



Futures-Spot Arbitrage of Stock Index Futures in China

Empirical Study on Arbitrage Strategy

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ACKNOWLEDGMENTS

We would like to thank our supervisor Professor Zsuzsanna Vincze. We really appreciate your support, your well-timed and sensible advices, and priceless time. It is our pleasure to do thesis under your guidance.

We also would like to thank Professor Barbara Cornelius, who gives us professional advices in financial field. It is really helpful for our thesis writing.

In the end, we are grateful to all of the lectures during this year with extremely useful and wonderful lectures.

Abstract

The main purpose of this thesis is to investigate what is the optimal futures-spot arbitrage strategy for China's stock index futures investment. Specifically, CSI 300 Index replication method and no-arbitrage pricing model are examined. We compare the different combinations of ETFs portfolio in mainland China with W.I.S.E-CSI 300 ETF in Hong Kong in three aspects including liquidity level, correlation of ETFs with underlying index, and tracking error of the replication methods. Then, we add several new parameters into interval pricing model to obtain a more accurate no-arbitrage band. As a result, we found that the portfolio of SSE 50 ETF, SZSE 100 ETF, and SSE Bonus ETF could provide the best tracking effect of CSI 300 Index, with different weight as 0.369, 0.403, and 0.19 in turn separately. Furthermore, the new modified pricing model could find out more arbitrage opportunities than interval pricing model especially for reverse cash-and-carry arbitrage. On the whole, the optimal arbitrage strategy for investment on CSI 300 Index futures consist of two steps, implement ETFs portfolio replicate CSI 300 Index and using new modified pricing model to discover and define arbitrage opportunities then to apply futures-spot arbitrage. At the end of thesis, we also give a small case study to illustrate how to exercise the arbitrage strategy in realistic situation.

Key words: Stock index futures, Futures-spot arbitrage, ETFs, Replication, no-arbitrage band

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Abbreviations

APT	Arbitrage Pricing Theory
ARCH	Autoregressive Conditional Heteroskedasticity
CAPM	Capital Asset Pricing Model
CFFEX	China Financial Futures Exchange
CSI	China Stock Index (also named Hu Shen 300 index)
EGARCH	Exponential General Autoregressive Conditional Heteroskedastic Model
ETF	Exchange Traded Funds
FXI	FTSE Xinhua Index
GARCH	Generalized Autoregressive Conditional Heteroscedastic Model
HKD	Hong Kong Dollar
LOF	Listed Open-Ended Fund
M-GARCH	Multivariate Generalized Autoregressive Conditional Heteroskedasticity
NAV	Net Asset Value
Nikkei 225	Nikkei heikin kabuka 225 Index
NYSE	New York Stock Exchange
OMXS 30	Optionsmarknaden/Helsinki Stock Exchange Stockholm 30
QFIIs	Qualified Foreign Institutional Investors
RMB	Ren Min Bi-Chinese Yuan
SEHK	Stock Exchange of Hong Kong Limited
SGX	Singapore Exchange
S&P 500	Standard & Poor's 500 Index
SSE	Shanghai Stock Exchange
SZSE	Shenzhen Stock Exchange

Chapter I

Introduction

In this chapter, we will describe the background of global stock index futures market first. After that, we will present the research question and research objectives of this thesis. In order to get better understanding, the definitions of key concepts are given at the end of this chapter.

1.1 Background

The stock index future is a cash-settled futures contract to buy or sell certain value of stock index in the future at the predetermined price and date. As one of the most important and successful financial instruments which came from financial innovation in the 1980s, the stock index futures has become a symbol of mature financial systems and designed for investors to hedge systematic risk in stock market.

According to the everyday news, stock index futures came into being in the United States and were the outcome of demand of securities market development. In 1970's, financial globalization and liberalization increased the sources and transmission channels of market risk, enlarged influences and consequences of risk. Following that, the price fluctuation of global commodities and asset was aggravated and financial crisis occurred frequently. Meanwhile, the western countries were far gone in Oil Crisis which directly caused economic instability, slow growth, frequent interest rates fluctuation, and serious inflation. Because of these, the U.S. stock markets have experienced the most severe crisis since World War II. Major stock indexes—S&P500 Index (Standard & Poor's 500 Index) plummeted from more than 110 points to 60 points and Dow Jones index fell to 1700 points (www.finance.yahoo.com). The stock index slumped over 50 percent between year 1973 and 1974, even more than twice fall during financial turmoil in 1930's. The drastic fluctuations of stock markets brought great pain to investors and led to higher demand for equity risk control instruments.

The first stock index futures was launched in 1982 when the Kansas City Board of Trade introduced futures on the Value Line Index. In the same year, the Chicago Mercantile Exchange introduced futures contract on the S&P 500 Index, later the futures contract of New York Stock Exchange (NYSE) Composite Index traded on the New York Futures Exchange. In 1986, the S&P 500 futures contract became one of the most active traded futures contract in the world, more than 19.5 million contracts were traded at that year (Vijh, 1994, p.220). Actually, before the Kansas introduced the first stock index futures, people had discussed and researched stock index futures more than ten years in the U.S, but at that time people did not establish cash delivery method to settle account at the maturity of futures. That is why stock index futures were not launched immediately.

After the stock index futures was introduced, it was welcomed by investors on account of its sufficient liquidity, low trade cost, and high efficiency. As a result, more and more investors used stock index futures to manage their equity portfolios. In 1984, the stock index futures trading volume accounted for 20% of all futures trading in U.S. Following the success in U.S, more and more countries launched their own stock index futures. We could actually trade them in America, Europe, Asia, and Africa. The Bloomberg statistics shows that there are 74 main stock indexes at present and hundreds of stock index futures in the world. Undoubtedly, most of stock index futures were operated in America and Europe. The three most famous index futures are S&P500 index future, FTSE100 index future, and Nikkei225 (Nikkei heikin kabuka 225) Index future. Among them, the S&P500 index future is most representative.

1.2 Significance of research

We are doing this analysis because the first stock index futures—CSI (China Stock Index) 300 Index¹ Futures just launched on 16th April, 2010 in China. Before this, China has operated a simulative index futures market for four years where investors could do the mock trading in it. The performance of stock index futures in other countries demonstrated that many futures-spot arbitrage opportunities appeared in the following several months after formal launch. Therefore, we intend to find out the feasible arbitrage strategy for CSI 300 Index futures and then provide some useful reference for futures investment. In this study, through theoretical and empirical research on stock index futures arbitrage, we got two objectives. First is to seek the replication method which has optimal tracking effect on underlying index. Secondly, we aim at finding out suitable pricing model for CSI 300 Index futures through empirical study. From the stated objectives we drive our guiding research question as:

How to build up futures-spot arbitrage strategy for China's Stock Index Futures investment?

The specific research questions are:

- 1) What is the optimal replication method to track CSI 300 Index in futures-spot arbitrage?**
- 2) What is the optimal pricing model for CSI 300 Index futures contract in futures-spot arbitrage?**

1.3 Outline of the study

The thesis is organized as follows: After the introduction, we make an overview of stock index futures market in China and provide some present information of futures-spot arbitrage in chapter two. In Chapter three we review the literatures, introduce relevant theories and previous empirical studies that have been conducted on this topic. Based on

¹ CSI 300 Index is a market capitalization weighted index which aims to reflect the price fluctuation and performance of China A-share market. It is designed for use as performance benchmarks and as basis for derivatives innovation and indexing. (China Security Index co, 2006). We will give details discussion in Chapter 2.

these we develop theoretical framework of stock index futures arbitrage. In Chapter four we talk about the methodology and describe the data applied in the study. The fifth Chapter we present the analysis and the empirical results. We discuss quality criteria based on research in Chapter six. The thesis is end with our conclusions and recommendation on further studies.

1.4 Limitations

In our thesis, we select the data from simulation trading system to do the empirical study. Although this system closely simulated the realistic situation, it still could not consider all aspects of formal market. Therefore, the data we used could reflect performance of stock index futures but not as accurate as real data. On the other hand, we also do not think over the incomplete convergence problem of stock index futures. Theoretically, there is no difference between price of future and spot index at the end of settlement day. Nevertheless, it is impossible to ensure every future's price is equal to spot index, we can find some future's settlement price was higher or lower spot index which named incomplete convergence problem and influence the final result. In addition, we assume the constituent stocks of underlying index do not change in the sample interval; however, the Exchange will examine and audit constituent stocks semiannually then adjust composition of constituent stocks according to the result of audit. In fact, the change of constituent stocks could directly affect performance of stock index.

1.5 Definitions

-Arbitrage is one of the most important concepts in finance and economics. There are many definitions of arbitrage by different authors:

Marshall said "Arbitrage is simultaneously transacting in two or more markets in order to earn a profit from a price discrepancy between the two markets. The arbitrage can be across markets separated by space (geographical or spatial arbitrage), across the time (temporal arbitrage), across tax rates (tax arbitrage), or across the structural components of the assets traded." (Marshall, 2000, p.10).

Sharpe, Alexander, & Bailey (1999) defined arbitrage is the "process of earning riskless profit by taking advantage of differential pricing for the same physical asset or security". As a widely applied investment tactic, "arbitrage typically entails the sale of a security at a relatively high price and the simultaneous purchase of the same security (or its functional equivalent) at a relatively low price" (Sharpe et al., 1999, p. 284). In this thesis, the definition from Sharpe et al. is appropriate for our research.

-Arbitrage opportunities arises when "an investor can earn riskless profits without making a net investment". (Bodie, Kane, & Marcus, 2005, p. 349).

-Mock trading refers to “simulated trading of stocks, bonds, commodities and mutual funds. Real money is not used”. (Downes & Goodman, 2003, p. 585).

-Futures-spot arbitrage in our understanding is an arbitrage activity between stock index futures market and index spot market. It is a strategy designed to get profit from variance between the prices of stocks consisting of an index and the price of futures contract on the same stock index.

These definitions are used in the thesis as starting point.

Chapter II

CSI 300 Index Futures and Arbitrage

In this Chapter we overview the stock index futures market in China and provide present information of futures-spot arbitrage. We briefly introduce the details of CSI 300 Index and CSI 300 Index futures and then illustrate the general process of futures-spot arbitrage.

Before introduced CSI 300 Index futures, China had launched the Shenzhen Stock Index futures in Hainan Securities Trading Centre in 1993. Unfortunately, it was forced to close five months later because of the immature rules and operations. More specifically, Chinese futures market had three obvious deficiencies at that time: inadequate regulations, lack of risk monitoring system, and inexperienced investors.

After years of development, Chinese securities market was incessantly growing and improving. The regulators thought that China already fulfill all the conditions to re-launch stock index futures. The establishment of CSI 300 Index and index futures simulation trading system indicated the advent of stock index futures.

2.1 CSI 300 Index

CSI 300 Index is a market capitalization weighted index that consists of 300 A-share stocks² listed on the Shanghai and Shenzhen Stock Exchanges. It was created by the China Securities Index Company Ltd on August 2005. The base day for CSI 300 is 31st Dec, 2004, base point is 1000, and the base period is the adjusted market value of 300 constituents on that day. CSI 300 is calculated by using a Paasche weighted composite price index formula (Figure 1):

$$\text{Current index} = \frac{\text{Current adjusted market cap of constituents}}{\text{Base Period}} \times 1000$$

(China Security Index co, 2006)

Figure1: Paasche weighted composite price index formula

Adjusted market value on the base day is also called divisor and it is equal to Σ (price \times adjusted number of shares) (China Security Index co, 2006). The calculation of constituents' adjusted shares (adjusted number of shares) depends on two methods. They are free float and category-weighted method. When changes occur in constituent list, or the share structure, or constituents' market value changes due to non-trading factors, the divisor is adjusted to keep the index comparable overtime.

