Arbitrage with CSI 300 Stock Index Futures: An analysis

By

Xue Mi

A Masters Research Project Submitted to
Saint Mary's University, Halifax, Nova Scotia in Partial Fulfillment of the Requirements
for the Degree of Master of Finance.

September, 2015, Halifax, Nova Scotia

Approved: Dr. George Ye
Faculty Advisor

Approved: Dr. Colin Dodds
MFIN Director

Date: September 10, 2015

Table of Contents

Acknowledgments……....…3
Abstract…….……4

Chapter 1: Introduction…….……5
1.1 Introduction of arbitrage……...……...….5
1.2 Purpose of study…….……..…5
1.3 Chapter organization…….…..6

Chapter 2: Literature Review……7
2.1 Empirical studies on ETF arbitrage opportunities…….…....7
2.2 Model decision……..……..9
2.3 Arbitrage costs…….…..…11

Chapter 3: Research Methodology…….……17
3.1 Cost of carry model after consider the trading costs…….……17
3.2 Cost of carry model with margin trading...……..…….19
.
Chapter 4: Result and Findings……...……22
4.1 Data choosing…….....22
4.2 Parameter determinations.....…….…24
4.3 Analysis of arbitrage opportunity under the cost of carry model……..…26
4.4 Calculation of actual yield of stock index futures arbitrage……..…32
4.5 Analysis of the results of empirical research…….35

Chapter 5: Conclusions and Recommendations……..39

References…….…..41

Acknowledgements

I would like to thank professor George Ye for his advice in completing this project. I also would like to thank all those people who directly or indirectly helped and guided me to complete this program. Lastly, I would like to express my appreciation to my friends and my family for their encouragement and patience.

Abstract

Arbitrage with CSI 300 Stock Index Futures: An analysis

by Xue Mi

Abstract: Based on the cost of carry model for futures pricing, this paper discussed the arbitrage-free interval in China spot-futures arbitrage trading market. The cases we analyze are the arbitrage between CSI 300 futures contract and the Huatai-PineBridge CSI 300 ETF, Harvest CSI 300 ETF based on the 1-minute high frequency data for 20 days. We find that the CSI 300 index futures' forward arbitrage opportunities do exist; however, they are related to the costs of the arbitrage capital. Compared to Huatai-PineBridge CSI 300 ETF, Harvest CSI 300 shows more arbitrage opportunities and a higher rate of return. This efficiency difference is a result of the subscription and redemption mode and trading mechanism of the two ETFs. The results indicate that China stock market is not fully efficient, although the mispricing duration is short.

Key words: Cost of carry model; Stock index futures; Spot-futures arbitrage;

September 10, 2015

Chapter 1 Introduction

1.1 Introduction of Arbitrage

The transaction types of stock index futures contracts generally include hedging, speculating and arbitraging. For arbitrage, it seeks the opportunity of market price deviation to obtain the risk-free profit. The study of arbitrage opportunities is both theoretically and practically significant. In practice, arbitrages provide a relatively stable, low-risk opportunity for investors to obtain revenues; to contribute to the correction of asset price to the true value; and also to stabilize the financial market. In theory, the study of arbitrage is a most influential test of efficient market theory, where there should be no arbitrage opportunities in an efficient market. When arbitrage opportunities arise, the sooner arbitrageurs activity is fell-in the market, the higher the degree of market efficiency; on the contrary, the presence of persistent arbitrage opportunities in the market means that the market is of very low efficiency.

1.2 Purpose of Study

In theory, the cost of carry model is only set up under the perfect market assumption, which ignores the cost of arbitrage. Moreover, the real financial market contains a lot of constrains such as transaction cost, short selling restrictions, lending and borrowing rate and so on, as a result, the simple application of the cost of carry model will overestimate the arbitrage revenue. In this paper, we consider the cost of carry model under a loosen condition, analyze the cost of the actual arbitrage activities, and then find out the arbitrage-free interval tailored to the Chinese financial market. On this basis, we discuss

the arbitrage revenue and the efficiency of financial markets.

1.3 Chapter Organization

Following is the main structure of this paper:

Chapter 1 provides the background and introduction of the arbitrage and the purpose of this study.

Chapter 2 is the introduction of cost of carry model. We discuss several costs of arbitrage in reality and revise the model.

Chapter 3 mainly discusses the methodology of this study. Basically, the cost of carry model after the consideration of different transaction costs.

Chapter 4 covers empirical results, we select the model parameters that accord with the actual situation of China's capital markets and find out arbitrage-free interval and arbitrage rate of return.

Chapter 5 is the conclusion and analyzes the problem that may exist in the process of stock index futures arbitraging.

Chapter 2 Literature Review

2.1 Empirical Studies on Arbitrage Opportunities

2.1.1 Studies on arbitrage in non-chinese market

The research of arbitrage on stock index futures is derived from the study of stock index futures contract pricing by Cornell and French (1983). They put forward the cost of carry model, which is the stock index futures contract pricing under the assumption of perfect capital market. On this basis, Cornell and French made an empirical research on S&P 500 stock index futures hedging performance and risk and found that the arbitrage opportunities quickly disappear. Ramaswarny and MacKinlay (1988) conducted a research on S&P 500 stock index futures and the data of spot trading day; they discovered that the volatility of futures price is more than the volatility of the spot index prices. They put forward two assumptions, which can explain mispricing: the degree of mispricing increases with the increase of maturity of the contract; and the mispricing is path dependent. Merrick (1988) 's empirical research suggests that, between 1982 and 1984, the stock index futures arbitrage trading could eliminate 85% mispricing of the day; and from 1985 to 1986, 90% mispricing of the day can be eliminated. Obviously, arbitrage trading is helpful to improve the market efficiency. The cost of carry model can determine the futures price to a great extent although there are still arbitrage opportunities.

Later, the researchers modified the basic cost of carry model when they took the cost of arbitrage into consideration. For example, Klemkosky and Lee (1991) found that the

price of S&P 500 stock index futures contract was overestimated in most of the time after they took borrowing rate, transaction cost, tax, dividend yield into consideration in the cost of carry model. In general situation, the arbitrage space still exists when the arbitrage signal appeared about 10 minutes. They also found that, with the maturity date of the futures approach, the amplitude and frequency of mispricing would get lower. Chang (1991) discussed the impact of different transaction cost, trading latency, short sale constraints on the cost of carry model and found the previous research overestimated the profit of arbitrage.

