EMPIRICAL RESEARCH ON PRICE DISCOVERY FUNCTION OF GOLD FUTURES MARKET IN CHINA

By

YINGGE TONG

An Independent Study
Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN FINANCE AND ECONOMICS

Martin de Tours School of Management and Economics
Assumption University
Bangkok, Thailand

August 2018

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By: Ms. Yingge Tong

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Nopphon T.

Asst.Prof.Dr.Nopphon Tangjitprom, Chairperson

Dr.Veeranuch Leelalai, Member

Dr.Wiyada Nittayagasetwat, Advisor

Date of Defense: August 30, 2018

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Empirical Research on Price Discovery Function of Gold Futures Market in China

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ID: 5919672

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I confirm that this independent study has been carried out under my supervision and it represents the original work of the candidate.

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Dr. Wiyada Nittayagasetwat, Advisor

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ABSTRACT

Since January 9, 2008, China gold futures contract has been listed on the Shanghai Futures Exchange. Now China's gold futures market has been developing for ten years. The purpose of this paper is to explore whether the Chinese gold futures market has the price discovery function. In this paper, 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. This paper selects the data for the period of 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. Daily spot price is the daily closing price of Au99.95. Au99.95 is the contract of the Shanghai Gold Exchange.

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 show that the gold spot price leads the gold futures price, but not vice versa. The conclusion of this paper is that China's gold futures market does not have price discovery function.

The findings of this paper are beneficial to producers, operators and investors 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 conclusion of this paper as a reference to develop corresponding trading strategies.

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I, Sunida Maetasiri, have proofread this independent study entitled "Empirical Research on Price Discovery Function of Gold Futures Market in China" and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in financial economics.

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Sunida Maetasiri, Proofreader
Contact Number: 0896673844 / Email Address: ajtukta@gmail.com

Date:

September 14, 2018
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CHAPTER I

GENERALITIES OF THE STUDY

1.1 Background of the Study

Futures contract is a financial derivative product with high management standard traded in futures market which is a high-level market organization form. Compared with forward contract traded in the over-the-counter, futures contract is standardized and traded on the exchange. Futures market has two basic economic functions: price discovery and hedging. In a single spot market, the lag of the spot market adjustment is likely to cause the volatility of commodity supply and demand and price. The violent fluctuations of the market price make the increasing price risk entirely borne by the producers, operators and consumers. The inherent defects of the spot market need to be compensated by other mechanisms, and the price discovery function of futures market can meet this requirement. The price discovery function means that the futures market can respond to new information faster, and can more accurately reflect current and future supply and demand, thus guide spot price change and make the market achieve equilibrium. Examining the function of futures price discovery can test the effectiveness of futures market, which is the premise to test whether futures can effectively carry out hedging. The mature futures market can not only effectively transfer market risk, but also help to form a market equilibrium price. Therefore, examining the price discovery function of the futures market not only helps us to evaluate the quality and the effectiveness of futures market, but also helps to understand the price information transmission mechanism between the futures market and the spot market, thus to formulate corresponding hedging strategies.

Gold has not only strong natural stability, but also gives the social attributes. It has the 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 been widely recognized, and has become an important tool for investment. In October 2002, the Shanghai Gold Exchange was officially opened. China's gold market has been gradually formed and opened up. Before 2008, China's gold market was relatively single. Shanghai gold spot market took on most of the gold trading functions. Therefore, in January 2008, in order to make China's gold market system develop better, China gold futures were officially listed on the Shanghai Futures Exchange. If Gold futures market plays a price discovery function, it will help promote the improvement of the gold pricing mechanism and, to a certain extent, eliminate the risk of fluctuations in international gold prices.

Compared with the gold futures market in developed countries, Chinese gold futures market has only developed for 10 years. There are still many problems that need to be analyzed. Among these issues, the relation between futures and spot prices should be first analyzed. Because whether the futures market can realize the price finding function is very important, this determines whether gold-related industries can 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 venture investment.