² CSI 300 constituents list:
http://www.csindex.com.cn/sseportal_en/csiportal/zs/jbxx/report.do?code=000300&&subdir=5

In order to be eligible for the CSI 300 Index, the stocks have to satisfy three criteria:

1. All of stocks should be A-shares and traded on the market for the past three months, or the daily trading volume of the stock is in the top 30 of A-shares.
2. The stocks should not have large volatility signs and any other signs that the stocks have been manipulated.
3. The stocks should be in the top 300 A-shares in terms of size and in the top 50% of the A-shares in terms of liquidity.

2.2 CSI 300 Index Futures

Before introduce the CSI 300 Index Futures, we want to present the mechanism of trading in futures market. This will help to understand deeper knowledge of the financial derivative. “The futures contract calls for delivery of a commodity at a specified delivery or maturity date, for an agreed-upon price, called the futures price, to be paid at contract maturity” (Bodie, Kane, & Marcus, 2008, p.784). The buyer of futures has a “long position” and seller of futures obtain “short position”. Unlike option and forward contract, futures must be traded on the exchange and set the clearinghouse as the partner of each trader. The obligation of clearinghouse is to deliver commodity to buyer and pay for the delivery from seller. In futures market, exchange implements daily settling to clear proceeds based on close price of each trading day which is also named marking to market. At the beginning of trading, each trader holds a margin account that ensures the trader has ability to fulfill the obligation of futures contract and this margin is set as a certain percentage of total value of the futures contract. When the exchange applies marking to market mechanism, traders should replenish or recapture the margin day-by-day in order to keep the margin account satisfy exchange’s requirement and this daily settling would be implemented until the settlement day. At last, buyer and seller close both their positions through clearinghouse at the settlement day which is also the last trading day.

China Financial Futures Exchange (CFFEX) was established in Shanghai in 2006. Two months later, CFFEX launched CSI 300 Index futures mock trading system which provides practical opportunity of stock index futures to regulators and investors. CFFEX modified the regulation and contract of CSI 300 Index futures mock trading system in 2007 and lay down detailed instructions for the smallest change in price, commission charge, settlement price, forced liquidation and so on. The CSI 300 Index futures was launched formally in 2010. This means the arrival of start new era of China’s financial market. (Appendix1)

In order to prevent sharp fluctuations of futures market, the CSI 300 Index futures introduced Circuit Breakers into trading system. Circuit Breakers are temporary trading restriction that is usually imposed after large and rapid price declines. The common trading restriction is price limit. If the price of the CSI 300 Index futures contract falls 6 percent below the previous day’s closing price continued for 1 minute, the CFFEX will prohibits trading at lower price for 10 minutes. After 10 minutes, the limitation of price

would raise to 10 percent. The Circuit Breakers could provide investors with "cooling off" period to calm fears or provide time to digest information when there are steep declines in the market. Moreover, it also reduces market volatility and protects investors from excessive market volatility. And because of existence of this system, the market has enough time to restore the equilibrium between buyers and sellers.

2.3 Present knowledge for stock index futures arbitrage

There are many forms of arbitrage in the index futures market. However, we can generally divide them into three types: futures-spot arbitrage, inter-delivery arbitrage, and cross-market arbitrage.

- **Futures-spot arbitrage.** Investors could make this arbitrage when the price of index futures deviate its theoretical value. However, on account of transaction cost and market restrictions, the theoretical value of future is not a specific numerical value but a price band. We call this band as no-arbitrage band. In general, futures-spot arbitrage consists of two inverse methods. If future's price exceeds upper limit of this band, investors could obtain profit by cash-and-carry arbitrage which make short (sell) position on index futures and long (buy) position on spot index (Table 1, p.7) then clear both positions at the settlement date. If the price is under lower limit of band, they would do the opposite actions of above. It is named reverse cash-and-carry arbitrage. (Figure 2)

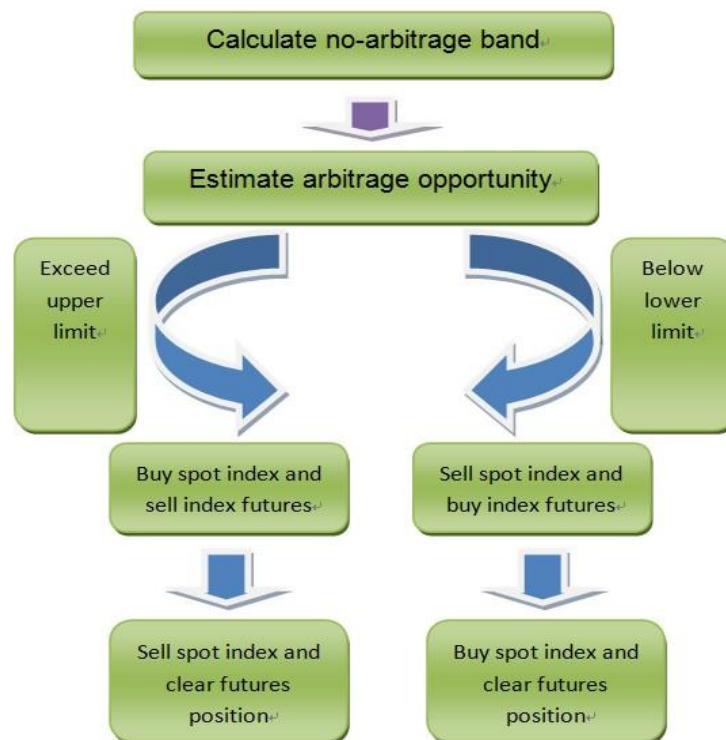


Figure2: Process of futures-spot arbitrage

- **Inter-delivery arbitrage.** In the mature futures market, the inter-delivery arbitrage is a prevalent strategy to get risk-free profit which exploit un-normal price differences between two future contracts with different delivery date on same underlying index. It also could be divided into two forms: bull spread and bear spread. If investors anticipate price rise of current month contract is higher than that of next month contract, they could buy current month contract meanwhile sell next month contract to make arbitrage which named bull spread. On the contrary, if they think price drop of next month contract is less than contract in current month, they would do bear spread which sell current month contract and buy next month contract.
- **Cross-market arbitrage.** The cross-market arbitrage means the arbitrage behavior between different markets. If the same type of futures traded in two or more markets, the prices of them would not hold a fixed relationship all the time. Thus, investors would find out these differences and trade same type futures in different market to earn profit.

Because China's stock index futures market was just formally established, it was far from maturity, especially compare with American or European futures markets. The requirements of inter-delivery or cross-market arbitrage are also not satisfied completely. We will elaborate details of futures-spot arbitrage which is the most useful and common strategy in China's index futures market at the moment.

The key issue of futures-spot arbitrage is how to determine limits of no-arbitrage band. Next, we will derive the limits (Figure 3):

Table 1: Cash flow of cash-and-carry arbitrage:

Cash-and-carry Arbitrage				
Time	Spot Index		Index Futures	
	Movement	Cash Flow	Movement	Cash Flow
t	buy spot index	$-S_t$	sell future (pay margin)	$-MF_t$
	impact cost	$-C_1$	impact cost	$-C_5$
	transaction cost	$-C_2$	transaction cost	$-C_6$
T	sell spot index	S_T	buy future (receive margin)	MF_t
	impact cost	$-C_3$	profit and loss	$F_t - F_T$
	dividend	D	impact cost	$-C_7$
	transaction cost	$-C_4$	transaction cost	$-C_8$
	settle spread	C_9		

*M is the margin rate

Spot index: $-S_t - C_1 - C_2 + (S_T - C_3 + D - C_4 - C_9) \times (1+r)^{T-t}$

Index futures: $-M \times F_t - C_5 - C_6 + (M \times F_T + F_t - F_T - C_7 - C_8) \times (1+r)^{T-t}$

If the total gains and losses is greater than zero, that means the future is mispriced and arbitrage opportunity is existing. So upper limit is:

$$\frac{S_t + C^* + C^{**} + D \times [1 + r \times (T - t)]}{1 + (1 + M) \times r \times (T - t)}$$

Where $C^* = C_5 + C_6 + (C_7 + C_8) \times [1 + r \times (T - t)]$

$$C^{**} = C_1 + C_2 + (C_3 + C_4 + C_9) \times [1 + r \times (T - t)]$$

Similarly, we can determine lower limit by analyze the total gains and losses of reverse cash-and-carry arbitrage, the lower limit is that:

$$\frac{S_t - E^* - E^{**} - D \times [1 + r \times (T - t)]}{1 + (1 - M) \times r \times (T - t)}$$

Where $E^* = C_7 + C_6 + (C_5 + C_8) \times [1 + r \times (T - t)]$

$$E^{**} = C_3 + C_2 + (C_1 + C_4 + C_9) \times [1 + r \times (T - t)]$$

Figure 3: Determining upper and lower limits

Chapter III

Literature Review & Theoretical Framework

The aim of this chapter is to review the relevant literatures, overview the significant research development on arbitrage of stock index futures, and find out the research gap in this field. In addition, we seek out the suitable models related to our research objectives through this review.

We describe and discuss the research results from different countries which are relevant to the stock index futures and especially on futures-spot arbitrage of stock index futures.

Generally speaking, there are several significant factors that should be considered carefully when implement arbitrage. First is to realize the relationship between index futures trading and stock spot market. Second is to price the stock index futures. Whether the futures are priced in correct level will directly influence the effect of arbitrage. The arbitrageurs who can price the futures in right way will be able to find out the optimal arbitrage opportunities. An additional factor is the spot position construction for futures-spot arbitrage on stock index futures. The optimal replication method will minimize the tracking error between tracking tools and underlying index.

Our literatures review is divided into three sections concerning 1) Relationship between index futures trading and stock spot market. 2) Pricing of stock index futures. 3) Replication method for spot position construction in arbitrage.

3.1 Literature Review

3.1.1 Relationship between index futures trading and stock spot market

The western researchers have plenty of research experience on the impact of index futures trading on the stock spot market. Based on our review, the research can be classified into four categories according to the research method approach. They are: experimental research, comparison research, cross-sectional research, and time series research.

Yu (2001) did research on the stock index futures market in USA, UK, Japan and Hong Kong by using the Generalized Autoregressive Conditional Heteroscedastic Model (GARCH) Model. He concluded that: “for the S&P 500 in USA and Nikkei 225 in Japan, the volatility of the spot market increases as a result of the introduction of index futures; while for FTSE 100 Index in UK and Hang Seng Index in Hong Kong, the volatility of the spot market decreases as a result of the introduction of index futures” (Yu, 2001, p.183-186). The research results vary so much. But this is reasonable because the index futures market in different countries has different characteristics.