In recent years, with the establishment of stock index futures in emerging markets, many scholars have also studied the arbitrage situation under a relatively imperfect market. For example, Puttonen (1993) verified a Finland arbitrage situation in an emerging stock index futures market. He found that the short-sell restriction does not exist in the Finland market. Wang (2010) applied 5 minutes intraday data to research the Singapore stock index futures market, which contains short sell constraints, transaction risk, market impact cost and the regulatory barrier and found that the relaxation of the short sell restriction are conductive to narrowing the arbitrage-free interval, improve market efficiency.

2.1.2 Studies related to arbitrage on China's market

China's stock index futures were launched in April 2010, and provide only CSI 300 stock index futures products to present. Due to the recent entry of the stock index futures in China's market, the studies of stock index futures arbitrage were conducted on the

simulation trading data. For example, Xiaokun Hang and Jinming Hou (2009) achieved a research on the arbitrage between Exchange Traded Funds and stock index futures' simulation trading data. After the launch of stock index futures, the researchers started to test the arbitrage opportunities between Exchange Traded Funds and CSI 300 stock index futures using real trading data. Zhuo Wei (2012) applied SSE (Shanghai Stock Exchange) 50, SSE dividend index and SZSE (Shenzhen Stock Exchange) 100 Exchange Traded Funds to take place of CSI 300 stock index; as a result, he discovered that the opportunity of unilateral arbitrage exist; however, this substitution led to a relatively large error, since no underlying stock corresponding to the stock index futures was available at the moment. In April, 2012, two fund management companies of China, Huatai-Pinebridge Fund Management Co., Ltd and Harvest Fund Management Co., Ltd, introduced the Exchange Traded Funds with CSI 300 index as the subject matter, after which, Tingli Yu (2012) found that an arbitrage opportunity could exist among Huatai-Pinebridge CSI 300 Exchange Traded Funds, Harvest CSI 300 ETF, and stock index futures when the cost of carry model is applied.

2.2 Model Decision

According to the cost of carry theory (French and Cornell 1983), the price relationship between futures and spot is as follow:

$$F_{t,T} = S_t \times [1 + (r - d) \times \frac{T-t}{360}] \quad (1)$$

Where,

$F_{t,T}$ represents stock index futures theoretical price in time t;

S_t is the real spot price at time t;

r is borrowing rate (we choose the situation of simple interest rate);

d is the dividend yield when the contract expires;

T is the time of the futures contract expires;

t is the current time,

then (T-t) is the remaining time (days) of futures contracts.

We consider the forward arbitrage transaction first (buying spot, short selling stock index futures). When the actual price of the stock index futures contract beyond the theoretical price at time t, that is, the price ratio between futures and spot is greater than $[1 + (r - d) \times \frac{T-t}{360}]$, arbitragers short sell stock index futures and buy the spot which is underestimated at the same time. When the contract expires, arbitragers will obtain the arbitrage gains by short sell the spot at the stock index futures' price and repay the principal and interest. However, in an actual operation, investors may not hold the futures and spot to maturity. They may close the position if the difference between real and theoretical price reduces before the maturity date.

Then we focus on reverse arbitrage transactions (short sell spot and buying stock index futures). When the price ratio between futures and spot is less than $[1 + (r - d) \times \frac{T-t}{360}]$, arbitragers short sell the spot and buying the stock index futures at the same time. When the contract expires, they buy spot at stock index futures price to fill the spot short. Similarly, investors will close the position before the maturity date if the difference between real and theoretical price reducing to the normal level.

Formula (1), that is, $F_{t,T} = S_t \times [1 + (r - d) \times \frac{T-t}{360}]$ is the theoretical model of stock index futures under the perfect market hypothesis. It is assumed that the capital market is perfect, that is, there is no tax and transaction costs; and no restrictions on short selling transactions; the assets can be infinitely subdivided; Risk- free interest rate is equal to and remain the same, and so on. However, the reality of the financial markets is often not satisfied with these assumptions. As a result, we will consider the cost of carry model under a relatively loosen constrain, and analyze the cost of actual arbitrage activities one by one, and then find out the non-arbitrage interval.

When taking the arbitrage costs into account, either a forward arbitrage or a reverse arbitrage, the profit of arbitrage activities is generated by the difference (spread) between futures contract real price and the theoretical price. When the spread is greater than the cost of arbitrage activities, we obtain a positive profit. That is:

$$|F_{t,T} - F_t| > C$$

In this equation,

C represents the arbitrage costs,

F_t is the market price of futures contracts at time t,

F_t is different from the theoretical price, $F_{t,T}$.

2.3 Arbitrage Costs

Arbitrage costs mainly include the trading cost of trading futures and the spot, margin

trading costs, stock index futures margin interest costs, tracking errors and impact costs, etc. Next, we analyze the costs factors respectively under the situation of China's financial market, and discuss the cost of carry model under a relatively loose perfect market assumption.

2.3.1 the Transaction cost

Transaction cost is the main cost of arbitrage. In the process of trading futures and spot, the broker may charge a commission to the transaction in accordance with the proportion of the share of the transaction. The commission rate includes the relevant fees charged by the securities exchange, the registration and clearing institution. Currently, the Exchange Traded Funds transaction do not charge transfer fees and stamp duty in China. We use C_{RS} and C_{RF} represent the one-way transaction rate of spot and futures. Since the different between buy and sell price is small in the high frequency trade, we use $2C_{RS}$ and $2C_{RF}$ to represent the transaction costs at time t.

2.3.2 Margin trading interest rate

In practice, there is a problem of the different interest rate of lending and borrowing. We choose a current deposit interest rate, however, the deposit interest rate is very low (0.43%), and the deposit term is short, we believe that the deposit interest can be neglected. We choose financing interest rate as the lending rate.

Arbitrage traders in the process of buy and sell spot will be related to the margin trading business. Financing (margin) means borrowing money to purchase the spot ETF. Margin trading-short occurs when investors sell the securities, which borrowed from brokers. We use C_{M1} and C_{M2} to represent financing interest rate and margin interest rate respectively. Also, the financing interest rate and margin interest rate are on a daily basis, that is, daily financing interest rate equals to $C_{M1}/360$, and daily margin interest rate equals to $C_{M2}/360$.

In the actual operation process, the majority investors will not hold stock index futures until expiry since they will close the position when the price backs to a normal level. As a result, the actual number of days cannot be decided before the margin.
However, when investors seek arbitrage opportunities, compared to the uncertainty of price movement, holding to maturity is more a certainty. Therefore, we calculate the arbitrage opportunity under the assumption of holding the futures to maturity.