In the previous empirical research on the Chinese gold futures market, the underlying asset used by Cao (2010) was Au99.95, Xu (2009) used Au99.99 and Zhou (2014) used AU (T+D). Although they used different underlying assets, they all found the same conclusion that China's gold spot market plays the dominant role in price discovery. Therefore, after several years of development, this article aims to explore in the Chinese context whether the gold futures market has the function of price discovery at present. Through the trading of gold futures, is it possible to have a reasonable expectation of futures spot prices? This paper tests 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.

1.2 Statement of the Problem

Since different countries have different levels of development, macroeconomic conditions, investment environment and regulatory policies, even in the same country, different markets also have different characteristics. Therefore, the efficiency of the price discovery function in futures market is different in different markets and countries. Under the background of India, Padhi and Shihabudheen (2010) did a research on the function of discovering price in commodity futures and spot markets. They discovered that during the process of discovering price, the commodity futures market has played a crucial role of price discovery for the commodity spot market. On the contrary, in China, Yang, Zhou and Yang (2012) examined the function of discovering price of the CSI 300 index futures market and the transmission of volatility between the two markets. From the result, they discovered that the spot market plays an important role and a leading role. However, in the Turkish context, Ersoy and Çıtak (2015) found that there is a bilateral interaction between the Turkish stock index and its futures.

In the early stage of the development of Chinese futures market, owing to the inadequate market supervision system and lack of supervisory experience, price manipulation events in the futures market have occurred from time to time. Due to excessive speculation, the function of discovering price in the futures market has been severely distorted. After a long period of time to regulate, the over-speculative behavior has been better suppressed, and the price discovery and hedging functions of the futures market have been better realized. Therefore, after years of regulation, this article aims to test whether the function of discovering price in Chinese gold futures market is perfect.

1.3 Research Objectives

1) To investigate the long-run relationship between Chinese gold spot market and the Chinese gold futures market.

2) To examine the short-run dynamic relationship between Chinese gold spot market and the Chinese gold futures market.

3) To determine whether China's gold futures market has the price discovery function.

1.4 Research Questions

1) Does Chinese gold futures market have a long-term relation with the Chinese gold spot market?

2) Does Chinese gold futures market have a short-term dynamic relation with the Chinese gold spot market?

3) Does Chinese gold futures market provide a price discovery function?

1.5 Scope of the Research

This paper selects the data for the period of 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. Daily spot price is the daily closing price of Au99.95. Au99.95 is the contract of the Shanghai Gold Exchange.

The data used in this paper are gathered from Wind Financial Terminal Database.

1.6 Limitations of the Research

This paper only considers the relationship between the Chinese gold futures market and the Chinese spot market. It does not take into account the international information transmission and market interaction between foreign markets and the Chinese market.

1.7 Significance of the Study

This paper provides the empirical results of whether Chinese gold futures market has a price discovery function. Gold producers and operators can design their hedging strategies based on 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. It is expected that this paper helps provide some references and suggestions to investors.

1.8 Definition of Terms

1.8.1 Futures contract

A futures contract is an agreement between two parties that agrees to purchase or sell a particular asset at a predetermined price at a specific time in the future (John C. Hull, 2014).

1.8.2 Futures price

The futures price is the price specified in the futures contract and agreed by both parties to trade on the settlement date (Investorwords, 2018).

1.8.3 Spot price

Spot price refers to the current market price of assets in the spot market, where assets can be delivered immediately (Nasdaq, 2018).

1.8.4 Au99.95

Au99.95 is a gold physical trading contract listed on the Shanghai Gold Exchange on October 30, 2006. Deliverable Bullion is 3kg gold ingot; Fineness no less than 99.95% (Shanghai Gold Exchange, 2018).

CHAPTER II

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter reviews theories related to the price discovery function of the futures market. Previous empirical studies in various countries and markets are discussed. It also introduces the background of industry. Additionally, the contract specification of gold futures contract is displayed.

2.1 Related Theories and concepts

2.1.1 Cost of Carry

The theory of cost of carry is one of the important theories which explains that futures have the function of price discovery.