Darrat and Rahman (2002) examined the role of index futures trading in spot market volatility in U.S. stock market. They emphasized on the analysis of causality and feedback relations between volatilities of spot and futures markets. The model they used was Exponential General Autoregressive Conditional Heteroskedastic Model (EGARCH). This EGARCH model can not only simulate the time series of variable volatility accurately, but also overcomes the shortcomings of the Autoregressive Conditional Heteroskedasticity (ARCH) model which can not reflect the asymmetric volatility. Finally, they found that “futures trading may not be blamed for increased volatility in the spot market”. On the contrary, their research supported that “volatility in the futures market is itself an outgrowth of a turbulent spot market”. (Darrat, Rahman, and Zhong, 2002)

Empirical studies provide support for the latter analysis. Merrick (1987) pronounced that stock price volatility lead by arbitrage trading volume in New York Stock Exchange is particular weak. Edwards (1988) stated there is no evidence to prove that trading of stock index futures will destabilize the spot stock market. Harris’s (1989) empirical results showed that “S&P 500 stocks are more volatile than non-S&P 500 stocks.” While the author emphasized the volatility discrepancy are too small to be significant statistically. (Harris, 1989, p.1155)

Carlson and Li (2008) summarized the previous studies about the impact of index futures trading on spot market volatility (See Appendix 2), and examined the relationship between index futures trading and stock spot market in Sweden. They compared volatilities of spot market before and after introduction of Swedish **Optionsm**äklarna/Helsinki Stock Exchange Stockholm 30 (OMXS 30) index futures. Moreover, the main methods were quite same like previous studies— the GARCH family models. In order to get more reliable result, they added a dummy variable in the equation and set this variable the different numerical values to simulate different situations in the market. As a result, they found “the introduction of the futures market did not impact spot volatility”. (Carlson & Li, 2008)

Swinerton, Curcis & Bennett (1988) found that the investors will make trading firstly in index futures market when some events put impact on stock spot market. Therefore the fluctuation in stock index futures market reflect on events is leading by 5 to 45 minutes than stock spot index. So the arbitrage opportunities were created as the time for price changes inconsistency. (Swinerton et al., 1988, p.300-323)

Sutcliffe (2006) has similar opinion with Swinerton, Curcis & Bennett (1988) in his book. He stated that: “for index futures there is clear evidence that the futures price leads the spot price by a few minutes”. But he considered the proof is weak for lags of a day. “Such lags may be consistent with an absence of arbitrage opportunities if they are caused by traders choosing to exploit information in the futures market, and the resulting movement in the futures price does not place it outside the no-arbitrage band because the transactions costs are not exceeded, allowing for the fact that the prices at

which the shares in the index basket could now be traded incorporate the market-wide information.” (Sutcliffe, 2006, p.175)

3.1.2 Pricing of stock index futures

The Law of One Price principle states that “if two assets are equivalent in all economically relevant respects, then they should have the same market price.” (Bodie, Kane & Marcus, 2008, p.336). But many factors influence the pricing of stock index futures, and lead to the mispricing of index futures and price basis between futures price and spot price.

● No-arbitrage equilibrium approach:

The no-arbitrage equilibrium approach is the cornerstone of modern finance. The centre meaning of it is based on no-arbitrage principle. This approach was reflected earliest in research result of Modigliani and Miller Theory (1958) (named as MM Theory). Because the principle assumed that every decision-maker in the market has access and enough sources to find any mispricing of securities. It emphasized there is no opportunity to obtain risk-free profit on an efficient market. If risk-free arbitrage opportunity emerges on the market, the arbitrage behaviors of investors would eliminate mispricing part rapidly and give a rational price to the underlying asset.

Therefore, according to the no-arbitrage equilibrium principle, the theoretical price of stock index futures contract should be presented as Equation 1:

Equation 1: No-arbitrage pricing of stock index futures contract

$$F_t = S_t (1+r)^{(T-t)/365} + \sum_{i=1}^n q_i (1+r)^{(T-t)/365}$$

Where:

F_t : the theoretical price of futures contract at time t

S_t : price of spot index at time t

r : risk-free interest rate

q_i : dividend rate of i^{th} stock

T : the date of maturity of futures contract

● Arbitrage Pricing Theory

Ross (1976) established the Arbitrage Pricing Theory (APT) by using the assumption that there is no persistent arbitrage opportunity in an efficient market. This theory presented that the expected return of financial assets could be calculated by a linear function which include different and various macro-economic factors or market indices. After obtain the expected return, we could correctly price assets, and the assets value would equal to the price at the end of period discounted by the rate calculated from linear function. Although the APT sets perfectly competitive market and efficient market as preconditions, it still has some differences between Capital Asset Pricing Model (CAPM). The APT holds that not only market risk, but also another many factors could influence the yield of assets. Therefore, we do not need to make a strict

assumption on investor's preference and the investors also would not to build assets portfolio just based on expected return and standard deviation. Therefore, the APT has the comparable advantage relative to CAPM both in inherence and practicability. To summarize, APT assumes that the yield of any asset in the market should be influenced by n factors, the Equation 2 is standard representation of it:

Equation 2: Expected Return in Arbitrage Pricing Theory

$$ER_i = \lambda_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \dots + \lambda_k b_{ik}$$

Where:

λ_0 : The yield of risk-free assets

λ_j : The risk premium of j^{th} asset

● **Cost of Carry Model**

The traditional pricing model for stock index futures is the Cost of Carry Model. Based on this model, Cornell & French (1983) do the early study on the pricing of stock index futures. They assume the capital markets are perfect. That means there is no taxes and transaction costs; no short selling restrictions; and the assets can be divided infinitely. They derived the general stock index futures pricing formula which base on no dividend assumption. After the empirical research on S&P500 index futures, they found that “the stock index futures prices are generally below the level predicted by simple arbitrage models. And this difference between the actual and predicted prices is caused by taxes.”(Cornell & French, 1983, p.675). Then they modified the traditional model by taking some factors into account. These factors including the timing option of common stock owner for taxes, random changes in interest rates and dividends with seasonal volatility. The modified model was named as interval pricing model.

● **Interval Pricing Model with market restrictions:**

Modest & Sundaresan (1983) and Klemkosky & Lee (1991) have derived the interval pricing model respectively.

-Modest & Sundaresan (1983) interval pricing model

Modest & Sundaresan (1983) hold that the transaction cost could not be ignored when investors make short position on spot index. Thus, they added transaction cost and short-sale restriction in the futures pricing model then derived the no-arbitrage band of stock index futures.(Modest & Sundaresan, 1983, p.15-41) (Equation 3)

Equation 3: Interval Pricing Model by Modest & Sundaresan

$$\frac{S_t - C_{PS} - C_{FL}}{B(t, T)} \leq F(S, t) \leq \frac{S_t + C_{PL} + C_{FS}}{B(t, T)}$$

(Modest & Sundaresan, 1983)

Where:

C_{PL} is cost of making long position on spot index

C_{PS} is cost of making short position on spot index

C_{FL} is transaction of making long position on index futures

C_{FS} is transaction of making short position on index futures

S_t is price of spot index

$F(S, t)$ is the price of index futures at time t with the maturity at time T

$B(t, T)$ is subsidy factor of payment at time T

If consider the effect of dividend payout, then the Equation 3 would become Equation 3a as followed. In which, d_τ means amount of dividend payment at time τ .

Equation 3a: Interval Pricing Model considered with effect of dividend

$$\frac{S_t - C_{PS} - C_{FL} - \sum_{\tau=1}^{T-t} B(t, t + \tau) d_\tau}{B(t, T)} \leq F(S, t) \frac{S_t + C_{PL} + C_{FS} - \sum_{\tau=1}^{T-t} B(t, t + \tau) d_\tau}{B(t, T)}$$

Following that, Modest (1984) extended the analysis of this pricing model in two ways. Firstly, he took discrete dividend payment into consideration to discuss how it affects the pricing of index futures. Secondly, Modest divided short-sale into three situations to verify the arbitrage opportunity whether exist. In addition, Modest researched the effect of random interest rate and daily settlement on pricing model. The result showed that there were a little relevance among random interest rate, daily settlement, and future's price.

-Klemkosky & Lee (1991) interval pricing model

Klemkosky & Lee (1991) introduced transaction cost, seasonal dividend payment, and different borrowing rate into pricing model, applied “borrowing money and selling futures” strategy to determine upper limit of price; “buying futures and lending short-sale income” strategy to determine lower limit (Klemkosky & Lee, 1991, p.291-311). The result is Equation 4 and Semi-equations for interval pricing model in Figure 4:

Equation 4: Interval Pricing Model by Klemkosky & Lee

$$F_L - C_{FL}(1+r)^{T-t} - C_{SS}(1+r)^{T-t} < F_a < F_S + C_{FS}(1+r)^{T-t} + C_{SL}(1+r)^{T-t}$$

$F_S = S(1+r)^{T-t} - \sum_{\tau=t}^T d_\tau (1+r)^{T-t}$ $F_L = S(1+r)^{T-t} - \sum_{\tau=t}^T d_\tau (1+r)^{T-t}$

Figure 4: Semi-equations for Interval Pricing Model by Klemkosky & Lee

Where:

S is spot index at time t

r' is borrowing rate

r is lending rate

d_t is the given daily dividend payment at time t

C_{FL} is cost of buying future contract

C_{SS} is cost of short-sail spot index

C_{FS} is cost of short-sail future contract

C_{SL} is cost of buying spot index

● Empirical review

The price spread between spot and futures market provide opportunity for arbitrageur to get profit by buying underlying assets in one market, and selling them in another market with a higher price. So the price spread also named price basis is one of the research objectives of stock index futures mispricing.

Equation 5: Price basis between futures and spot price

$$\text{Price basis} = \text{Futures price} - \text{Spot price}$$

(Equation: Hull, 2001, p.36)

Generally speaking, the price basis is larger in the initial period of launch the stock index futures. One of the reasons to arise this basis (Equation 5) is mispricing in futures market. But this price spread is a temporary phenomenon because the arbitrage trading in stock index futures market will helps to find the reasonable price for the underlying and automatically modify the price spread. So price discovery for stock spot market is one of the functions of stock index futures, and the arbitrage between stock spot market and index future market is an important trading as it will help to keep the prices closed.

Brennan & Schwartz (1990) mentioned in the research that the index futures prices will eventually very close to the price which calculated by cost of carry model. And the possible reason is the arbitrage activity of stock index futures investors. (Brennan & Schwartz, 1990, pS7)

So & Tse (2004) investigated the relative contribution of the Hang Seng Index and relative Index Futures to price discovery by using the data from year 1999 to 2002 with the multivariate generalized autoregressive conditional heteroskedasticity (M-GARCH) model. The result shows that the price discovery function is more powerful in future market than that in spot market. The future market in charge of 75%-80% price discovery and the spot market in charge of 20%-25%. (So & Tse, 2004, p.887-907)

Fremault (1991) found three effects of arbitrage trading through doing research on hedgers, speculators and arbitrageurs both in futures and spot market. The first effect is that the arbitrage behavior in stock index futures will pass on exposure of hedgers from one market to speculators in another market. Secondly, the arbitrage behavior will

enhance the liquidity level between futures and spot market because it can complement the long and short position gaps in both two markets. Thirdly, the arbitrageurs can help to modify the mispricing basis between futures and spot price. To sum up, the author believes that the futures-spot arbitrage will help to reduce information asymmetry between future and spot market, and to make the reaction speed of two markets on same information at same level. So it improved the market efficiency. (Fremault, 1991, p.523-525)

As the stock index futures entered into Asian market later than western countries, so the theoretical and empirical development in stock index futures pricing appeared in Asia in recent decades. In a study made by Zheng (1998, cited in Wu 2008, p.3), He introduces the concept about spread changes strength, and built up relative arbitrage pricing model. The author using this model to predict the profit and loss of arbitrage trading method which arbitrageur employed under different situation.