2.3.3 Tracking errors

Currently, we can only find Shanghai and Shenzhen 300 stock index futures in China's stock index futures market. In the spot trading process, if the arbitragers buy and sell Shanghai and Shenzhen 300 index constituent stocks as the underlying assets directly, the operation is complex and cost a lot. Therefore, they trade CSI 300 ETF, which minimizes the tracking error of CSI 300 index by using the fully replicated passive investment

management strategy. At present, there are two CSI 300 ETFs in China's financial market, Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF, in the contract, some terms declare that they will control the daily tracking error degree within 0.2% and annually tracking error degree within 2%. For instance, Huatai-Pinebridge CSI 300 ETF was established in May 2012. To the end of that year, the accumulative tracking error is +1.4%, and the absolute value of the average daily tracking error degree is 0.022%. As a result, in the following analysis, we will regard CSI 300 ETF as the underlying asset of the stock index futures contract, and ignore the tracking error between ETF and underlying assets.

2.3.4 Impact cost

The impact cost is measured in the chosen numeraire of the market, and is how much additionally a trader must pay over the initial price due to market slippage, i.e. the most incurred because the transaction itself changes the price of the asset (Wiki, 2015).The better the market liquidity, the smaller the impact cost; and given the market liquidity, the smaller the size of the transaction, the smaller the impact cost. Overall, the liquidity of CSI 300 index constituent stock and ETF is very good; the impact cost is negligibly small unless the transaction amount is extremely large.

Ping An Securities Research Institute (2010) calculated the annually impact cost of the small and medium-size board ETF and SSE 180 ETF around 0.1 million Yuan volume of the transaction is less than 2%. Consider the liquidity of CSI 300 ETF is better; the

impact cost should be smaller. For example, the CSI 300 constituent stock is the top 20 of average daily volume, and the impact cost of 1 million Yuan volume is less than 0.01%. Compare to the spot, the impact cost of stock index futures are lower, which is only 0.015%. Due to the low impact cost and the difficult to measure directly, the following analysis assumed the impact cost could be neglected.

2.3.5 Margin interest rate opportunity costs

To control the risks, a security deposit may be required in securities margin trading and futures trading. When the stock index futures and spot price fluctuate, the minimum margin requirement amount will change accordingly. If the margin deposit does not meet the minimum requirements, investors will be forced to close the position. Therefore, investors should have sufficient margin deposit, and this margin deposit has an opportunity cost of interest. Even though the change of margin deposit will cause the opportunity cost of interest difficult to measure, according to the current situation of China's financial market, futures companies generally do not pay deposit interest, when the securities institution will pay the margin deposit interest counted at the rate of current deposit. As mentioned above, due to the low rate and short effective period of current deposit interest rate, the basic analysis result will be not effected if we ignore the opportunity cost of the margin interest rate.

2.3.6 Dividend yield

The dividend yield of constituent stocks of CSI 300 index asset portfolio will affect the price and lead to the uncertainty of the arbitrage transaction. Theoretically, we can estimate the annual dividend rate based on the historical dividend payment. In China's capital market, the dividend rate is relatively low, as an example the 2012 CSI 300 stocks weighted average dividend rate was 2.06%; also dividend in China's stock market generally only announced in the annual final report, the actual time of paying the dividend is about 5 to 7 months after the completion of the disclosure of the annual report. As described below, the sample period of this study is from March 2013 to April 2013, where the dividend rate of CSI 300 index before April 19th, 2012 is only 0.027%, which concludes only 1% of the total dividend in that year. Therefore, we set the dividend yield equals to zero.

Chapter 3 Research Methodology

3.1 Cost of Carry Model After Consideration of Trading Costs

3.1.1 Cost of carry model with equity fund, and the arbitrage-free interval

In the forward arbitrage transactions, we assume that purchase fund of spot, transaction costs, and margin deposits are all come from equity. That is, investors will not generate fund from financial institutions, will not consider the use of securities companies' financing services, and will consider no extra margin costs. Under this assumption, we consider the price ratio between futures and spot in the forward arbitrage trading. That is, investors buy the spot S_t, and shot sell stock index futures at time t to open a position. They reverse the operation to close the position afterwards. Considerate the two-way trading fees of both the spot and the futures, the transaction costs of forward arbitrage activities were shown in Table 1 and Table 3.

Table 1: Transaction fees in forward arbitrage trade

	Cost
Spot trade	$2C_{RS}S_t$
Futures trade	$2C_{RF}F_t$
Total	$2C_{RS}S_t + 2C_{RF}F_t$

The total costs of the forward arbitrage transaction is:

$$C = 2C_{RS}S_t + 2C_{RF}F_t \qquad (2)$$

Investors can precede a forward arbitrage if the following conditions can be satisfied:

$$F_t - F_{t,T} > C = 2C_{RS}S_t + 2C_{RF}F_t \qquad (3)$$

Put equation (1) & (2) into (3) we can get:

$$P_R = \frac{F_t}{S_t} > \frac{1+(r-d)\times\frac{T-t}{360}+2C_{RS}}{1-2C_{RF}} \qquad (4)$$

Then we consider the price ratio between spot and futures in a reverse arbitrage activity. The reverse arbitrage trade will involve margin trading, although investors have their own equity funds. That is, investors short sell a basket of stocks borrowed from Security Company and see it as a short sell spot S_t at time t, and buy the stock index futures at the same time. Then at time T, investors buy the spot at F_t's price to cover the short position. Similarly, considering the two-way trading fees and the borrowing costs respectively, the transaction costs of reverse arbitrage activities were shown in Table 2.