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 the research of stock index futures. For gold, warehousing costs, transportation costs and insurance costs may be relatively small (Fama & French, 1988). The cost of gold comes 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 and 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:

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

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

After deformation of formula, we can get:

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

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, the futures price will not deviate from the spot price for a long time. When there is bullish news on the market, the futures market will first respond to this bullish message, which will result in an increase in the price of futures. However, the spot market has not yet responded, at this time, $F - S > C_t$, that is, the difference between the futures price and the spot price is greater than the cost of the holding. This implies that the spot price of the commodity is undervalued. In this case, the arbitrageur can short the futures contract while long the commodity. On the expiration date of the futures contract, arbitrager will deliver the spot commodity and earn the difference. Therefore, the number of sellers in futures market increases, and the number of buyers in the spot market increases. As a result, futures prices will fall and spot prices will rise until the basis and holding costs are equal, and finally reach the equilibrium state of $F - S = C_t$.

The entire arbitrage process is also the trader's process of transferring futures market information to the spot market. As the whole process is over, 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 the 1961. Rational expectations assume that each economic participant's expectation of future events is rational. Consumers take the maximum utility of consumption as a rule of action, while the producer takes profit maximization. When they predict the economic phenomenon, they will try their best to get all useful information. People's rational expectations, based on the valid information, can guide their economic behavior, and the more accurate the expectations, the greater the benefits that people can get.

Of course, rational expectations do not mean that people's subjective prediction must be completely consistent with the objective reality. The rational expectation school does not deny 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, they emphasize that once people find mistakes, they will react immediately and adjust their expectations to levels consistent with actual values. Therefore, people do more accurately in predicting the future rather than making systematic errors.

Rational expectation theory can also explain the function of discovering 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, and prices change as well. Thus, under the normal market operation mechanism, the futures prices can more accurately predict spot prices. Therefore, according to rational expectations theory, the futures market will have an effective price discovery function.

2.1.3 Efficient Market Hypothesis

The Efficient Market Hypothesis was advanced and 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 does not work and investors can use fundamental analysis to get excess returns. In the semi-strong form efficient market, in addition to fully reflect historical price information, prices can also contain all public information associated with the company. At this time, technical analysis 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 spot prices in the future.

2.1.4 Price Discovery Function

Regarding the definition of the price discovery function of the futures market, 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 the relevant information. The price discovery process is the process of determining the price of assets in the market through the interaction between buyers and sellers. There are many participants in futures trading, such as commodity producers, sellers, speculators, and so on. They analyze and judge the supply and demand of commodities and the price trend according to their production costs and expected profits, and quote their ideal prices to compete with many competitors. The resulting futures price reflects most people's prediction and therefore approaches the equilibrium price. 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

Due to the influence and restriction of the same factors in the same economic system, the trend of futures price and spot price of the same commodity is basically the same. The closer the futures contract is to the maturity date, the more the futures price converges to the spot price. So, the relationship between spot price and futures price is very close.

From the above analysis, an investigation on the relationship between futures market and spot market is the starting point. If one of the markets performs more fully and rapidly in response to the information, then the market will certainly be stronger in price discovery than in another market. The price discovery function will mostly be done in this market. As to how to test whether a market has price discovery function, and which market has an advantage in price discovery, one way is to test the lead-lag relationship. Testing the lead-lag relationship of price means that if futures price leads spot price, we can predict the future spot price by using the futures price. This demonstrates that the futures market plays the role of price discovery.

A dynamic model of the interrelationship between spot and futures prices was constructed by Silber and Garbade (1983). They examined the function of futures markets and spot markets on price discovery by examining the impact of basis change in the previous period on subsequent futures and spot prices. Afterwards, Engle and Granger (1987), Johansen (1988), and Juselius and Johansen (1990) put forward cointegration analysis to provide a new approach to investigate the equilibrium relationship of nonstationary economic variables. Cointegration analysis is now widely used to examine the dynamic relation between spot and futures prices.

Due to the difference of economic development level, the lead–lag relationship between futures prices and spot prices is different in different markets.

