run dynamic interaction between spot prices and futures prices. The Impulse Response Function is used to detect the effect on the current value and future value of endogenous variables by adding a standard deviation size shock to the random error term. Impulse Response Function can intuitively describe the dynamic interaction and impact between variables.

One way to analyze the relationship using the time series model is to consider how the influence of the disturbance term is transmitted to variables. In the VAR(K) model:

$$F_t = a_1 F_{t-1} + \ldots + a_k F_{t-k} + b_1 S_{t-1} + \ldots + b_k S_{t-k} + \varepsilon_{1t} \quad (12)$$

$$S_t = c_1 S_{t-1} + \ldots + c_k S_{t-k} + d_1 F_{t-1} + \ldots + d_k F_{t-k} + \varepsilon_{2t} \quad (13)$$

where S_t and F_t represent the spot price and the futures price respectively, the random disturbance term, ε_{1t}, ε_{2t}, is called innovation. Adding a shock to the random error term will not only change the current futures price, but will also affect the future spot price and futures price. By describing the track of these influences, the Impulse Response Function shows how the change in one variable affects others and ultimately feeds back into itself.

3.3 Research Hypotheses

(1) Cointegration test

H_0 : There is no long-term relation between futures prices and spot prices.

H_1 : There is a long-term relation between futures prices and spot prices.

(2) Vector Error Correction Model (VECM) Tests

H_0 : There is no short-term relation between futures prices and spot prices.

H_1 : There is a short-term relation between futures prices and spot prices.

(3) Granger Causality Test

H_0 : Futures price does not Granger Cause spot price.

H_1 : Futures price Granger Causes spot price.

H_0 : Spot price does not Granger Cause futures price.

H_1 : Spot price Granger Causes futures price.

4. Presentation and Critical Discussion of Results

This section reports the results obtained from various econometric tests. A discussion on the results is also presented. Since the trading date of gold spot price and futures price is not completely consistent, the data of different trading days are eliminated, and finally 2,435 data sets are obtained. In the following sections, AU9995 is used to represent the spot price of gold, and AU00 represents the price of gold futures.

4.1 Unit Root Test Results

Table 1 displays the results of the unit root test. The p-values of the original series of gold spot price and futures price are 0.3888 and 0.3411, respectively. This implies that the null hypothesis, that there is at least one unit root, is not rejected at the level of 1% significance. The two series are not stationary, so the first order difference for the two series is then applied, and then the ADF test is repeated for the new series.

From the last two rows in the table, the p-values of ΔAU9995 and ΔAU00 are significantly less than 0.01. Therefore, the gold spot price series and the gold futures price series after the first order difference do not contain a unit root, meaning that these two series are stationary significantly at 1% level. Because the spot price series and the futures price series are both integrated of order one, there may be a cointegration relationship between the two series. The next test is therefore, the cointegration test.

Table 1 Results of Unit Root Test

Variables	Augmented Dickey-Fuller Test Statistic	Prob.
AU9995	-1.783986	0.3888
AU00	-1.881992	0.3411
ΔAU9995	-51.46536	0.0001**
ΔAU00	-51.74342	0.0001**

Note: ** denotes 1% significance level

4.2 Cointegration Test Results

Before testing the cointegration relationship, it is necessary to determine the optimal lag order first. The optimal lag order is identified by establishing a VAR model. Table 2 shows that most of the criteria choose a lag order of 5, so this paper chooses 5 as the optimal lag order. The order used for Cointegration test, VECM test and Granger Causality test is obtained by subtracting 1 from the optimal lag period, that is, 4.

Table 2 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-20233.84	NA	59048.53	16.66187	16.66664	16.66360
1	-12019.56	16408.27	68.43604	9.901654	9.915969*	9.906858
2	-12004.14	30.79731	67.79496	9.892242	9.916101	9.990916*
3	-11998.82	10.58495	67.72200	9.891165	9.924567	9.903309
4	-11996.55	4.526549	67.81845	9.892588	9.935534	9.908202
5	-11982.70	27.56781*	67.27083*	9.884481*	9.936970	9.903565
6	-11978.86	7.652129	67.27933	9.884607	9.946639	9.907161

Note: * indicates lag order selected by the criterion

The results of the Trace test is reported in Table 3. The null hypothesis of “no cointegration vector” is rejected at the 5% significance level. For the null hypothesis of “at most 1 cointegration vector”, Trace Statistic is 2.941807 which is less than the critical value of 3.841466, at the level of 5% significance. Therefore, the null hypothesis of “at most one cointegration vector” is not rejected at the level of 5% significance. This means that there is only one cointegration vector between the futures price and the spot price. Therefore, it can be concluded that there is a long-run equilibrium relationship between gold futures price and gold spot price.