Table 2: Transaction costs in reverse arbitrage trade

	Spot Trade (Short sell)	Future Trade (Buy)
Transaction Cost	$2C_{RS}S_t$	$2C_{RF}F_t$
Margin Cost	$\frac{T-t}{360}C_{M2}S_t$	0
Total	$[2C_{RS}+\frac{T-t}{360}C_{M2}]S_t$	$2C_{RF}F_t$

Investors can proceed a reverse arbitrage if the following conditions can be satisfied:

$$F_t - F_{t,T} > C = \left[2C_{RS} + \tfrac{T-t}{360}C_{M2}\right]S_t + 2C_{RF}F_t \qquad (5)$$

Similarly, we can prove that:

$$P_R = \frac{F_t}{S_t} < \frac{1+(r-d-C_{M2})\times\frac{T-t}{360}-2C_{RS}}{1+2C_{RF}} \qquad (6)$$

Considering the forward and reverse arbitrage, we can get the arbitrage-free interval of the spot and future price ratio:

$$\frac{1+(r-d-C_{M2})\times\frac{T-t}{360}-2C_{RS}}{1+2C_{RF}} < P_R < \frac{1+(r-d)\times\frac{T-t}{360}+2C_{RS}}{1-2C_{RF}} \qquad (7)$$

3.1.2 Cost of carry model with margin trading, and the arbitrage-free interval

In the forward arbitrage trading, some of the investors do not have a large amount of cash assets to carry out in arbitrage activities. As a result, they can choose the way of financing to carry on the investment. However, investors generally cannot get short-term loans from banks as the fund of arbitrage trading. More often, the funds of buying a basket of stocks or an investment portfolio is come from the financing business provided by the security companies. We assume that all funds are coming from the financing business, only the transaction cost and margin deposit come from their own equity funds. Under this assumption, the price ratio between spot and futures of the forward arbitrage will be recalculated. In the forward arbitrage process, investors buy the spot using the funds generated through the security companies at time t, at the same time, they short sell stock index futures to open the position. As a result, the costs of the forward arbitrage transaction is shown in Table 3:

Table 3 Transaction costs in forward arbitrage trade with margin trading

	Spot Trade (buy)	Future trade (short sell)
Transaction Cost	$2C_{RS}S_t$	$2C_{RF}F_t$
Margin interest	$\frac{T-t}{360}C_{M1}S_t$	0
Total	$[2C_{RS}+\frac{T-t}{360}C_{M1}]S_t$	$2C_{RF}F_t$

We can find the transaction costs of forward arbitrage activities changed by the appearance of margin interest:

$$C = \left[2C_{RS} + \frac{T-t}{360} C_{M1}\right] S_t + 2C_{RF} F_t \qquad (8)$$

Compare to the analysis of no arbitrage interval when using equity funds, the no arbitrage interval of the spot and the future price ratio with margin trading is:

$$\frac{1 + (r - d - C_{M2}) \times \frac{T-t}{360} - 2C_{RS}}{1 + 2C_{RF}} < P_R < \frac{1 + (r - d + C_{M1}) \times \frac{T-t}{360} + 2C_{RS}}{1 - 2C_{RF}}$$

Chapter 4 Results and Findings

4.1 Data Choosing

In this paper, we use Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF as the spot since the underlying asset of these two funds is CSI 300 index, which is the same as the stock index futures' underlying asset. Moreover, Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF have a relatively large scale and good liquidity. These two funds specific product profiles are shown in Table 4.

Table 4: CSI 300 ETFs profile

Fund Name	Huatai-Pinebridge CSI 300 ETF	Harvest CSI 300 ETF
Fund Code	510300	159919
Stock Exchange	Shanghai Stock Exchange	Shenzhen Stock Exchange
Date of listing	May 28, 2012	May 28, 2012
Minimum Redemption Unit	900,000	2,000,000
Liquidity	Buy stock at T, Buy ETF at T; Buy ETF at T, Short ETF at T. Buy ETF at T, Redeem at T; Redeem stock at T, short at T.	Buy stock at T, Buy ETF at T+1; Buy ETF at T, Short ETF at T+2. Buy ETF at T, Redeem at T+2; Redeem stock at T, short at T+2.

The China financial futures exchange issue four types of CSI 300 stock index futures contract, they are expires at the end of the month; expires next month; expires at the end of the first quarter and expires at the end of the second quarter, respectively. The last trading day of each futures contract is due on the third Friday in the contract expire month. In order to guarantee the continuity and the activity of the arbitrage data, this paper will choose the same month contract data to carry out empirical research.

The trading day of IF 1304 is from February 19, 2013 to April 19th, this is a total of 42 trading days. Taking into account the final trading days of IF 1303 contract, the activity of IF 1304 contract before March 15, 2013 is limited, especially in February and early March, the trading of the futures contract is not active. However, the final trading day close to IF 1304 is too high, as a result, there is an effect of maturity, that is, with the increasing volume of amplification, the stock market and stock index futures market will appear an abnormal price fluctuations. As a result, it is more difficult for investors to complete the reverse arbitrage steadily. Therefore, we choose the data from March 11, 2013 to April 9th for the 20 trading days as a historical data to do the research.

The trading time of CSI 300 stock index futures contract is generally at 9:15 to 11:30 in the morning, 13:00 to 15:15 in the afternoon. ETF's trading hour is from 9:30 to 11:30 in the morning of the trading day, and 13:00 to 15:00 in the afternoon. To ensure the feasibility of operation and data consistency, we reject the 30 minutes difference between CSI 300 stock index futures trading time and the ETF trading hours. Due to the high liquidity in the financial market, arbitrage opportunities are often fleeting; we then select

the high frequency data of 1-minute closing price to do the research. Based on the above, this paper will use the high frequency data of 1 minute closing price from 20 trading days, that is, a total of 4800 sets of data for the measurement of data modeling and calculation (Wind).

4.2 Parameter Determinations

4.2.1 Transaction cost

According to the regulations of ETF transactions, the broker can charge commissions without exceed the standard charge of 0.5% of the purchase or redemption of shares, which includes the fees received by the securities exchange, registration and clearing institutions and other related expenses. However, according to the market situation, due to the competitive relationship between the agents and the bargaining power of block trade investors, ETF transaction costs are greatly depressed. As a result, the commission is only 0.06% of the purchase or redemption of shares. Then, we use 0.06% as ETFs transaction costs. China's current ETF transaction does not charge transfer fees and stamp duty. China Financial Exchange announced that from September 1st, 2012, the stock index futures transaction would be charged 0.0026% of total transaction amount as the transaction fee. Then, we use 0.0026% as stock index futures transaction fee to calculate the arbitrage-free interval.

4.2.2 Lending rate, financing and borrowing rate

For the calculation of the theory futures price, we need to consider the loan interest rate. Since on July 6, 2012, when the people's Bank of China lowered the benchmark interest rate of RMB deposits in financial institutions, the 6 months interest rate of short-term loans in our country is 5.6%. Considered that the actual operation process is less than 6 months, we choose this loan interest rate as the basis to calculate the theory price. In accordance with international standards, the financing and borrowing rate are 3% higher than the benchmark loan interest rate. According to China's six months short-term interest rate (5.6%), the financing and borrowing rate are 8.6%. The arbitrage cost parameters is shown in Table 5.