1) Many researchers have studied the relationship between futures prices and spot prices. Some researchers believe that futures price leads spot price.

Campbell and Hendry (2007) analyzed the futures and spot prices of Canadian government bonds. From the empirical results, they discovered that futures prices play a crucial role in price discovery. Similarly, in the context of the United States, Farris, Oellermann and Brorsen (1989) tested the feeder cattle market, and Goodwin and Schroeder (1991) tested the live hog market. The results all found 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. He discovered that futures price leads the major market cash index, which is strongly supported by the evidences. However, the result of cash index leading the futures is not obvious. Evidence suggests that futures leads the major market cash index to a greater extent, which indicates that the whole market information mainly comes from the futures market. The price discovery function of the Mexico stock index futures market was tested by Darrat, Zhong and Otero (2004). The results showed that futures market can effectively implement the function of discovering price, although futures market transactions are also the cause of unstable in the spot market.

In Korea, Najand and Min (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 for 30 minutes. Similarly, under the background of India, Mahalik, Babu and Acharya (2014) conducted an empirical study on price discovery and volatility spillovers in the spot commodity market and futures commodity market. They applied bivariate Exponential GARCH Model and Vector Error Correction Model. The results revealed that the futures commodity markets play a leading role and effectively provide price discovery for the spot market, while there is no reverse causality relations. Using the same method, 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. Kao and Wan (2008) used Hasbrouck information shares model and the EGARCH model to study the market interaction and international information dissemination between the United States and the United Kingdom natural gas markets. They found that information is effectively transmitted in four relevant markets. The United States futures market is dominant in price discovery while the United Kingdom futures market is ranked second. In America and Britain, the efficiency of the spot market is lower than their corresponding futures market. In three of the four markets, an asymmetric volatility spillover effect was found. 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 of price finding.

2) On the contrary, some researchers believe that the changes of spot price are ahead of the futures market.

Yang, Zhou and Yang (2012), using high frequency of intraday data, studied the volatility transmission and the function of discovering price between China's stock index and its relevant futures market. The result revealed that the price of the spot market has the ability to reflect the expected futures price. In the same context of the Chinese market, using the Error Correction Model, Wang, Wu and Jiang (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. Research by Pradhan (2017) also found similar results in the Indian market. The study used Impulse Response function, Vector Error Correction Model (VECM), and Variance Decomposition analysis to analyze the Nifty spot Index and Nifty futures Index. Spot prices are able to detect new information much faster than futures prices. So, 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 discovered through Granger Causality, Variance Decomposition analysis and Impulse Response function.

3) Another conclusion is that there is a bilateral causality.

Moosa and Silvapulle (1999) studied the causal relationship between futures price of crude oil and crude oil spot price. Nonlinear causality test showed that a bilateral causality between crude oil spot price and futures price is found. Zha (2014) made a study on the efficiency of soybean futures market in China. The existence of bi-directional information flow between the soybean futures market and soybean spot market is also discovered by her. Shu and Zhang (2012) tested the function of discovering price of VIX futures contract traded on Chicago Board Options Exchange and its information efficiency. They used an Error Correction Mechanism and the EG cointegration test. The test showed that the futures price leads the VIX index throughout the whole sample period, which means that the VIX futures market has a certain function of discovering price. However, the Granger Causality test discovered 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 the context of Turkey, Ersoy and Çıtak (2015) used 5-minute data to investigate the lead and lag relationship between ISE-30 index futures and its underlying asset in spot market over the period of 2007-2010. The results of the research showed 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 are discovered. In the South African market, Floros (2009) used the daily data from 2002 to 2006 to test the relationship between FTSE/JSE Top 40 of stock index futures price and spot price. By using VECM test, Granger test and Impulse Response test, he discovered that there is a two-way causality between the futures price and the FTSE/JSE Top 40 stock index price. Using the VAR model and the Impulse Response function method, the clear two-way causality between AOI index price and AOI index futures price is also verified by Turkington and Walsh (1999) in the Australian market.