Sutcliffe (2006) claimed that it is important to separate arbitrage opportunities from mispricing. “The proportionate mispricing is the current futures price less the no-arbitrage futures price, all divided by the current futures (or spot) price. While mispricing is small, they are seldom exactly zero, and so mispricing exists most of the time. An arbitrage opportunity only exists when the mispricing exceeds the transactions costs of an arbitrage trade, and this is rare.” (Sutcliffe, 2006, p.61)

Schwarz and Laatsch (1991) do the empirical analysis on the Major Market Index (MMI) by using intraday, daily and weekly data from 1985 to 1988. They considered the closeness relationship between futures and spot market through supply of arbitrage, and conclude that: There is large persistence of mispricing even on a daily basis, and this mispricing is not always eliminated within one day interval. This result reflects not only the early stock index futures trading, but also in later period. Meanwhile, it shows that “the relationship between spot and futures market is not stable over time highlighting the time-variance element.” (Schwarz & Laatsch , 1991, p.669-683)

In 1990s, many researches pay more attention on the arbitrage strategies in stock index futures trading, especially focused on the expiration dates of the futures contracts. Brennan & Schwartz (1990) examined the profitability of unwind arbitrage position early by using four years data in every fifteen minutes price on S&P 500 Index since 1983. This early unwinding might happen when the transaction cost is highly cover the initial mispricing, but the arbitrageurs still determine to do the risky arbitrage in their expectation because they think the combined profit from early unwinding and arbitrage in the initial time would be sufficient enough to offset the whole transaction costs. According to this arbitrage strategy, the authors found an average profit after eliminate transaction costs of each index point in the initial arbitrage position. (Brennan & Schwartz, 1990, p.57)

Habeb, Hill & Rza (1991) highlight the suggestion that arbitrageurs need to set profit

level for entry and exit arbitrage trading. They described that the arbitrage trading could be launched when the mispricing exceed sum of arbitrage transaction costs and required entry profit. And the early unwinding could occurred when mispricing reversal was sufficient to cover sum of transaction costs and required exit profit level. Through empirical research on S&P 500 Index data at 5 minute interval from 1987 to 1990, they found the entry profit level is from 0.8 to 0.9 index points, and exit profit level is from 0.2 to 0.4 points. This strategy will bring highest returns for futures-spot arbitrage. (Habeb et al., 1991, p.180-203)

Neal (1996) using minute by minute data to analyze 837 arbitrage trades on the NYSE for first contract in 1989. The researcher employ logit regression model. The result shows that there is a significant positive coefficient between mispricing reversal and absolute mispricing amount; meanwhile, there exist negative coefficient between absolute mispricing and number of days for delivery. In other words, the arbitrageurs would like to construct the arbitrage position between stock index futures and spot market under the condition that the mispricing volatility is high. Then the early unwinding of the arbitrage position will become more valuable. (Neal, 1996, P.541-562)

3.1.3 Replication method for spot position construction in arbitrage

Varian (1987) pronounced that if one financial derivative can be replicated by other derivatives combination, in which the value of each derivative in combination is known, then the value of replicated financial derivative and the value of replicating portfolio must be equal and arbitrage opportunity will arise if the value is unequal. The arbitrage can be used for valuing single or combined financial derivatives. (Varian, 1987, p.55-72)

Lei (2007) collect the simulation trading data in Chinese stock index futures market from June till September in 2006. They used full replication method in spot market and investigated six futures contracts during this time. They found that there exist large arbitrage opportunities after deducting all possible costs. They also believe that the full replication by buying stocks is the optimal way to tracking the underlying index. (Lei, 2007, p.33-50)

Aber, Li & Can (2009) investigate the price volatility and tracking ability of four ETFs in iShares Company in Singapore by comparing with general index funds which relevant to same underlying index. After comparing premium and discount trading, tracking error and daily return rate, the authors found that “the four studied ETFs are frequently traded at premium instead of discount with big daily price volatility.” They also state that “Although the degree of co-movement with underlying index for both two kinds of fund is almost equal, the tracking ability of general index funds is superior to ETFs.” (Aber et al.,2009, p.210-221)

To sum up, the mainstream researches focused on the function and effect of stock index futures. They investigated index futures' property, the impact after introduction of index

futures; the pricing and mispricing of stock index futures, and how to reduce total risk of invest in index future markets. Statistical and mathematical models were commonly used in the stock index future research, especially the GARCH family models. However, there are also some drawbacks in previous studies. Firstly, almost all of them used the GARCH family models to do the evaluation, whether in hedging, volatility analysis, or risk calculation. The only differences among them were just the conditional circumstances and additional variables. This would cause the similar results under various situations which should have different outcomes. Secondly, most studies do research only on the stock index futures and the influence on other markets but few of them focused on what could influence index futures and whether there is a correlation between stock index futures and something else. Meanwhile, after the review we can find that there is little empirical research on replication of spot position in futures-spot arbitrage and most of the researchers do empirical research on pricing by using APT model or Cost of Carry Model. Refer to our research question about strategy establishment in futures-spot arbitrage in China, we will estimate different combinations of ETFs to construct spot position in arbitrage and employ the no-arbitrage interval pricing model for futures pricing.

3.2 Theoretical Framework

The futures-spot arbitrage, also called index arbitrage, in our own words is an arbitrage behavior between stock index futures market and spot index market. Exactly, it is a strategy designed to obtain profit through utilize different prices between spot index and futures contract on the same stock index. Sometimes, the arbitrageurs can take advantage from market inefficiency to get profit by setting long position in the stocks or the futures contract, and short selling the other. It is the easiest method to do stock index futures arbitrage at present.

According to the long or short position, futures-spot arbitrage can be classified as cash-and-carry arbitrage and reverse cash-and-carry arbitrage. Generally speaking, the cash-and-carry arbitrage means making long position in spot market, and short position in futures market. In practice, it means if the price ratio of stock index futures to stock index spot price is higher than the upper limit of no-arbitrage band, then the arbitrageur can sell a stock index futures contract, and coinstantaneous buy the relevant index in spot market with the same value. At settlement date, they will close positions in both two markets at same time to get risk-free profit when price ratio fall back into no-arbitrage band; obviously, the reverse cash-and-carry arbitrage means buying in futures market, and selling in spot market. In practice, it means if the price ratio of stock index futures to stock index spot price is under the lower limit of no-arbitrage band, then the arbitrageur can buy a stock index futures contract, and sell the relevant index in spot market with the same value simultaneously. They will also close positions in two markets at same time to gain risk-free profit when price rise into no-arbitrage band again (Kolb & Overdahl, 2007, p.819).

The operation of futures-spot arbitrage in stock index futures contains two main aspects. First is to construct stocks portfolio in spot market according to stock index futures constituent stocks. Second is to build up the arbitrage model and determine the arbitrage-free interval. In this paper we will make a detailed demonstration analysis around these two core aspects.

3.2.1 Construction of the spot position

The arbitrageurs need to establish stocks portfolio which can directly replicate the underlying index (that means the portfolio should depend on the constituent shares contained in the stock index) to make arbitrage trading between futures and spot market. Hence the stock portfolio can be the constituent shares, or Exchange Traded Funds (ETF) in single and composite way.

The ETFs, differ from the traditional open-end mutual funds, defined as: “a baskets of securities that are traded, like individual stocks, through a brokerage firm on a stock exchange.” (Ferri, 2009,p.xvii). It is a good instrument to track the stock index in spot market. The ETF can be purchased either from fund manager with net value after the stock market close, or directly purchase from other investors in security trading market which also named secondary market. It can be seen as spot index when you construct spot position in stock index futures arbitrage. The attractive advantage to investors is the risk of stocks fluctuation happened in specific companies could be diversified away. As the result, the market risk becomes the only risk which investors need to consider associated with spot index construction for arbitrage.

There are four methods available to construct spot portfolio. They are full replication, stratified sampling replication, market capitalization weighted method and optimization method.

Full replication, that is to buy or sell corresponding amount of stocks in the spot market according to the weight of constituent stocks in the underlying index. Lei (2007) stated in his research that the full replication method is the optimal way to track the underlying index. To consider about the pros and cons of this method: Full replication has perfect tracking effect, but not a good choice for application. If the index consists of lots of stocks such as CSI 300 Index, then the full replication method for spot construction will meet a series of problems like many constituent stocks suspension at same time, arbitrage scale restricted by liquidity of one single constituent stock, or adjustment of constituent stocks for index portfolio. The principle of stratified sampling replication method is to keep the same industry weight both in spot stocks portfolio and in index portfolio without considering stock that occupied small proportion in its industry; The market capitalization weighted method means select some stocks first by sampling in one principle, and then determine each stock weight in the construction portfolio according to its market value. The optimization method is popular for professional using. It means select some stocks first by sampling in one principle, and then to determine investment weight in each stock by using quadratic programming. Among these four

methods, we will discuss four application methods in practice

- Sampling Simulation Method

The sampling simulation method is to construct the spot position by sampling part of shares from high-weighted shares within the 300 constituent stocks basket. But it is not an optimal way because there are plenty constituent stocks contained in the CSI 300 Index, and the weight of each constituent stock is lower than 5%. Then the investors need to choose a lot of stocks to build up a good replication portfolio. Too many stocks lead to small tracking error of index, but on the other hand, it will also create big trading difficulties and high transaction cost. Moreover, the frequency of stock price fluctuation would influence index tracking effect, thus if the investors want to have good tracking effect, they need to adjust the tracking portfolio frequently. From points of view above, the sampling simulation method is lack of maneuverability and persistent replication effect. So this method will not be used in this paper.

- Index fund replication method (not include ETF)

This method uses index funds (such as JiaShi 300 index fund, DaCheng 300 index fund, etc) to build replication portfolio in spot market. Compared with sampling simulation method, the index fund replication method has relative high maneuverability. But the transaction period of this method is too long. For instance, DaCheng CSI 300 Index Funds is a general open-ended fund and only can be purchased or redeemed through consignment institutions or fund companies. Because of this restriction, the whole transaction period will take three to four trading days in total. Furthermore, the investors do not know exact transaction price of the fund as the “unknown value” trade principle for purchasing and redemption of open-end funds. This kind of systemic risk cannot be controlled easily. For another choice, JiaShi CSI 300 Index Fund is a Listed Open-Ended Fund (LOF). This fund unit of LOF can be traded in the secondary market. So the liquidity of this kind of index fund is better than general open-ended fund. But one point should be mentioned that the fund price in secondary market is not completely related to the net value of funds, there may be high possibility for long-term systematic discount or premium conditions. In other words, the fund price in the secondary market may be higher or lower than the par value of the fund in the long-term because of systematic risk. This will not benefit for futures-spot arbitrage activity. Because there is a close relationship between stock index futures price and underlying index price. If the correlation relatively low between index funds price and underlying index, it will result in big uncontrollable risk. Meanwhile, the oversized irrelevance will directly influence requirement of arbitrage trading.

Actually, JiaShi CSI 300 and DaCheng CSI 300, this kind of open-ended index funds is not belong to full replication of CSI 300 Index. The index fund yield was calculated as 95% of CSI 300 Index yield plus 5% of inter-bank deposit yield. So the arbitrage efficiency cannot be guaranteed in this method because of highly tracking error for spot position construction relative to CSI 300 Index. In addition, on account of the limitation on fund scale and unit amount , the open-ended index funds do not suitable to be

underlying index fund for arbitrage of stock index futures, especially not suitable for short-term or huge scale capital trading in futures-spot arbitrage. Similar as mention early, the method which discussed here is out of consideration.