Table 5: Arbitrage costs

Arbitrage costs type		Symbol	Trade share percent
Transaction cost	ETF	C_{RS}	0.06%
	Stock Index Futures	C_{RF}	0.0026%
Interest rate		r	5.6%
Financing rate/Borrowing rate		C_{M1}/C_{M2}	8.6%

4.3 The Empirical Analysis of Arbitrage Opportunity Under the Cost of Carry Model

CSI stock index futures contract multiplayer is 300 Yuan per point. For one CSI 300 stock index futures contract corresponding 300,000 ETF. Therefore, we take each unit of futures trading shares as the stock index futures contracts points multiplied by 300 Yuan. Also, we take each unit of stock ETF trading shares as the current price multiplied by 300,000 units. As a result, we use one unit stock index futures contract and the corresponding spot ETF share as the unit for the arbitrage activity analysis.

4.3.1 Arbitrage opportunities under the situation of invest with investors' own equity funds

Synthesizing the discussion of the influencing factors of the cost of carry model previously and ignoring the neglected parameters, when investors are applying their own funds to carry out stock index futures arbitrage, and to substitute the selected parameters, the arbitrage-free interval of price ratio between spot and futures is:

$$\frac{1+\frac{T-t}{360}(5.6\%-8.6\%)-2*0.06\%}{1+2*0.0026\%}<P_R<\frac{1+\frac{T-t}{360}*5.6\%+2*0.06\%}{1-2*0.0026\%} \quad (10)$$

After using Stata software for data processing, programming calculation and image rendering, we found the Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF price

ratio between spot and futures and the arbitrage-free interval, as shown in Figure 1 and Figure 2.

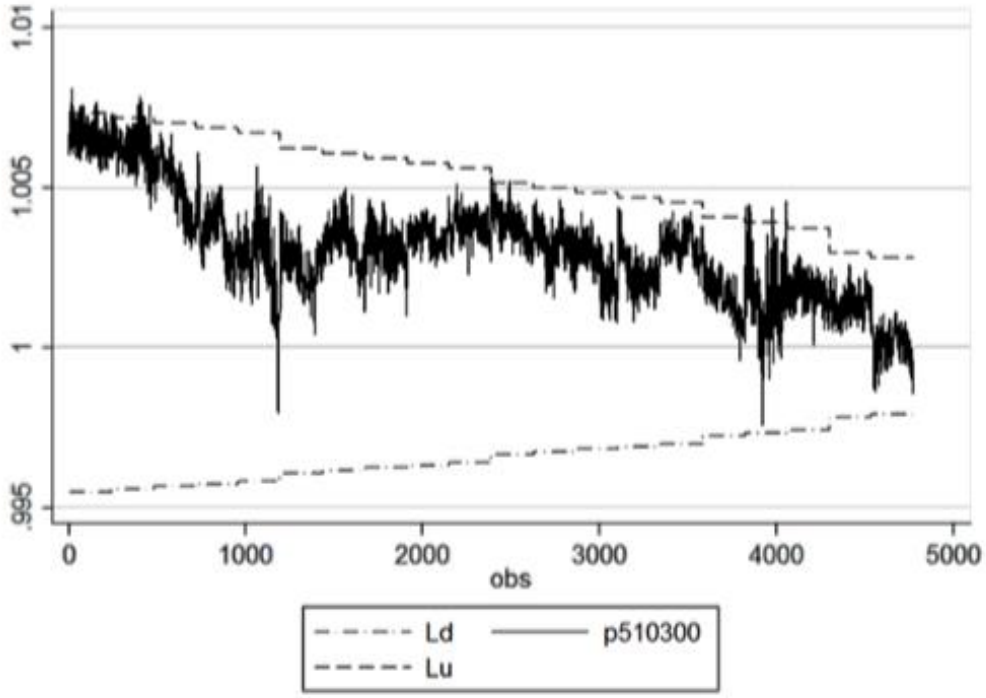

Figure 1 Huatai-Pinebridge CSI 300 ETF price ratio between spot and futures and the arbitrage-free interval (arbitrage with own funds).

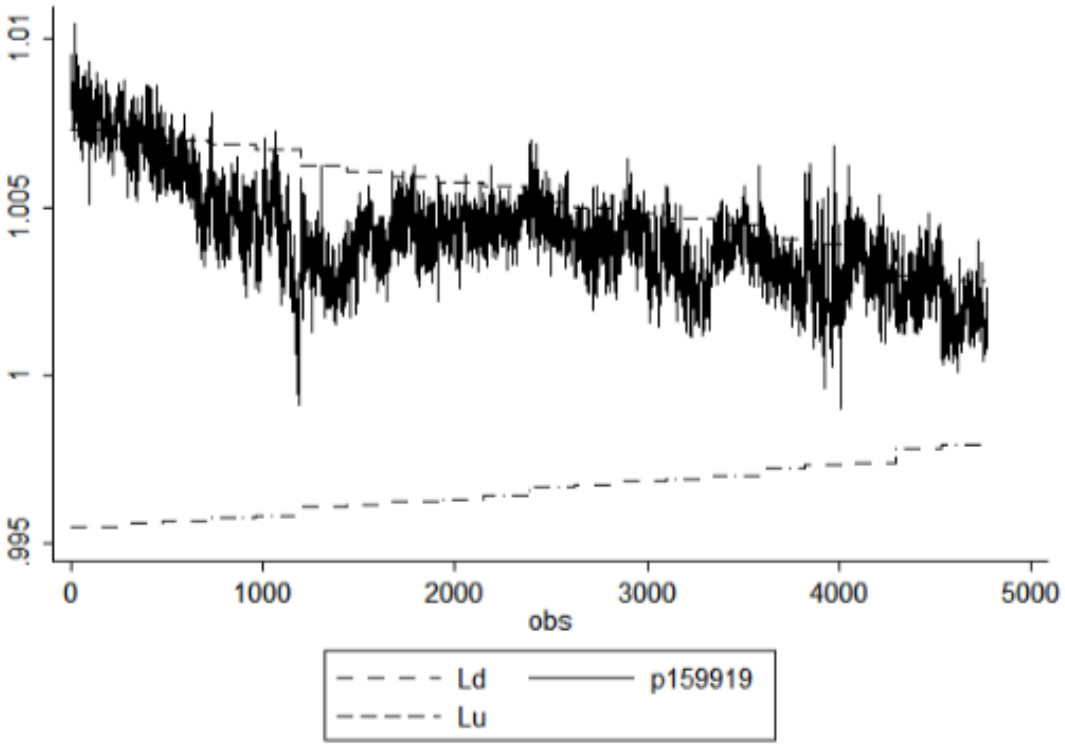

Figure 2 Harvest CSI 300 ETF price ratio between spot and futures and the arbitrage-free interval (arbitrage with own funds).