Table 2.1: Summary of Empirical Results

Relationship between futures prices and spot prices	Authors	Markets	Products
Futures prices lead spot prices	Campbell and Hendry (2007)	Canada	Canadian government bond
	Oellermann, Farris and Brorsen (1989)	U.S.	Feeder cattle
	Schroeder and Goodwin (1991)	U.S.	Live hog
	Chan(1992)	U.S.	Major Market and S&P 500 Index
	Min and Najand (1999)	Korea	KOSPI 200 Index
	Shihabudheen and Padhi (2010)	India	Gold, Silver, Castor seed, Jeera, Sugar ,Crude oil
	Zhong, Darrat and Otero (2004)	Mexico	IPC index
	Mahalik, Acharya and Babu (2014)	India	Agriculture futures price index, energy futures price index, aggregate commodity index
	Kao and Wan (2008)	U.S. and U.K.	Natural gas
	Feng, Liu, Lai and Deng (2007)	Nordic Europe	Electricity
Spot prices lead futures prices	Wang, Wu and Jiang (2001)	China	Copper
	Yang, Yang and Zhou (2012)	China	CSI 300 Index
	Pradhan (2017)	India	Nifty Index
	Qin and Heo (2017)	Korea	VKOSPI Index
Bilateral causality	Silvapulle and Moosa (1999)	U.S.	WTI crude oil
	Zha (2014)	China	Soybean
	Shu and Zhang (2012)	U.S.	VIX index
	Ersoy and Çıtak (2015)	Turkey	ISE-30 Index
	Floros (2009)	South Africa	FTSE/JSE Top 40 f stock index
	Turkington and Walsh (1999)	Australia	All-Ordinaries Index

Source: Developed for this study

2.3 Background of industry

As a precious metal, gold has the characteristics of stable value and not being easy to damage. Gold has also been used as a currency for circulation, and as the economy continues to evolve, gold has also developed its financial attributes. After the subprime mortgage crisis in the United States in 2008, many investors who invested in the bond market and the stock market suffered heavy losses. People became more aware of the hedging characteristics of gold. Gold has become an important investment tool and has been better developed. Because of these characteristics and attributes, gold has many functions and uses, such as balancing the balance of payments and maintaining the national currency exchange rate. At present, gold is still purchased and stored by most governments as reserve funds to maintain the stability of currency and economy. Gold is also the symbol of national wealth and the foundation of currency credit. In the first half of 2017, China produced a total of 206.542 tons of gold.

There are now five major Gold Exchanges in the world: the London Gold Exchange, the U.S. Exchange, the Zurich Exchange, the Tokyo Exchange and the Hong Kong Exchange. Currently the London gold market is the world's largest gold market. In the global market, investors can trade continuously for 24 hours, which forms a global gold trading market with continuous transactions.

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 so on. 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 avoid risks effectively.

Table 2.2: Contract Specification of Gold Futures Contract

Product	Gold
Contract Size	1 kilogram/lot
Price Quotation	(RMB) Yuan /gram
Minimum Price Fluctuation	0.05 Yuan/gram
Daily Price Limit	Within 3% above or below the settlement price of the previous trading day
Contract Series	Monthly contract of the recent 3 consecutive months and consecutive even months contracts within the recent 11 months
Trading Hours	9:00 a.m. to 11:30 a.m., 1:30 p.m. to 3:00 p.m. (the Beijing Time) and other trading hours as prescribed by the SHFE
Last Trading Day	The 15th day of the spot month (If it is a public holiday, the Last Trading Day shall be the 1st business day after the holiday)
Delivery Period	The 5 consecutive business days after the last trading day
Grade and Quality Specifications	Domestic product: gold bullion with a fineness of no lower than 99.95% Foreign product: Standard bullions of the suppliers and refiners of the gold list of LBMA good delivery that are certified by the SHFE for physical delivery. (More details on quality specifications to be found in the Appendix)
Delivery Venue	SHFE Certified Delivery Warehouse
Minimum Trade Margin	4% of contract value
Settlement Type	Physical Delivery
Contract Symbol	AU
Exchange	SHFE

Source: Shanghai Futures Exchange

CHAPTER III

RESEARCH METHODOLOGY

This chapter presents the details about the source and length of data included in this study. Various econometric methods including Unit Root Test, Cointegration Test, Vector Error Correction Model Test, Granger Causality Test and Impulse Response Function Test are shown. And the chapter ends with the research hypotheses to be tested in this study.