Table 3 Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.086106	221.7417	15.49471	0.0001
At most 1	0.001210	2.941807	3.841466	0.0863

4.3 Vector Error Correction Model (VECM) Results

Vector Error Correction Model (VECM) is now applied to test the short-term relationships between gold futures price and spot price, and the results are obtained in Table 4. Firstly, equation (8), which is the equation of Au99.95 spot price is analyzed. According to Table 4, the t-value of the coefficient φ_s of the error correction term is not significant at the level of 5%. Similarly, in the lead-lag relationship, all the lagged terms of gold futures prices are not statistically significant at 5% level. This means that the gold futures price does not have a leading function for the spot price.

Table 4 Vector Error Correction Model Test

Error Correction:	D(AU00)	D(AU9995)
CointEq1	-0.206937**	-0.008713
	[-14.0058]	[-0.62316]
D(AU00(-1))	-0.054787*	0.004882
	[-2.38279]	[0.22434]
D(AU00(-2))	0.003786	-0.039420
	[0.16769]	[-1.84507]
D(AU00(-3))	0.019691	-0.013201
	[0.89461]	[-0.63374]
D(AU00(-4))	0.051161*	0.033362
	[2.44136]	[1.68227]
D(AU9995(-1))	0.091032**	-0.048820*
	[3.46200]	[-1.96190]
D(AU9995(-2))	0.052903*	0.032251
	[2.02047]	[1.30153]
D(AU9995(-3))	0.012851	0.015164
	[0.49604]	[0.61850]
D(AU9995(-4))	-0.129238**	-0.038944
	[-5.14221]	[-1.63735]
C	0.019511	0.028315
	[0.31243]	[0.47910]

Note: t-statistics in [ ]

* Denotes 5% significance level

** Denotes 1% significance level

Then the equation (9), which is the equation of gold futures price, is analyzed. First, the value of the coefficient φ_f of the error correction term is -0.206937, and the absolute value of its t-value is larger than the critical value at the 1% significance level. This shows that the error correction term has a negative adjustment effect on the price of futures, indicating that in the previous period, when the short-term fluctuation between gold spot price and futures price deviates from the long-run equilibrium state, the price of gold futures will adjust to the equilibrium state at a speed of -0.206937. In the lead-lag relationship, the coefficients of gold spot price return with lag of one period and four periods are statistically significant at 1% level. The coefficient of the spot price return of the two-period lag is significant at the level of 5%. These show that the lag of gold spot price return can predict the current futures price return.

4.4 Granger Causality Test Results

After determining the long-run cointegration relation between the Au99.95 spot price and the futures price (AU00) and the short-term relationship between them, the Granger Causality test is now conducted to analyze the direction of long-term causality between gold spot price and futures price.

Table 5 reports the results of the Granger Causality test. For the null hypothesis, “AU9995 does not Granger Cause AU00”, the p-value of the test result is equal to 0.0000, which is less than 1%. Therefore, the null hypothesis is rejected and it can be concluded that Gold Spot Price Granger Causes Gold Futures Price. However, the p-value of the null hypothesis of “AU00 does not Granger Cause AU9995” is greater than 5%, which implies that the null hypothesis cannot be rejected, hence, Gold Futures Price does not Granger cause the Spot Price.

Table 5 Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
AU9995 does not Granger Cause AU00	2431	88.3583	0.0000
AU00 does not Granger Cause AU9995		1.65483	0.1578

Note: ** denotes 1% significance level

From the above two hypothesis tests, the price change of gold futures is obviously affected by the price change of gold spot, but gold futures price change has no significant effect on the price change of gold spot. Therefore, it can be concluded that there is a one-way Granger causal relationship between gold spot price and futures price. Investors can predict gold futures prices based on gold spot prices, but cannot predict gold spot prices based on gold futures prices. This also shows that the price discovery function of the China's gold futures market has not been fully examined.

4.5 Impulse Response Function Results

Impulse Response Function is used to further investigate the information shock and reaction process between gold spot and futures markets. After applying a unit of shock to the error term of equations (12) and (13), and analyzing the impulse response function graphs of the AU9995 spot series and the AU00 futures series, the leading relationship between the two and the strength of the price discovery function can be reported.