According to Figure 1 and Figure 2, during the 4800 minutes trading session, there is only a forward arbitrage opportunity in Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF. In which, Huatai-Pinebridge CSI 300 ETF has 38 minutes that the price ratio between spot and futures is greater than the upper bound of arbitrage-free interval, it means, there is a forward arbitrage opportunity. However, Harvest CSI 300 ETF has a 707 minutes long forward arbitrage opportunity. In which, Huatai-Pinebridge CSI 300 ETF has a total of 32 times that the price ratio between spot and futures is greater than the upper bound of arbitrage-free interval, but the arbitrage opportunity is fleeting at each time, the longest time of the arbitrage opportunity was only remained for 3 minutes. For

Harvest CSI 300 ETF, it has a total of 313 times that the price ratio between spot and futures is greater than the upper bound of arbitrage-free interval. Compare to Huatai-Pinebridge, Harvest CSI 300 ETF has a relatively long lasting period of mispricing, the longest one lasted about 17 minutes.

4.3.2 Arbitrage opportunities under the situation of invest with margin trading

Synthesizing the discussion of the influencing factors of the cost of carry model previously and ignoring the neglected parameters, when investors using margin trading to carry out stock index futures arbitrage, and to substitute the selected parameters, the arbitrage-free interval of price ratio between spot and futures is:

$$\frac{1+\frac{T-t}{360}(5.6\%-8.6\%)-2*0.06\%}{1+2*0.0026\%} < P_R < \frac{1+\frac{T-t}{360}(5.6\%+8.6\%)+2*0.06\%}{1-2*0.0026\%}$$

Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF price ratio between spot and futures and the arbitrage-free interval under the situation of investment with margin trading, as shown in Figure 3 and Figure 4.

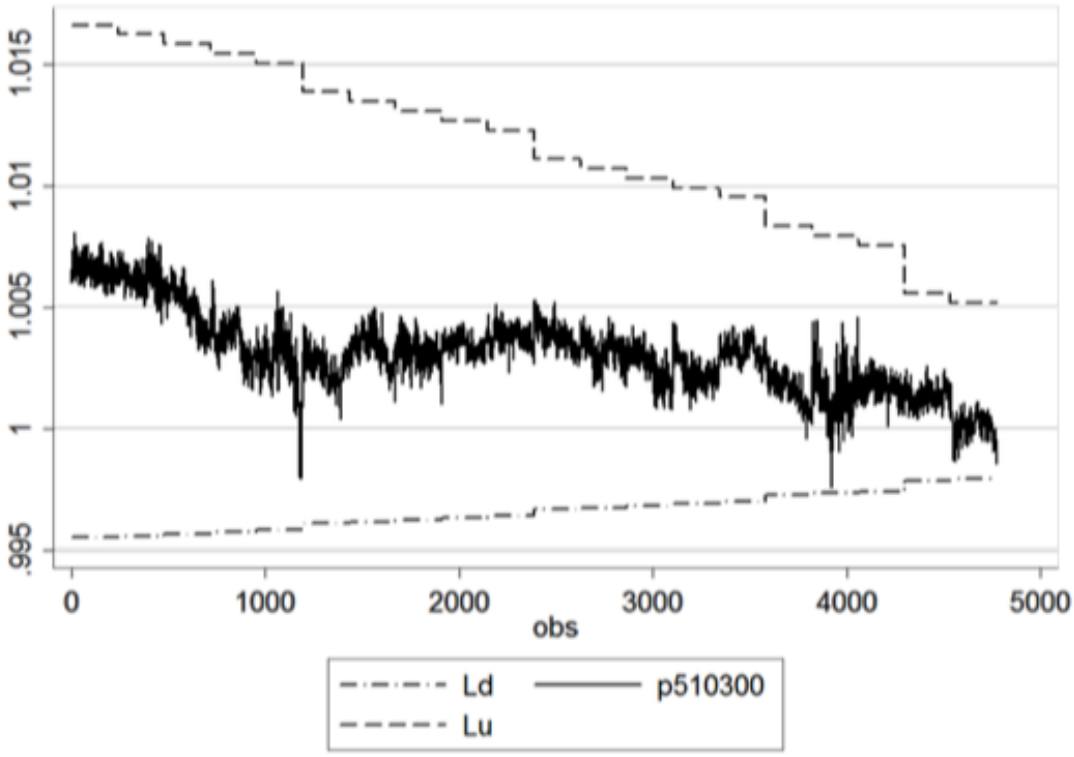

Figure 3 Huatai-Pinebridge CSI 300 ETF price ratio between spot and futures and the arbitrage-free interval (arbitrage with margin trading).