3.1 Data collection

On January 9, 2008, the first futures contract of gold was listed on the Shanghai Gold Futures Exchange. Therefore, this paper selects the 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 report chooses 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 theory suggests that if non-stationary time series data are used directly for the econometric study with stationary time series data as a prerequisite, it will lead to "pseudo-regression" phenomena that affect the validity of the results. In order to avoid the occurrence of "pseudo-regression", the stationarity of time series data should be tested. 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:

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

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

$H_0: \delta = 0$
$H_1: \delta < 0$

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} represent 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.

In the process of doing ADF test, if the absolute value of the Augmented Dickey-Fuller statistic of the coefficient δ in the above equation is higher than the value of the critical value of the t value, then the null hypothesis, δ=0, can be rejected. There is no unit root in this series, and this series is stationary. However, if the test cannot reject H_0, then this indicates that the series is not stationary. Therefore, we need to perform a difference method to correct it and then do the ADF test again. If it is still not a stationary series, then the difference is needed again. This process will continue until the stationary series is obtained. We can use this to determine the order of the series.

3.2.2 Cointegration Tests

The ADF test is used to test 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, check whether the first difference term is stationary. If the two series are integrated of the same order, then we can do the next test, that is, cointegration test.

From the economic mechanism, the existence of some long-run equilibrium relations among economic variables can be tested. In the short-run, when an economic variable deviates away from its long-run equilibrium after being disturbed 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 cannot be said that there is an equilibrium relationship between these variables. Cointegration test is used to investigate a question: Is there a long-term equilibrium relation existing between non-stationary variables? In this paper, Johansen method is used to verify whether there actually exists cointegration relation between the prices in futures and spot market of gold.

3.2.3 Johansen Method

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:

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

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

Johansen (1988,1991) provides two methods to test the amount of cointegration vectors, which are the trace test and the maximum eigenvalue test.

1) Trace test

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

$$H_{r0}:\ \lambda_{r+1} = 0$$
$$H_{r1}:\ \lambda_{r+1} > 0,\ r = 0,1,\cdots,k-1$$

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.

2) Maximum Eigenvalue test

$$\lambda_{max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \quad (7)$$

$$H_{r0}: \lambda_{r+1} = 0$$
$$H_{r1}: \lambda_{r+1} > 0, r = 0, 1, \cdots, k-1$$

Under this model, $\lambda_{max}(r, r+1)$ is simply modeled as ξ_r. First of all, the ξ_0 will be examined. If ξ_0 is less than the critical value, then the cointegration vector does not exist. Conversely, if ξ_0 is more than the critical value, then H_{00} will be rejected. This shows that the equation has at least one cointegration vector. Next is to test ξ_1. If ξ_1 is significant, then the alternative hypothesis H_{11} with at least two cointegration vectors cannot be rejected. This process will be continued until H_{r0} is not rejected and it can be concluded that there are *r* cointegration vectors in all.

3.2.4 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 with further analysis for 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.

3.2.5 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:

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

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

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.

3.2.6 Impulse Response Function

Granger Causality test only examines the directional relation between spot price and futures price, but it does not give a precise guidance relationship. 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:

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

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

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. As can be seen from the model, 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 of a certain variable affects other variables 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.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter reports the results obtained from various econometric tests. 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 4.1: Results of Unit Root Test

	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**

**Denotes 1% significance level

Table 4.1 displays the results of the unit root test. It can be seen that the p-values of the original series of gold spot price and futures price are 0.3888 and 0.3411, respectively. Both series have p-values greater than 1%, implying that the null hypothesis that there is at least one unit root cannot be rejected at the level of 1% significance. And the two series are not stable at this time. So the first order difference for the two series is then applied, and then the ADF test is done again 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. Next test is therefore, the Cointegration Test.