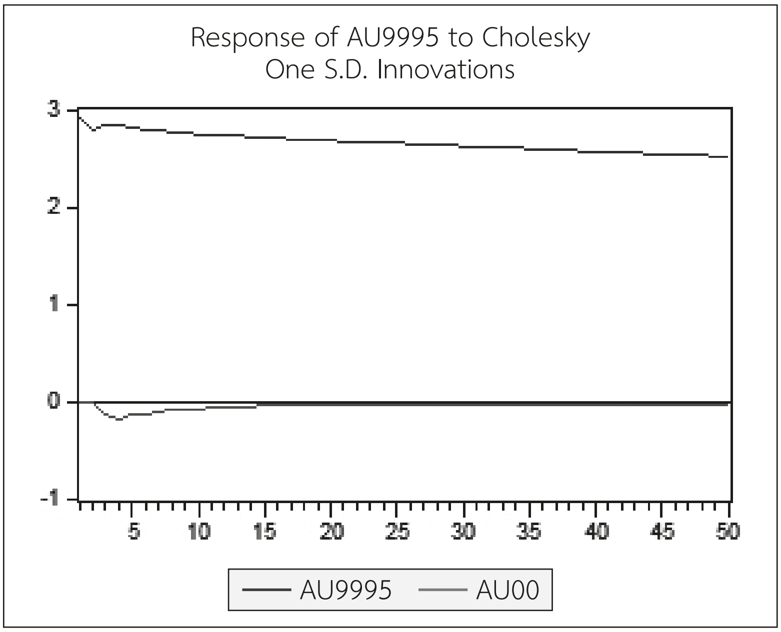

Figure 1 Impulse Responses of Spot Price (AU9995)

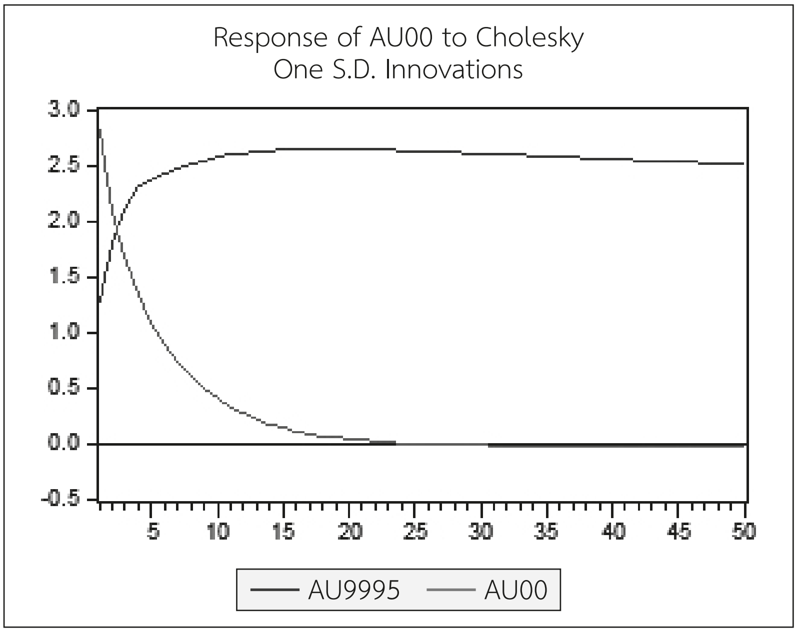

Figure 2 Impulse Responses of Futures Price (AU00)

Figure 1 shows the response of the gold spot price (AU9995) to a standard deviation shock of its own and a standard deviation shock of the futures price (AU00) where the graph of AU9995 is above AU00. The spot price has a relatively large response to a unit shock of its own, reaching a maximum of 2.9 in the first lag period and then slowly decreasing. For the response to a standard deviation shock from the futures market, the spot price response is not significant, and the fluctuations are basically maintained near zero. This shows that the impact of futures market price shocks on spot market prices is weak.

Figure 2 shows the response of the gold futures price (AU00) to a standard deviation shock of its own and a standard deviation shock of the spot price (AU9995). The impact of a unit shock from the futures price itself causes the futures price to fluctuate to 2.82, followed by a downward trend, falling to zero on the 24th day. However, for the response to a standard deviation shock from the spot market, the futures price increases from 1.28 to 2.31 in the first four periods at a relatively fast speed, peaking on the 16th day and then slowly declining. This means that the futures price is mainly affected by the spot price in the long run.

Therefore, it is clearly shown that the fluctuation of China's gold spot price is mainly affected by its own spot market, while the fluctuation of gold futures price is mainly affected by the spot market. This indicates that the leading ability of China's gold futures market to the gold spot market is less than that of gold spot market to the gold futures market. Consequently, the empirical results of the impulse response prove once again that the price discovery function of the Chinese gold futures market is weak, which is consistent with the conclusions obtained from previous test results.