● China Mainland ETF Portfolio Replication Method

This method uses ETFs in China's mainland both from Shanghai and Shenzhen Exchanges to make replication portfolio as the spot position according to calculated weighted ratio between each other. There are five ETFs in China's Mainland which rely on A-shares both in Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) totally. They are: AnHua SSE 180 ETF, HuaXia SSE 50 ETF, YiFangDa SZSE 100 ETF, HuaTai SSE Bonus ETF, and ZhongXiaoBan ETF. As the ZhongXiaoBan ETF is built up according to medium-to-small industries in mainland China, it cannot be used to represent performance of A-shares. So the first four ETFs will be used as analyzing objects to construct the spot position portfolio. (Table 2)

Aber et al (2009) stated that the tracking ability of normal open-end fund is better than ETFs. But we decide to use ETFs as replication method in the spot market. The reasons are that: firstly, we have different research object. Aber et al investigate the tracking ability of ETFs in iShare Company in Singapore. Their research result has limited generalizability to apply the result in Chinese market. Secondly, besides the discussion on the shortcomings of general index fund, the ETFs also have some advantages. Similar to the LOF, ETF not only traded in primary market for purchase and redemption, but also making directly transaction in secondary market. So the liquidity level of ETF is high. In addition, the ETF have some advantages which LOF and general open-ended funds do not have. The ETF has lower transaction cost and easier to trade with efficient transaction. Moreover, the ETF is used in completely passive index-based investment strategy. The aim of passive index fund is not to seek excellent performance which exceed market average level, but try to simulate the behavior of underlying index and track it. Arbitrageurs could invest in one 'basket' constituent shares of underlying index with low cost on account of lower risk and management cost, and higher transparent operation. As a whole, this method belongs to full replication. It can perfect replicate the underlying index by several ETFs instead of 300 constituent shares with lower transaction cost, lower track error, lower risk and higher operability. So we choose this China mainland ETF portfolio replication method as one of the empirical analysis objects in this paper.

Table 2: The ETF in China Mainland (until May, 2010)

Name	Net Value(¥)	Unit Scale (billion)	Start Trading Date
SSE 50 ETF	4.008	54.35	23 rd Feb, 2005
SSE 180 ETF	11.561	10.73	18 th May, 2006
SZSE 100 ETF	5.393	51.58	24 th April, 2006
Bonus ETF	4.409	...	18 th Jan, 2007

(www.chinafundinc.com)

- Replication by W.I.S.E-CSI 300 ETF Tracker

The W.I.S.E-CSI 300 China Tracker is an index-tracking fund which listed in the Stock Exchange of Hong Kong Limited (SEHK) (Stock Code 2827). It was able to be short selling at the list date in 2007. In order to track the performance of CSI 300 Index, the fund manager invested all non-cash assets solely in A-Shares Access Products (AXPs) instead of direct investment on A-shares. The reason is that non-domestic persons can only invest in China's A-shares through QFII (Qualified Foreign Institutional Investors). "Each AXP is a derivative instrument linked to a basket of A-shares but it does not give the fund any right, ownership or interest in the underlying A-share(s)" (SEHK, 2010). It should be notice that this tracking fund pricing in HK\$, differ from the underlying index which pricing in RMB (Ren Min Bi-Chinese Yuan- ¥). So the investors have to pay attention on exchange rate risk also if they use this kind of ETF to build spot index position for arbitrage.

As we talk above, compare to other replication methods the ETF replication is a creative method to do futures-spot arbitrage in stock index futures market. In this thesis, we will choose ETF to track the CSI 300 Index on account of its large comparable advantages. However, the major issue of ETF replication method is to select the correct and suitable ETF from various candidates. More specifically, we will think about choose W.I.S.E CSI 300 ETF or ETFs portfolio in Mainland China as replication method in arbitrage. Therefore, we analyze and compare tracking effect of both methods, and find out the optimal strategy for index spot construction.

3.2.2 Tracking Error

Meade & Salkin (1989) examined the measurement of index funds' ability to track underlying index. They said that: the measurement for index funds' performance is determined in terms of tracking error. They defined the tracking error with Equation 6 as below:

Equation 6: Tracking Error

$$R_L = \left[\sum_{t=L}^T (d_{t,L} - p_{t,L})^2 \right]^{0.5}$$

(Meade & Salkin, 1989, p.872)

R_L , The tracking error over L time periods is the root mean square deviation between index fund return and spot index return, with T observations of index and index-fund values.

In order to find out the return on index fund over L time periods ($p_{t,L}$) and the corresponding return of the spot index ($d_{t,L}$), they denote P_t as the value of index fund at time t and I_t as the value of index at time t. Then $p_{t,L}$ and $d_{t,L}$ could be calculated in Figure 5.

$$p_{t,L} = (P_t - P_{t-L}) / P_{t-L}$$

$$d_{t,L} = (I_t - I_{t-L}) / I_{t-L}$$

Figure 5: Semi-equation for tracking error

The researchers also said that: “The tracking error is dependent on the frequency of the observations and the value of L.” So the tracking error measuring returns will not change in a given period whatever time unit you chose (like daily data and weekly data). (Meade & Salkin, 1989, p.871-879)

Swinnerton et al (1988) found that the arbitrage opportunities were created as the time for price changes inconsistency. The investors could look for arbitrage opportunities when the constructed spot position is able to track spot index effectively. If the stock index futures price located within the no-arbitrage band, there is no available arbitrage opportunity. But if the price exceeds the limits of band, investors would gain risk-free profit by arbitrage. Therefore, the determination of no-arbitrage band is a vital step in futures-spot arbitrage. Here we start discussing about how to calculate this no-arbitrage band.

3.2.3 Modified no-arbitrage Interval Pricing Model

As too many sub titles discussed in this issue, we listed overview outline of sub titles in this section. (Figure 6)

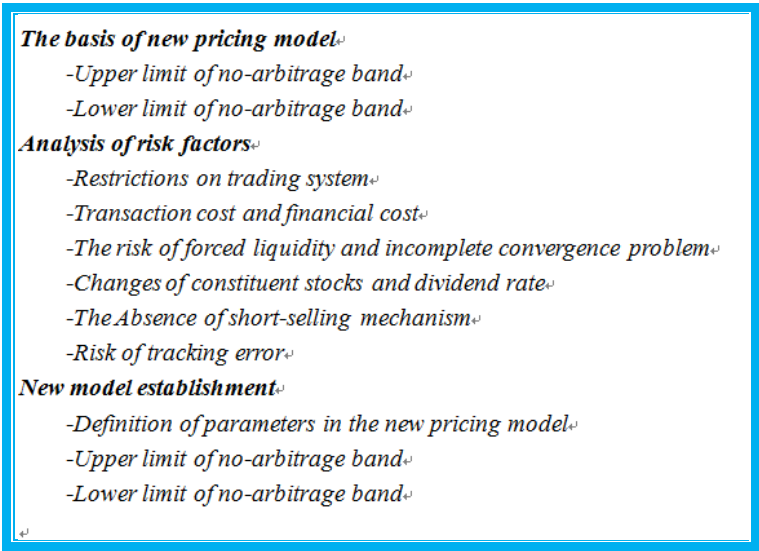


Figure 6: Sub titles in section 3.2.3

- **The basis of new pricing model**

Because the shortages of former models, we want to establish a new pricing model to measure the no-arbitrage band. Through empirical research Brennan & Schwartz (1990)

found that the price of index futures which calculated by cost of carry model is very close to the actual futures price. Therefore, the basis of our new pricing model is interval pricing model which derivate from the cost-of-carry theory and the following is this model with consideration of trading commission and impact cost.

First of all, we provide the definition of each parameter in interval pricing model (Table 3)

Table 3: Definition of parameters in interval pricing model

Parameters	Definition
S_t	price of spot index at time t
S_T	price of spot index at time T ($T > t$)
C_{st}	trading commission of spot index trading
C_{sl}	impact cost of buying spot index
C_{ss}	impact cost of selling spot index
C_{ft}	transaction cost of index futures trading
C_{fl}	impact cost of buying index futures contract
C_{fs}	impact cost of selling index futures contract
F_t	price of index futures contract at time t
F_T	price of index futures contract at time T
F_{TT}	theoretical price of index futures contract at time T
r	risk-free interest rate
$T-t$	the period from t to T

- Upper limit of no-arbitrage band

As we know, the cost of futures position is the summation of transaction cost on buying index futures contract and selling index futures contract. Similarly, the cost of spot index also includes cost of buying spot index and cost of selling spot index. Therefore we can derive the upper limit through the process in Figure 7:

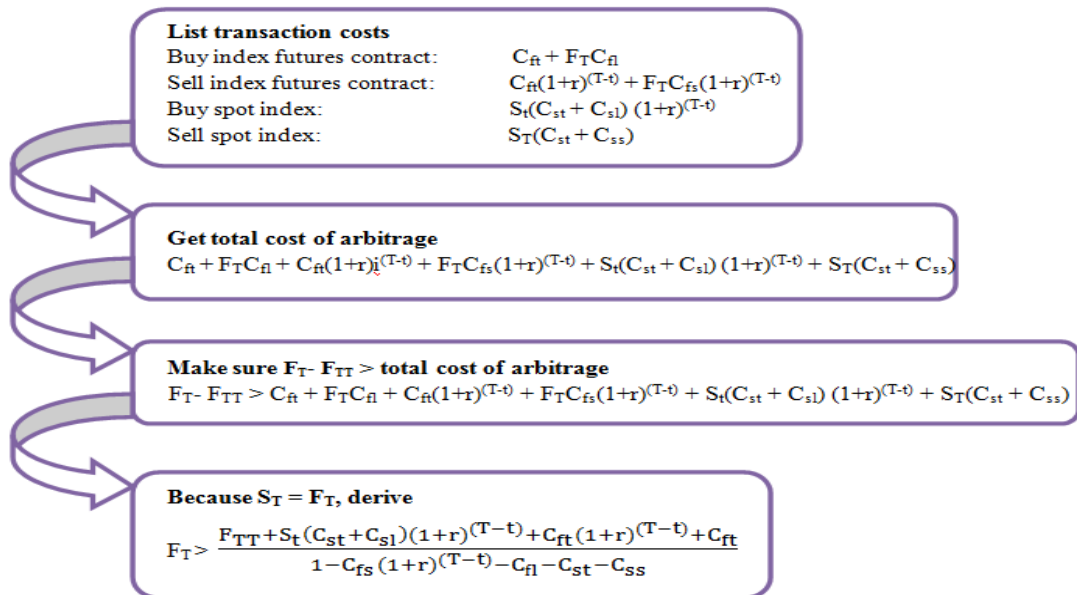


Figure 7: Derive upper limit of no-arbitrage band

Therefore, the upper limit is showing in Equation 7:

Equation 7: Upper limit of no-arbitrage band

$$F_t > \frac{F_{TT} + S_t(C_{st} + C_{sl})(1+r)^{(T-t)} + C_{ft}(1+r)^{(T-t)} + C_{ft}}{1 - C_{fs}(1+r)^{(T-t)} - C_{fl} - C_{st} - C_{ss}}$$

- Lower limit of no-arbitrage band

The calculation of lower limit is contrary of upper limit but the computation process is same. We also need to get cost of futures contract and cost of spot index. The calculation is in Figure 8:

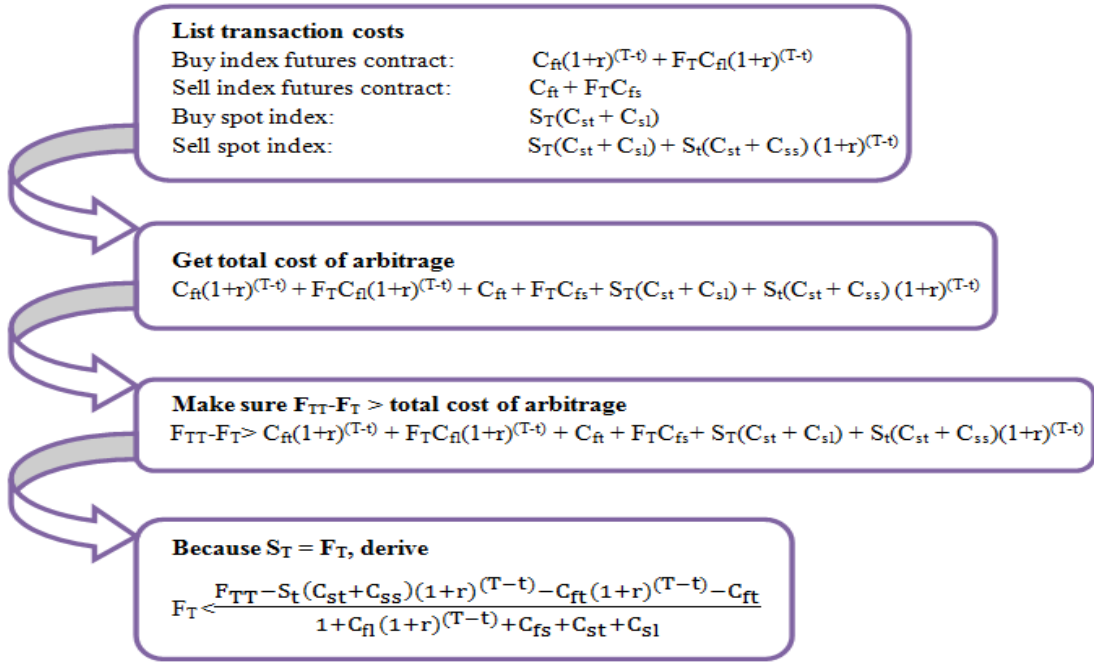


Figure 8: Derive lower limit of no-arbitrage band

Consequently, we get the lower limit of arbitrage presented in Equation 8:

Equation 8: Lower limit of no-arbitrage band

$$F_t < \frac{F_{TT} - S_t(C_{st} + C_{ss})(1+r)^{(T-t)} - C_{ft}(1+r)^{(T-t)} - C_{ft}}{1 + C_{fl}(1+r)^{(T-t)} + C_{fs} + C_{st} + C_{sl}}$$

● Analysis of risk factors

As we discuss above, the ordinary interval price model just concentrate on trading commission and impact cost. However, in the realistic situation, there are still many factors could affect the result of model even the success of arbitrage behavior which based on such pricing model. Thus, we will discuss and analyze some unavoidable affecting factors in China's financial market.

- **Restrictions on trading system**

Firstly, on account of the rules from regulator, China's stock market carries out T+1 settlement and stock index futures market implements T+0 settlement. Therefore, investors in futures market would have to face a serious problem that they could not close the position to obtain profit timely. Because the opportunities of arbitrage are very short, and in many cases, the future's price could exceed no-arbitrage band close behind position establishment at the same day but drop into it again at next day. The T+1 settlement would have a strong impact on synchronization between close positions on futures and spot market. As a result, these restrictions increase the risk of arbitrage and reduce the efficiency in the use of funds.

In addition, the restrictions on price changes are also cannot be ignored. The limits of price changes on stock and index futures are both 10 percent. Moreover, the CSI 300 Index futures introduced an extra Circuit Breakers mechanism at 6 percent price changes.

- **Transaction cost and financing cost**

Sutcliffe (2006) claimed that the arbitrage opportunity only exists when the mispricing exceeds the transactions costs of the arbitrage trade. Thus, to consider about the transaction cost and relevant financing cost is significant. In financial market, total transaction cost contains cost of spot and cost of futures. In spot market, the main transaction costs are trading commission and stamp duty. For futures market, it just has trading commission. At the present, the transaction cost of CSI 300 Index futures is 30 RMB each unit. In reality, stock index futures arbitrage is not a totally risk-free. When you establish the arbitrage portfolio, you have to invest funds and then inevitably create financing cost. On the other hand, when you implement the reverse cash-and-carry arbitrage, you also have to consider the cost of securities loan.

- **The risk of forced liquidation and incomplete convergence problem**

Futures trading implement the margin system and the fluctuation of market would enforce investors to make margin calls at any time. So, if they could not meet the minimum margin requirement, they have to take the risk of forced liquidation which means the arbitrage would be forced to end and even to result in a loss.

In terms of convergence of futures and spot, because the settlement price of CSI 300 Index futures is calculated by CFFEX and equal to the weighted price of the last 2 hours in last trading day. That makes the settlement price may not converge to the spot price at the end of trading and create the incomplete convergence problem. Because our model is built on the assumption that settlement price completely converge to the spot price, so incomplete convergence problem would influence the final arbitrage result obviously.

- **Changes of constituent stocks and dividend rate**

The CFFEX will examine and audit constituent stocks semiannually and adjust composition of constituent stocks according to the result of audit. The adjustment of constituent stocks will be carried out at each first trading day in July and November; the

percentage of changed constituent stocks normally not exceeds 10 percent of all. Furthermore, if one stock meets every requirement of constituent stock and its market value is within the Top 10 in stock market, then it will be added into constituent stocks immediately and instead the worst performing one. On the whole, the changes of constituent stocks will influence spot position, and then influence arbitrage effect.

Moreover, the dividend rates of constituent stocks are also not same and the payments of dividend are uncertainty. All of them would affect the calculation of price and practical arbitrage behavior.

- **The absence of short-selling mechanism**

Because the margin trading is not allowed in China at present, investors could not borrow the stocks when they want to do the reverse cash-and-carry arbitrage. So when the price of futures exceed no-arbitrage band and below lower limit, all the investors just only calculate how much profit they could obtain by arbitrage, but do nothing! As the result, the arbitrage only be applied in cash and carry arbitrage situation and investors loss many opportunities to do the arbitrage when the futures' price go down.

- **Risk of tracking error**

CSI 300 Index includes 300 constituent stocks and the best way to track this index is establishing a portfolio that contains all of constituent stocks. However, this method is impossible to apply by individual investors because it requires a large number of funds and must buy or sell all the stocks at the same time. So, almost all the investors in futures market use ETF to tracking index. In our thesis, we use a portfolio of ETF instead of just use one ETF. But, although ETF simulates index very well, it still could not achieve 100% tracking index. The error of tracking would influence the effect of arbitrage and should be considered in the model.

● **New Model Establishment**

Based on the interval pricing model, we will establish a new pricing model for CSI 300 arbitrage and consider more affecting factors in this new model. To put them more specifically, we discuss transaction cost, impact cost, different borrowing rate, dividend rate, risk reserve for forced liquidation, and spot tracking error. We will focus on yield instead of cost which used in the two original interval pricing models established separately by Modest & Sundaresan (1983) and Klemkosky & Lee (1991). The reason is that: If we build our pricing model based on cost, we have to calculate the theoretical price of index futures contract first, and then use the pricing model to find out no-arbitrage band. However, if we choose yield as the basis to construct model, we would not calculate the theoretical price of index futures contract because it could be offset at the process of model deviation. In addition, building model based on yield is also more understandable than in view of cost. After that we will find out the new upper limit and lower limit of no-arbitrage band for CSI 300 Index futures that we deem it could more factually reflect realistic situation.

- **Definition of parameters in the new pricing model**

In our new pricing model, we added some new parameters into it, Table 4 is the definition of these parameters and others are same with Table 3.

Table 4: Definition of parameters in new pricing model

Parameters	Definition
M_1	margin level of index futures contract
M_2	reserve ratio of forced liquidation
H	price multiple
C_l	cost of loan
C_{ls}	cost of equity financing
S_e	effect of tracking error on yield
D_{Tt}	present value of dividend issued from t to T

- **Upper limit of no-arbitrage band**

If the price of futures exceeds upper limit of no-arbitrage band, we think the index future is overvalued and spot index is undervalued. At this situation, we should buy spot index and sell index futures. From calculating the yield we can find out the limit of no-arbitrage band. Details show in Figure 9.

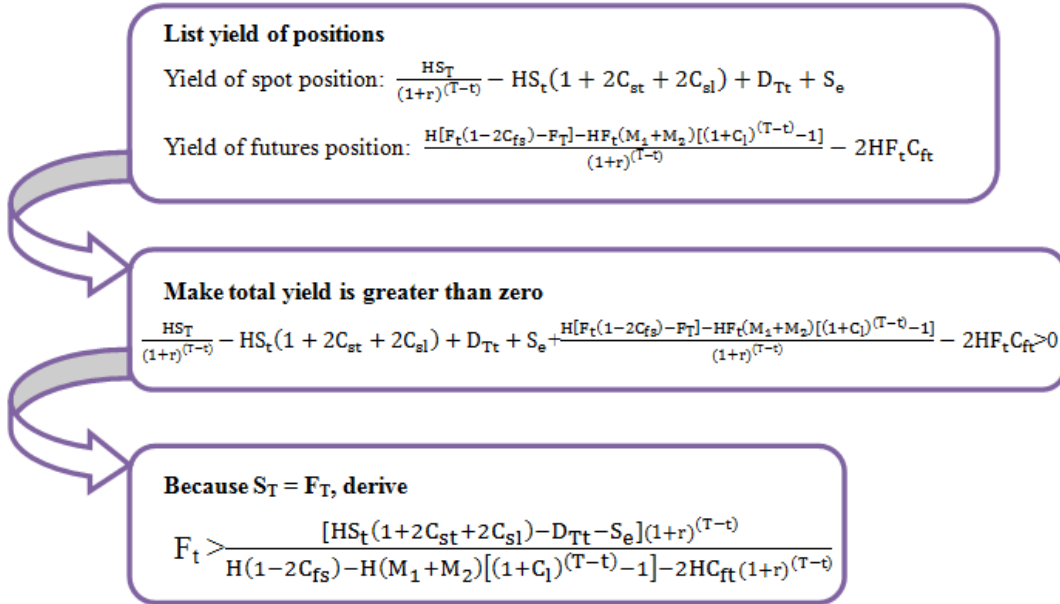


Figure 9: Upper limit of new pricing model

In order to get profit, we should ensure the total yield is greater than zero. The result of this requirement is that F_t should be more than a numerical value which is the upper limit of no-arbitrage band. (Equation 9)

Equation 9: Upper limit of new pricing model

$$F_t > \frac{[HS_t(1 + 2C_{st} + 2C_{sl}) - D_{Tt} - S_e](1+r)^{(T-t)}}{H(1-2C_{fs}) - H(M_1 + M_2)[(1+C_l)^{(T-t)} - 1] - 2HC_{ft}(1+r)^{(T-t)}}$$

- **Lower limit of no-arbitrage band**

If the price of futures is below lower limit, we think the index future is undervalued and spot index is overvalued. We do the opposite process of before, sell spot index and buy index futures. (Figure 10)

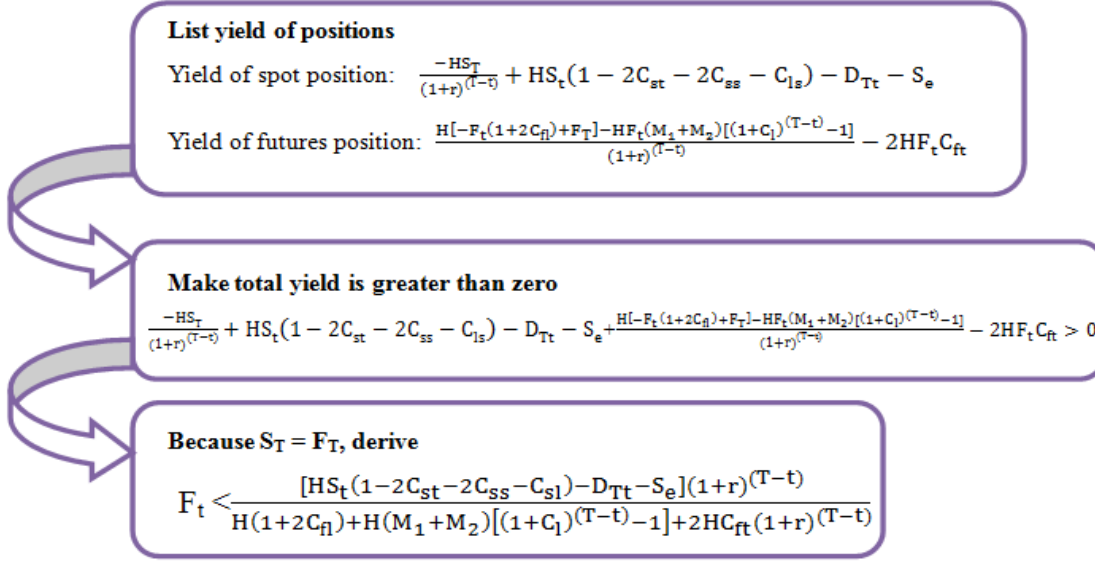


Figure 10: Lower limit of new pricing model

To conclusion, revised limits are showing in Equation 10 and 11, which will be used as theoretical framework in this paper. Then we will apply these equations to calculate no-arbitrage band after collecting the data.