4.2 Cointegration Test Results

Table 4.2: 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	-12004.13	30.79731	67.79496	9.892242	9.916101	9.900916*
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

* indicates lag order selected by the criterion

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. However, in many cases, the optimal lag order by different criteria may be different. Table 4.2 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 4.3: 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

Table 4.4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.086106	218.7999	14.26460	0.0001
At most 1	0.001210	2.941807	3.841466	0.0863

The results of the Trace test and the results of the Maximum Eigenvalue test are reported in Table 4.3 and Table 4.4, respectively. As can be seen from Table 4.3, in the 5% level of significance, the null hypothesis of "no cointegration vector" is rejected. This means that at least one cointegration vector exists between the spot price and the futures price. 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" cannot be rejected at the level of 5% significance, so there is only one cointegration vector between the futures price and the spot price. The same result is also obtained by the Maximum Eigenvalue test in Table 4.4. Therefore, it can be concluded that there is a long-run equilibrium relationship between gold futures price and gold spot price.

4.3 Vector Error Correction Model (VECM) Results

The expression of VECM is only applicable to the cointegration series, and the previous table reports the cointegration relationship between gold futures price and spot price, Vector Error Correction Model (VECM) is now applied to test their short-term relationships, and the results are obtained in Table 4.5.

Table 4.5: Vector Error Correction Model Test

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

t-statistics in [ ]
*Denotes 5% significance level
**Denotes 1% significance level

Firstly, equation (8), which is the equation of Au99.95 spot price is analyzed. According to Table 4.5, 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 significant statistically at 5% level. This means that the gold futures price does not have a leading function for the spot price.

Then we analyze the equation (9), which is the equation of gold futures price. 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 4.6: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
AU9995 does not Granger Cause AU00	2431	88.3583	4.E-70**
AU00 does not Granger Cause AU9995		1.65483	0.1578

**Denotes 1% significance level

Table 4.6 shows 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 of "AU9995 does not Granger Cause AU00" is rejected. 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, so Gold Futures Price does not Granger cause the Spot Price.

Through 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. The guidance of the Chinese gold spot market on the futures market is unidirectional. Investors can predict gold futures prices based on gold spot prices, and 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 well realized.

4.5 Impulse Response Function Results

In order to better study the dynamic relationship between gold futures prices and gold spot prices, this paper will use the Impulse Response Function to further examine 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 4.1: Impulse Responses of Spot Price (AU9995)

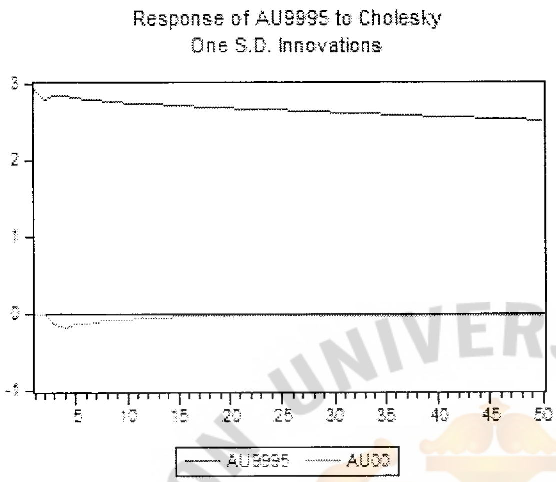

Figure 4.2: Impulse Responses of Futures Price (AU00)