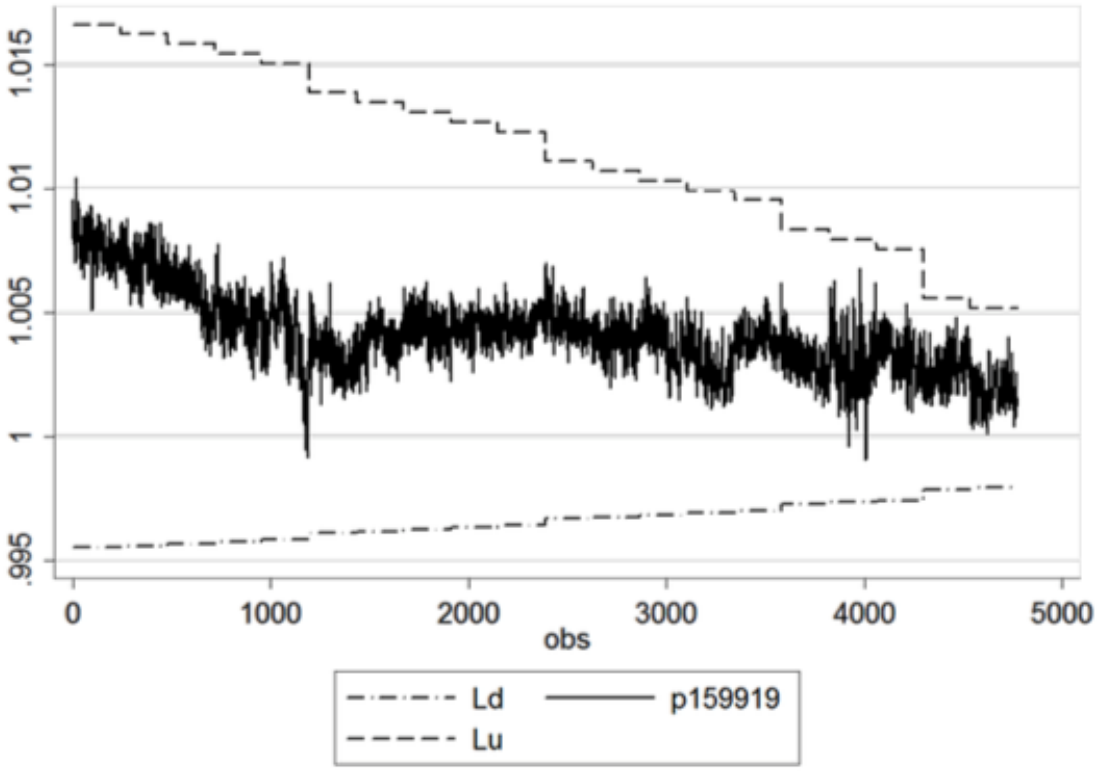

Figure 4 Harvest CSI 300 ETF price ratio between spot and futures and the arbitrage-free interval (arbitrage with margin trading).

According to Figure 3 and Figure 4, during the 4800 minutes trading session, there is no arbitrage opportunity since both of the price ratios of Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF are inside the upper and lower bound of the arbitrage-free interval.

4.4 The calculation of actual yield of stock index futures arbitrage

In order to further explore the arbitrage activities, the actual yield of arbitrage under the situation of investors using their own funds will be calculated. According to the above analysis of arbitrage opportunities, only the actual yield of the forward arbitrage trading will be analyzed.

4.4.1 The conditions of closing the position

We assume that investors can open the position immediately when they observed an arbitrage opportunity, that is, investors can buy the ETF and short sell stock index futures under the situation of mispricing. There are four conditions of closing a position.

4.4.1.1 Achieve the target rate of return

Based on the above analysis we can found that arbitrage opportunities are fleeting. Time is very short from observing the mispricing to that price ratio return to the arbitrage-free interval. So we set the target rate of return as a single trading yield rather than annual yield. According to experience, with the gradual maturity of the market, the ideal single trading yield of current stock index futures arbitrage is generally 1/1,000, i.e. 0.1%. So we set the target rate at 0.1%.

4.4.1.2 Not meet the minimum margin deposit requirement.

Since June 29, 2012, China financial futures exchange (CFFE) adjusts the margin requirement of CSI 300 stock index futures to 12%. In the actual operation, the futures companies will charge 3% more to the margin requirement, that is, a total of 15% requirement of the margin deposit. When arbitragers not meet their minimum margin requirement, they will be forced to close the position.

4.4.1.3 Achieve the stop-loss level

In order to ensure the arbitrager not suffer huge loss caused by the price spread, we set the negative two times of target yield as the single transaction stop-loss point, that is, -0.2%. When the single arbitrage trading loss is more than –0.2%, investors will close the position to prevent further losses.

4.4.1.4 Contract expires

Investors will hold the contract expires and close the position if the first 3 conditions were not met.

4.4.2 Arbitrage rate of return

The single trade rate of return of forward arbitrage transaction can be defined as:

$$return = \frac{(1 - C_{RS})S_T - (1 + C_{RS})S_t - C_{RF}(F_t + F_T)}{S_t + 30\% * F_t} \qquad (12)$$

In which, the 30% is the combination of the stock index futures' minimum margin deposit (15%) and the 15% reserve floating margin rate. Based on this formula, we carry out the tracking of the actual rate of return on each of the two funds; and calculate the single transaction rate of return when the conditions of closing a position were met. During the investigation, all the arbitrage trading position were closed due to reach the goal of arbitrage gains or meet the stop-loss level; the situation of not meet the minimum margin deposit or contract expired are not exist. The actual tracking results of arbitrage rate of return are shown in Table 6.

	Huatai-Pinebridge CSI 300 ETF	Harvest CSI 300 ETF
Observation Time	4,800 mins	4,800 mins
Above L_u of Arbitrage-free Interval	38 mins	707 mins
Arbitrage Opportunity	32 times	313 times
Meet the Target Rate of Return	29 times	284 times
Meet the Stop-Loss Point	3 times	29 times
Real Rate of Return (Avg.)	0.1242%	0.1600%
Single Trading Loss Rate (Max.)	-0.2724%	-0.3730%
Single Trading Yield (Max.)	0.2379%	0.5280%
Position Holding Time (Avg.)	119.0938 mins	119.0543 mins
Position Holding Time (Max.)	923 mins	1,732 mins

Table 6 Actual tracking results of arbitrage rate of return

4.5 Analysis of the Results of Empirical Research.

4.5.1 Own funds or margin trading

According to the empirical results, in the case of investors have their own funds; these two funds have a certain positive arbitrage space. However, the positive arbitrage space disappeared when investors use margin trading to carry out the arbitrage activity. On the one hand, the arbitrage-free interval size is mainly dependent on the costs, and the costs are mainly derived from the transaction cost and margin trading cost. Investors would pay for the interest up to 8.6% to carry out the arbitrage activity when using the margin trading, which eliminates the forward arbitrage opportunities; on the other hand, regardless of whether using their own funds, in the reverse arbitrage activities, investors are required to use security loan service to short sell the spot, while the loan interest rate is also up to 8.6%, which also eliminates the reverse arbitrage opportunities. Of course, we do not deny that there is still a reverse arbitrage opportunities under a high margin-trading rate.

4.5.2 The differences between Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF.

Within the range of our observations, we can find obviously that the Harvest CSI 300 ETF have more forward arbitrage opportunities than Huatai-Pinebridge CSI 300 ETF. At the same time, compare to Huatai-Pinebridge CSI 300 ETF, Harvest CSI 300 ETF has a

situation of polarization on the position holding period, which means, part of the position holding time is very long, and part of the arbitrage trading opportunities are fleeting. We believe that this phenomenon is mainly due to the purchase and redemption mode and transaction mechanism between these two CSI 300 ETFs.