Equation 10: Upper limit in theoretical framework

$$F_t > \frac{[HS_t(1 + 2C_{st} + 2C_{sl}) - D_{Tt} - S_e](1 + r)^{(T-t)}}{H(1 - 2C_{fs}) - H(M_1 + M_2)[(1 + C_l)^{(T-t)} - 1] - 2HC_{ft}(1 + r)^{(T-t)}}$$

Equation 11: Lower limit in theoretical framework

$$F_t < \frac{[HS_t(1 - 2C_{st} - 2C_{ss} - C_{sl}) - D_{Tt} - S_e](1 + r)^{(T-t)}}{H(1 + 2C_{fl}) + H(M_1 + M_2)[(1 + C_l)^{(T-t)} - 1] + 2HC_{ft}(1 + r)^{(T-t)}}$$

Overall, the limits we have found are demarcations of no-arbitrage band and investors could only make arbitrage when the price of future is outside this band. Specifically, they can do the cash-and-carry arbitrage if price is greater than upper limit, or reverse cash-and-carry arbitrage if price is less than lower limit.

This is the new model what we use instead of original interval pricing model by Modest & Sundaresan (1983) and Klemkosky & Lee (1991). We will try to show in empirical research that our new model has better result than the original one.

Chapter IV

Methodology and Data

In this chapter, we present practical methodology used in thesis. First of all, we interpret the reasons for choosing of this research subject. Secondly, we explain our scientific perspectives and research strategy in this thesis. Furthermore, we describe the details about data selection, data collection and resources of data.

4.1 Choice of Subject

CSI 300 stock index futures is interesting and fresh to Chinese investors when it was launched in mainland China on 16th April, 2010. As an emerging financial instrument, it has many inherent characteristics which are worth to research and study. In addition, stock index futures market was supported strongly by Chinese government. The government and CFFEX spent five years for market launching preparation, and even running a simulation trading system around four years. Therefore, we choose this newly instrument as our main research subject. After the literature review, we realized that the major functions of stock index futures are arbitrage and hedging. Between them, the arbitrage is very active in the early development of stock index futures market especially futures-spot arbitrage. Then the direction of our research subject comes out as: how to build up futures-spot arbitrage strategy for China's stock index futures investment? As master students major in finance field, this interesting topic is valuable for us to do empirical research on.

4.2 Scientific Perspectives

There are various factors should be taken into consideration for scientific perspectives of our research. We will indicate what scientific perspectives are influencing our investigation and analysis. In terms of ontology concerns about what the real world is, as well as the epistemology which emphasizes how to know the real world.

4.2.1 Objectivism

In this paper, the ontological position is objectivism. The objective of this study is to build up futures-spot arbitrage strategy for stock index futures. In other words, the two key targets in our paper are estimating the replication method of spot position construction and looking for appropriate method to determining no-arbitrage band. We gather simulation data from year 2007 to 2010, and measure efficiency of different replication methods by using liquidity level, correlation level with underlying index, and tracking error of each method (Details in chapter 3). Then we modify the interval pricing model by adding some significant affecting factors in China. The data were collected in order to calculate or estimate the factors mentioned above. These kinds of

numbers are “out there” and independent of social actors. Therefore, the scientific research questions are in the view of objectivism. The ontology often focuses on the nature of social entities. The emphasis of objectivism is on social phenomena and it focuses on meanings that exist independent of social actors. In other words, social reality is seem external to the researchers, it therefore have an existence that independent of researchers’ mind. (Bryman & Bell, 2007, p.22).

4.2.2 Positivism

This paper is concerned with the question of how to build up futures-spot arbitrage strategy for stock index futures trading in China and the positivism paradigm is employed in order to resolve the problem statement. This epistemology paradigm, positivism, presents that: knowledge, which employed to support investigation, should be objective. The intention of the researcher, who is influenced by positivistic, is to explain what the truth is and carry out deep exploration of the unknown. (Gummesson, 2000, p. 177). We are guided by positivism to do the research because it requires us to gather data over long term and to evaluate each of the replication methods by empirical research on stock index futures simulation market in China according to particular equations. So the positivism position is adopted in our research in contrast to the realistic and interpretivestic research position.

4.2.3 Deductive

In this paper, we follow the deductive logic. In practice, we employed no-arbitrage interval pricing model for stock index futures pricing in China, and modified the model by considering additional affecting factors, such as reserve ratio of forced liquidation, effect of tracking error on yield, and cost of equity financing, etc. This means that we refine the theory. Then we use replication theory to construct the spot position in arbitrage. After determining the research period, we collect data from 2007 to 2010. Through calculation and empirical analysis, we find optimal method to construct index spot position by testing different combination of ETFs both in Mainland China and in Hong Kong. Meanwhile, we obtain no-arbitrage interval by using the modified equation. Through comparison in mispricing ratio between original and modified pricing method, we decide to use the modified pricing equation in the futures-spot arbitrage. At the end of the research, we will test our empirical result by using one month real trading data from 19th April till 17th May, 2010 to calculate the rate of return by using our optimal futures-spot arbitrage strategy in stock index futures market.

The deductive logic devoted to resolve the research question by reviewing the existent theories and deduce hypothesis which are tested afterward on the basis of empirical findings. At the end of this deductive process the relevant theories can be revised through confirming or rejecting hypotheses which pose at the beginning of the research. (Byrman & Bell, 2007, p.11-15). Without presenting our formally hypothesis and their test, our research logic is belongs to deductive approach.

4.2.4 Research Strategy and Research Design

We divide the research into two main parts. First is to replicate the spot index in futures-spot arbitrage. Second is to determine the pricing model of futures contract.

After discussion in chapter 3, we decide to use ETF as the replication method in spot index market. The replication method could be the ETFs portfolio in mainland China or direct investment on W.I.S.E CSI 300 ETF in Hong Kong. We will choose one of optimal method with comparative research design in three aspects. First is liquidity level. It can be measured by turnover rate of ETF, and calculated as daily average trading amount divided by total ETF units in the market. Second is correlation of replication method to the spot index both in price and in yield. The close price of CSI 300 Index and net asset value of each ETF in units will apply in this aspect. Through regression analysis in SPSS software, we select three of four ETFs in mainland China to construct the replication portfolio, and calculate four times for permutation and combination of three ETFs. Then choose the combination method which R-square is closest to 1 (Table 8). In the meantime, we establish the correlate equation according to the different coefficient weight shows in Appendix 4, compare the R-square of tested portfolio with W.I.S.E-CSI 300 ETF. The last aspect is tracking error. According to equation 15, the tracking error can only be calculated rely on the result of tracking difference and average tracking difference results. As we have determine the replication ETFs portfolio in mainland China, the tracking error for both replication methods can be calculated easily by the equation. In the end, we make a table that contains three aspects in both methods, and do final decision through intuitionistic comparison.

Through the literature review, we employ interval pricing model as the basic model. After discussion various risk factors on pricing, we add considered variables which could influence the pricing effect in a large extend. Then we derived the upper and lower arbitrage limits respectively from cash-and-carry arbitrage and reverse arbitrage procedure (details in theoretical framework). The arbitrage opportunities can be found through observing the distribution of futures trading price combine with no-arbitrage band figure. Next step we will introduce the mispricing ratio and apply this ratio both on original and modified no-arbitrage pricing model. Then we can see which pricing method is better for futures-spot arbitrage in China's stock index futures market. Last but not least, we will retest the modified model together with replication portfolio by using one month real trading data in China, to describe detailed futures-spot arbitrage procedure and strategy in practice, and calculated the rate of return under our arbitrage strategy.

According to characteristics of research strategy in this paper, our research belongs to quantitative approach. Compared with other research strategies, we are not only pinpoint the differences between cases (i.e. ETFs portfolio in mainland China and W.I.S.E CSI 300 ETF in Hong Kong), but also collect the numerical data instead of select data in form of words and explanations (Bryman & Bell, 2003, p. 154). We do the logical analysis step by step to refine the theory. In addition, our data is derived from

numbers, numerical information, and academic analysis conducted through using of statistics (Saunders, Lewis & Thornhill, 2009, p.482). Thus, our research strategy is quantitative approach

4.3 Data

4.3.1 Data Selection

Since the real trading data of China's stock index futures just available from 16th April 2010, the limited data groups in daily is not enough to be used for analyzing. So the simulation trading data on CSI 300 stock index futures was selected to do empirical research first. And then we will retest our arbitrage strategy by using one month real trading data.

The empirical research data for construction of spot position selected from 17th July, 2007 to 15th April, 2010. Totally up to 672 data sets in daily observation (only include trading day). W.I.S.E-CSI 300 ETF is the newest one in our research objects which start trading at 17th July, 2007. We choose this as the start point for analysis. Because the formal trading for CSI 300 Index futures was operated in April 2010, it could lead to considerable fluctuation of ETFs trading volume. So the ETFs trading data after launching date of stock index futures would be avoided. Otherwise, the abnormal change in trading volume will influence the accuracy of research.

The empirical research data for pricing of stock index futures was selected from 17th July, 2007 to 31st March, 2010. This is different with the research period above. The reason is that: the data for pricing analysis is classified according to the time period of each futures contract. Different futures contract has different delivery date. The futures contract can be one month, three months or half a year. In this paper, we just examine the monthly contract. Generally speaking, the maturity date for monthly contract is the third Friday in each month. There are 20 contracts totally during our observation period.

The data selection for retesting our arbitrage strategy at the end of the thesis was selected from 19th April, 2010 to 17th May in the same year. This is the available real trading data for stock index futures in China.

4.3.2 Data Collection

We have two major data sources: first is the official institution website such as SSE, SZSE and HKSE. Second is the professional financial website as Yahoo Finance. The official institution website is the main data sources because it's high reliability. But some of the data, such as net asset value of ETFs in Mainland China is not available on the primary source. So we search the rest of necessary data from Yahoo Finance. After confirm the research period, we collected all of the necessary data, including close price of CSI 300 Index; trading volume and net asset value in unit of SSE 50 ETF, SSE 180 ETF, SZSE 100 ETF, SSE Bonus ETF and W.I.S.E-CSI 300 ETF in Honk Kong. It can be found easily from historical data review part. Then we processing data through Excel

and calculate by SPSS software for regression analysis.

4.3.3 Choice of Secondary Resources

According to our specific research questions, articles and student thesis database, printed books in Umea University library and E-books on Google website are main sources for literature review and theoretical framework writing. The reference list of scholarly papers also provides valuable sources for academic writing. In addition, some official web pages in financial field, such as Yahoo Finance and Shanghai Stock Exchange were employed in data collection and empirical research section. These sources mentioned above all belong to secondary resource.