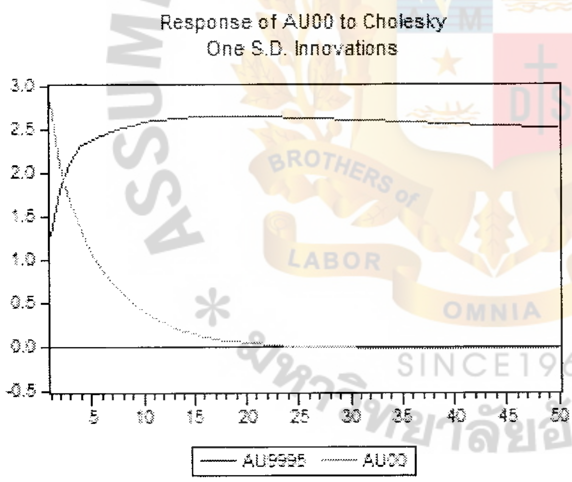

Figure 4.1 shows the response of the gold spot price (AU9995) to a standard deviation shock of its own and a standard deviation shock of the futures price (AU00). It can be seen that the spot price has a relatively large response to a unit shock of its own, reaching a maximum of 2.9 in the first lag 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 4.2 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). According to Figure 4.2, it can be seen that 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 and falls 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, from the above analysis, 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 the previous tests.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the previous findings and draws conclusions. Implications and recommendations for future research on price discovery functions in futures markets are also illustrated in this chapter.

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. This paper first analyzes the reasons for the formation of the price discovery function in the futures market from a theoretical perspective. Then this paper reviews the literature on the study of the price discovery function of the futures market in various countries. Through comparative analysis, reference and absorption of knowledge, the econometric models used in this paper are Cointegration test, VECM test, Granger Causality test and Impulse Response. The Cointegration test is used to test the long-run relation between the price of Au99.95 and the price of continuous futures, and the short-term relationship is examined by the Vector Error Correction Model. Granger Causality test and Impulse Response are used to investigate the direction of the relation between Au99.95 spot price and gold futures price. Through empirical analysis, 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 unstable. However, after the first order difference of the two series, there is no unit root at 1% significance level, that is, the two series are stationary. On this basis, the Cointegration test of gold spot price series and gold futures price series verifies that there is a long-term stable equilibrium relation between gold futures price and gold spot price.

(2) From the research results of the Vector Error Correction Model for analyzing short-term dynamic relations, it can be seen 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 we 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 the futures market.

(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 more 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, we can draw the conclusion that the price discovery function of Chinese gold futures market is weak, and the gold spot market is still playing a major role in price discovery.

5.2 Conclusion

The conclusion from the above empirical analysis is that the Chinese gold futures market does not have a price discovery function. This is consistent with previous empirical studies, such as the copper futures market studied by Wang, Wu and Jiang (2001) and the CSI 300 index futures market researched by Yang, Yang and Zhou (2012) in the same Chinese context, and also the Nifty Index futures market researched by Pradhan (2017) in the Indian context and the futures market of VKOSPI Index examined by Qin and Heo (2017) in Korea.

The reason for this result may be that the Chinese gold futures market is still in the initial stage of development because of its relatively late start compared with developed countries, and its development is still very immature. Therefore, it does not perform the price discovery function like the futures market in developed countries. The deeper reason may be: (1) 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. (2) The investor structure of China gold futures is not reasonable, and most of the investors are Futures Company with the purpose of speculation and arbitrage, while the spot traders with hedging as the purpose are less. Hedging is the link between spot market and futures market, which can make the prices of the two markets more reasonable. Too few hedgers will inevitably lead to a reduction in the efficiency of price discovery in the gold futures market.

5.3 Implications

The findings of this paper are beneficial to producers, operators and investors 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.

5.4 Recommendations for Future Research

(1) As the gold spot market has many varieties, not only Au99.95 but also Au100g, Au99.99, etc., this paper only selects Au99.95 as a proxy of China's gold spot price. Therefore, the gold spot price data may not represent the entire gold spot market. 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) This paper only studies the leading relationship between China's gold futures market and the spot market. However, information is not only transmitted within one country, but also between futures market and spot market in different countries. Therefore, we can do further empirical research on the relationship between international gold futures and spot prices and domestic gold futures and spot prices.

(3) 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 article does not discuss in depth the factors that affect the price discovery function of the gold futures market. Further research can focus on finding out the reasons why the price discovery function cannot be effectively played, and what effective measures can be taken to improve the leading function of China's gold futures prices and how to improve the effectiveness of the futures market.

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