Huatai-Pinebridge CSI 300 ETF using the in-kind, partially cash purchase and redemption mode. However, Harvest CSI 300 ETF uses over-the-counter in-kind purchase and redemption mode. In the arbitrage trading of Huatai-Pinebridge CSI 300 ETF, the holder will only need a basket of Shanghai securities and a part of cash to make purchase in Shanghai Stock Exchange. The cash portion is paid to the fund manager to buy the Shenzhen securities.

The differences in the purchase and redemption pattern also led to the differences in the transaction mechanism. Due to the partially cash substitution purchase and redemption mode, Huatai-Pinebridge CSI 300 ETF use the T+0 day transaction mechanism. Harvest CSI 300 ETF using T+2 days transaction mechanism. The former trading mechanism allows arbitragers' high frequency trading in one day, which is more flexible and the transaction activity will be relatively high. Those differences make the Harvest CSI 300 ETF trading active degree much lower, thus the mispricing cannot correcting back to the arbitrage-free interval quickly, which brings more arbitrage opportunities.

4.5.3 Actual rate of return and the position holding time

In the sample interval, Huatai-Pinebridge CSI 300 ETF has 32 arbitrage opportunities, in which, 29 times were succeeded and achieve the 0.1% target rate of return. The arbitrage success rete is 90.625%; the average position holding time is 119 minutes; the longest holding period is 923 minutes, it is almost two days based on the 480 minutes per trading day. Harvest CSI 300 ETF has 313 arbitrage opportunities and 284 times were succeeded. The arbitrage success rete is 90.735%; the average position holding time is 104 minutes; the longest holding period is up to 1668 minutes, which is almost three and a half days. Moreover, these two funds have a certain number of arbitrage failure, the average single trade arbitrage rate of return is 0.1242% and 0.1600%, respectively.

According to the total profit we count up in the observation interval and the maximum principal requirement of this kind of transaction strategy, we can get the annual arbitrage rate of return. Assume all arbitrage trade can be operate successfully, according to the calculation, the annual arbitrage rate of return of Huatai-Pinebridge CSI 300 ETF is 7.82%, Harvest CSI 300 ETF's annual arbitrage rate of return is 15.03%.

In which, due to the T+2 trading mode of Harvest CSI 300 ETF, the maximum principal requirement is relatively high. We know that large mount occupation on the principal will reduce the mobility of capital and the arbitrage rate of return. Then, investors use the margin trading strategy to avoid the disadvantage, under this strategy, the principal only

increased by a 15% minimum margin requirement, and the margin trading cost increased by 8.6% of 2 days' single trade arbitrage transactions.

Taking to account that the investors cannot capture all the arbitrage opportunities in the actual operation, the annual arbitrage rate of return is not significant. On the one hand, the target yield is set at 0.1%, however, in the actual operation, arbitragers may further integrate all kind of factors to reconsider the transaction time which may bring a higher annual arbitrage rate of return. On the other hand, the maximum amount of funds we assumed is relatively conservative, which is 30% of the futures value. However, the actual maximum amount of funds may not be so high.

Chapter 5 Conclusions and Recommendations

Based on the cost of carry model, this paper applies 20 trading days 1-minute high frequency data from March to April 2013 tests the arbitrage effect of Huatai-Pinebridge CSI 300 ETF and Harvest CSI 300 ETF listed on the Shanghai and Shenzhen exchange, respectively.

In this paper, we consider the actual situations of the actual market as much as possible; and use the parameters that are consistent with the market to calculate and analyze. As a result, we found that there is a certain forward arbitrage space of these two funds; however, the arbitrage space is limited by the cost of capital. In other words, when the capital resource changes from own funds to margin trading, the forward arbitrage space is significantly reduced. Moreover, this paper calculates the actual rate of return under the condition of 1% target single trade rate of return and shows that more than 90% of the arbitrage opportunities can achieve the target rate of return. Relatively speaking, in our observation interval, Harvest CSI 300 ETF has more arbitrage opportunities; it can achieve 15.03% annual rate of return, which is higher than Huatai-Pinebridge CSI 300 ETF (7.82%). Finally, the research of this paper shows that the current China's stock index futures and ETF spot market are still not fully effective, although the mispricing duration is short.

Although this paper considers the actual situations as much as possible, there are still some limitations, such as data availability; the number of contracts and the contracts

period are all based on a small sample. Moreover, in the calculation of the arbitrage-free interval, the model is simplified and the tracking error is not considered. We only pay attention to the factors that may influence the arbitrage activities, such as impact cost and the conditions of close a position. When calculate the actual arbitrage rate of return, this paper only considers the 0.1% of the target yield, as a result, the different target yield can be compared in the actual arbitrage activities.

Considering the above problems, this paper still indicates that a lot of further research can be carried out. Such as include more stock index futures contracts, extend the period of the arbitrage trading days, and use VaR to analyze the risk factors, etc.

Reference:

MacKinlay, A. C., and K Ramaswamy.1988. Index-Futures Arbitrage and the Behavior of Stock Index Futures Prices. The Review of Financial Studies, Vol. 2.

Klemkosky, R. C. 1991.The intraday ex post and ex ante profitability of index arbitrage. The Journal of Futures Markets. Vol. 11, No.3.

Puttonen, V. 1993.Stock index futures arbitrage in Finland. Vol. 68, No. 3.

Wang J. 2010, Short Selling and Index Arbitrage Profitability. Vol. 46,

Wei Chen, Chao Lv, Zhiqing Ding. The Arbitrage-Free Pricing Model of Stock Index Futures [J]. Science-Technology and Management, 2004(6)

Hui Zhang. An Empirical Analysis of Stock Index Futures Arbitrage Under the Cost of Carry Model. Academic Journal of Shang Hai Dian Ji University, 2011(14).

Cheng Lu. The Use of CSI 300 Stock Index Futures for the Arbitrage. Economic Management, 2008(11).

Xiaokun Huang, Jingming Hou. Research On the Method of Stock Index Futures Arbitrage Based on ETF. Statistics and Decision, 2009(18).

Zhuo Wei, Chong Chen, Xianhua Wei. Chinese Market Stock Index Futures Arbitrage Based on High Frequency Data. System Engineering Theory and Practice, 2012(32).

Tingli Ding. Empitical Analysis on the Difference of the CSI 300 ETF Arbitrage Opportunities. Teaching and Research in Fiance, 2012(25).