5. Summary, Conclusions, Implications and Recommendations

This section summarizes the previous findings and draws conclusions. Recommendations for future research are also illustrated.

5.1 Summary of the Findings

The purpose of this paper is to reveal whether China's gold futures market has the function of price discovery. In this paper, the daily price of gold contract Au99.95 represents the spot price of gold, and the price of gold futures is the time series of continuous futures price constructed by the method of rolling over the nearest month futures contract. The time interval for data selection is from January 9, 2008 to January 9, 2018. The conclusions of this paper are as follows:

(1) The unit root results of gold spot price series and gold futures price series show that the original series of spot price and futures price are not stationary. However, after the first order difference, the two series are stationary at 1% significance level. On this basis, the Cointegration test verifies that there is a long-term stable equilibrium relation between gold futures price and gold spot price.

(2) For the short-term dynamic relations, the Vector Error Correction Model reports that when the futures price of gold and the spot price of gold deviate from the equilibrium in the long run, the deviation is corrected by the spot market. And the lag of spot price can predict the current gold futures price. However, in the equation of spot price, the coefficient of the error correction term is not significant, and the lag term of the gold futures price does not affect the current spot price. This shows that one cannot predict the spot price of gold with the price of gold futures.

(3) Granger causality test reveals the one-way price leading relationship between gold spot market and futures market. At 1% significance level, Gold Spot Price Granger Causes Gold Futures Price, but not vice versa. This one-way leading relationship indicates that the spot market plays a major role in the process of price discovery in China's gold market, not vice versa.

(4) Impulse response analysis further examines the response of the two markets to one standard deviation size shock. The result shows that a price impact from the gold spot market has a long-term impact on the price of the futures market. The price of gold futures is sensitive to a shock from the spot price and has a long duration, indicating that the price of gold futures in China is affected by the spot price. However, the gold spot market is relatively slow to respond to a shock from the futures market, and the fluctuations are small. The fluctuation of the spot price of gold mainly comes from its own influence. Therefore, it can be concluded that the price discovery function of Chinese gold futures market is weak, and the gold spot market plays a major role in price discovery.

5.2 Conclusion

The study concludes that Chinese gold futures market does not have a price discovery function. This is consistent with previous empirical studies, such as the copper futures market by Wang, Jiang and Wu (2001), the CSI 300 index futures market by Yang, Yang and Zhou (2012) in China, and also the Nifty Index futures market by Pradhan (2017) in India and the futures market of VKOSPI Index by Qin and Heo (2017) in Korea.

The main reasons may be that the Chinese gold futures market is still in the initial stage of development compared with developed countries and the contract size of the gold futures contract is 1 kilogram/lot on the Shanghai Futures Exchange. However, the current mature gold futures market, such as the Tokyo Commodity Exchange, has a small gold futures contract of 100 grams/lot. The threshold of 1 kilogram/lot is too high for ordinary investors, thus reducing the incentives for small and medium investors to participate.

[1]Another reason may be because the gold price is set based on financial evaluations of anonymous auction rounds run every 45 seconds and the ICE Benchmark Administration (IBA) publishes the London Bullion Market Association (LBMA) Price which becomes the benchmark for gold price to be used worldwide (Sepanek, 2017). On the other hand, Gold Futures price in China is based mainly on supply and demand of local investors which is strongly influenced by LMBA Price. Therefore, this may lead to the result that spot price leads futures price, but not vice versa.

5.3 Implications

The findings of this paper are beneficial to producers, operators, investors and regulator involved in gold trading. Gold producers and operators can design their hedging strategies through the results of this paper to make more scientific production and management decisions. For investors, due to the existence of global economic uncertainty, whether as a commodity or money, gold has shown excellent investment value. Investors can use the conclusions of this paper as a reference to develop corresponding trading strategies. Lastly, the gold futures regulator may initiate the ways to help promoting price discovery function because it is considered one of the important functions of the futures market.

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[1] Special thanks to the anonymous readers who helped pointing out this idea.

5.4 Recommenations for Future Research

(1) The gold spot market has many varieties, not only Au99.95 but also Au100g, Au99.99, etc.; this paper has only selected Au99.95 as a proxy of China's gold spot price. Further research can use the price of different gold contracts as a proxy of spot prices to study the relationship between the gold spot market and the futures market.

(2) The gold futures market in China is still in the primary stage, and the price discovery function of gold futures is still not obvious. This paper does not discuss in depth the factors that affect the price discovery function of the gold futures market. Further research can focus on analyzing the reasons of not finding the price discovery function of futures prices and what effective measures can be taken to improve the leading function of China's gold futures prices.

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