Bryman & Bell presented that “Secondary analysis is the analysis of data by researches who will probably not have been involved in the collection of those data, for purposes that in all likelihood were not envisaged by those responsible for the data collection.” (Bryman & Bell, 2007, p. 326). In this thesis, we do research in China's financial market. Due to time and geographical constraints, we choose secondary resources as mainly reference. The reasons are that: firstly the secondary data is more convenient to use than primary data because the author do not need to collect original data by themselves. Secondly, the secondary resources will help to save research cost. It can be collected in inexpensive way. Last but not least, the information provided by secondary resources has high quality and creditability with great value because it is research result from previous researchers. Those are reasons why we use secondary resources in our thesis work.

Besides the merits, the secondary resources still have some disadvantages which have to be considered.

Initially, secondary data is not specific to what researchers aim at. The secondary data is collected by former researchers or institutes and classified in different segments between researchers' need. In addition, secondary data may not gather in particular region or time period that match the demand of current researchers. Moreover, the no-special data would lead to changes of definition or categorization of variables which researchers want to choose.

In the next place, the secondary data may have the problem of incomplete information. This claim consists of two aspects. First one is that the former study missed some important information of objects which crucial for researchers, such as specific date or special property. Secondly, upon most occasions, some data of former studies are free for everyone, but the whole of them are very expensive. In terms of the researchers, they could not obtain enough data unless pay much money for that previous data.

Furthermore, the secondary data is often outdated. The inherent nature of secondary data determines that all of them were collected well in the past. However, the out-of-date data does not reflect everything at present; it just could provide little value

than before. The researchers have to pay much attention on this problem.

Last but not least, the quality of secondary data. As the researchers do not participate in the planning and implement of previous data collection process, they do not know how exactly the data was done. Moreover, the researchers could not know how the data was done and therefore not ensure how seriously the data were affected by some factors. Thirdly, every collection of data has the “dirty little secrets” which could not invalidate data but should be considered by the researchers. If the researchers did not take part in the data collection process, they have to find out this information through other ways.

On balance, we will employ the secondary resources during the whole research, but use it very carefully by considering factors mentioned above.

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Chapter V

Empirical Analysis

In this chapter, we evaluate tracking effect of different ETFs portfolio combinations. The evaluation indicators include liquidity level of ETF, correlation with CSI 300 Index, and ETFs tracking error. Moreover, we explore futures-spot arbitrage opportunities according to the modified no-arbitrage pricing model, using both simulation data and one month formal trading data, and then provide a case of arbitrage by using this futures-spot arbitrage strategy.

After discussion about pros and cons of different construction methods of spot index position, we choose China mainland ETFs portfolio replication method and W.I.S.E-CSI 300 ETF tracker replication method as empirical analysis objects. Through comparison, we will find the merits and demerits of both two methods, and select optimal one to track the CSI 300 Index for futures-spot arbitrage.

The empirical analysis mainly consists of three aspects which are liquidity analysis, price and yield correlation analysis, and tracking error analysis. Among them, the main indicators of liquidity are total transaction value, trading volume, and turnover rate. The higher liquidity the better for arbitrage; the main indicators of correlation include price coefficient and yield coefficient. The higher coefficient the better for arbitrage; the tracking error means the yield deviation between the spot index tracking portfolio and underlying index. Keep the tracking error as small as possible.

5.1 Empirical research on ETF portfolio in China's mainland

The analyzing objects of ETF portfolio include SSE 50 ETF, SSE 180 ETF, SZSE 100 ETF, and SSE Bonus ETF. And the data extend is from 17th July, 2007 to 15th April, 2010. Totally up to 672 trading days.

5.1.1 Liquidity Analysis

After calculate daily average trading volume, trading amount and ETF's turnover, we compared the liquidity of the ETF in China mainland in Table 5 below.

Table 5: Liquidity indicators comparison for ETF in mainland China (within research interval)

ETF	Total ETF Units in Market (billion)	Daily Average Trading Volume (billion ¥)	Daily Average Trading Amount (billion units)	Daily Turnover (%)
SSE 180 ETF	6.131226740	0.0731891	0.074987	1.22
SSE 50 ETF	11.389566757	1.2246566	0.5496676	4.82
SZSE 100 ETF	6.027166634	0.3604609	0.1014851	1.68
SSE Bonus ETF	1.618675703	0.2137913	0.0815028	5.03

*The total ETF scale data is collected on 15th April, 2010. (<http://finance.cn.yahoo.com/fin/fund/list/etf.html?c=7>)

(Data sources: Website of SSE and SZSE)

The daily turnover rate equals to the daily average trading amount divided by total ETF units in the market. Through comprehensive comparison of three liquidity factors, we can see that SSE50 ETF has the best liquidity, followed by SZSE 100 ETF and SSE 50 ETF with relative satisfactory liquidity level. The SSE 180 ETF is the worst one of all.

5.1.2 Correlation Analysis

- Correlation in price

The close price of CSI 300 Index and Net Asset Value (NAV) per unit of each ETF is used to estimate the price correlation separately in regression analysis. We use the R-square to compare the relation between ETF and CSI 300 Index, the result of R-square for each ETF is listed in Table 6:

Table 6: Price Correlation of each ETF to CSI 300 Index in Mainland China

	SSE 180 ETF	SSE 50 ETF	SZSE 100 ETF	SSE Bonus ETF
R-square	0.996	0.981	0.967	0.985

From the Table 6 we can see that the net asset value of SSE 180 ETF has the strongest correlation with CSI 300 Index price because its R-square is closest to 1, and degree of correlation of the SSE Bonus ETF and SSE 50 ETF are also acceptable. Compared with others, SZSE 100 ETF is less correlated to the price of underlying index.

-Correlation in Yield

Here the yield is not in yearly, but in daily return. The Equation 12 shows how to calculate it:

Equation 12: Yield of ETF

$$R_t = (P_t - P_{t-1}) / P_{t-1}$$

P indicates the daily closing price of CSI 300 Index and the yield of ETF is calculated with same formula by using net asset value per unit instead of close price. Then we do the regression analysis one by one for each ETF to exam yield correlation with underlying index in Table 7. The results are showing as followed:

Table 7: Yield Correlation of each ETF to CSI 300 Index in Mainland China

	SSE 180 ETF	SSE 50 ETF	SZSE 100 ETF	SSE Bonus ETF
R-square	0.896	0.923	0.941	0.921

Here the result presents that SSE 180 ETF has the worst correlation with CSI 300 Index. In contrast, other three ETFs have satisfactory R-square value to prove their yield correlated to CSI 300 Index. The yield correlation is a major reference variable because it could directly influence tracking error of ETF to underlying index.

Consider the analysis result above, we decide to remove SSE 180 ETF from the tracking portfolio. The reasons are definitely, first, it has poor liquidity level compared with other three ETFs; secondly, SSE 180 ETF has lower correlation with CSI 300 Index which will influence the arbitrage effect of portfolio; Last but not least, the more ETFs contain in portfolio, the higher transaction cost and transaction difficulty are brought to spot position construction and affecting arbitrage effect. So we will construct the spot portfolio by SSE 50 EFT, SZSE 100 ETF and SSE Bonus ETF only.

In order to find the optimal portfolio to track underlying index, we do regression analysis on different combinations of the ETF portfolio by using yield of each factors in observation period. Table 8 below shows the result. (Regression details in Appendix 4)

Table8: Regression analysis of different portfolio combinations to CSI 300 Index

Constant	SSE 50 ETF	SZSE 100 ETF	SSE Bonus ETF	R-square	Standard Error of the Estimate
0	0.442	0.521		0.976	0.373%
0	0.495		0.453	0.961	0.477%
0		0.547	0.375	0.961	0.482%
0	0.369	0.403	0.19	0.980	0.34%

We choose the portfolio which R-square is most close to 1, and with lowest standard error of the estimation. Obviously, we should use all three ETFs combination to construct portfolio for CSI 300 stock index arbitrage.

The coefficient of three ETFs to underlying index is 0.369, 0.403 and 0.19. It can be seen as the weight of each ETF in portfolio. We define CSI 300 Index, SSE 50 ETF, SZSE 100 ETF, and SSE Bonus ETF separately as: Y, X₁, X₂, X₃. Then we get the

Equation 13 as followed:

Equation 13: Coefficient of three China mainland ETFs to underlying index

$$Y=0.369X_1+0.403X_2+0.19X_3$$

Apply this equation in practice. If the institution investor has 100 million RMB for spot position construction, they can establish the portfolio by buying 36.9 million in SSE 50 ETF, 40.3 million in SZSE 100 ETF, and 19 million in SSE Bonus ETF.

5.1.3 Tracking Error Estimation

In this paper, we employ the root-mean-square deviation of Tracking Difference (TD) to estimate Tracking Error (TE). Tracking difference means the difference between underlying index yield and tracking ETF yield. According to the tracking error Equation 6 (Page 20) from Meade & Salkin (1989) we have described before, the tracking error will be examined by following Equation 14, 15 and 16:

Equation 14: Tracking Difference of ETF to CSI 300 Index

$$TD_t = \frac{NAV_t - NAV_{t-1}}{NAV_{t-1}} - \frac{P_t - P_{t-1}}{P_{t-1}} = \frac{NAV_t}{NAV_{t-1}} - \frac{P_t}{P_{t-1}}$$

Equation 15: Tracking Error of ETF to CSI 300 Index

$$TE = \sqrt{\frac{\sum_{t=1}^N (TD_t - \overline{TD})^2}{N-1}}$$

Equation 16: Average Tracking Difference of ETF to CSI 300 Index

$$\text{And: } \overline{TD} = \frac{1}{N} \sum_{t=1}^N TD_t$$

In which NAV_t indicates the unit net asset value of ETFs in date t, and P_t denotes the closing price of CSI 300 Index in date t. N is the total observation numbers.

First of all, we calculate the NAVs of the portfolio according to weight in regression equation. The total NAVs equals to sum of each ETF's weight times relevant NAV per unit. Then according to Equation 14 and 16, we get average tracking difference of portfolio as 0.005065%. And the total tracking error of established portfolio is equal to 0.363915%.

5.2 Empirical research on W.I.S.E-CSI 300 ETF Tracker

The empirical data in this part amount to 652 observations, which include trading data of W.I.S.E-CSI 300 ETF, CSI 300 Index and NAV per unit of the ETF. The interval of

data is from 17th July, 2007 to 15th April, 2010. One point should be mentioned that the trading date is a little bit different in mainland China because of various public holidays.

5.2.1 Liquidity Analysis

By using the same calculation method in section 5.1.1, we collected daily average trading volume as 0.002467 billion, and total trading units of W.I.S.E-CSI 300 ETF in market as 5.67666 billion in observation period. Then we get the liquidity level indicated as turnover rate of W.I.S.E-CSI 300 ETF is 4.346%. Because turnover is a ratio, it is not necessary to consider about the exchange rate between HKD (Hong Kong Dollar) and RMB. (Hong Kong Stock Exchange: www.hkex.com.hk)

5.2.2 Correlation Analysis

Here is to examine the correlation between CSI 300 Index and W.I.S.E CSI 300 ETF, both on price and rate of return. Of which the sampling data relevant to price correlation is represented as closing price of CSI 300 Index and unit NAV of W.I.S.E-CSI 300 ETF within observation period. Same data employed in yield correlation.

● Price correlation



Figure 11: Trend Stacking of CSI 300 Index & WISE-CSI 300 ETF (Between CSI 300 Index & NAV of W.I.S.E-CSI 300 ETF)

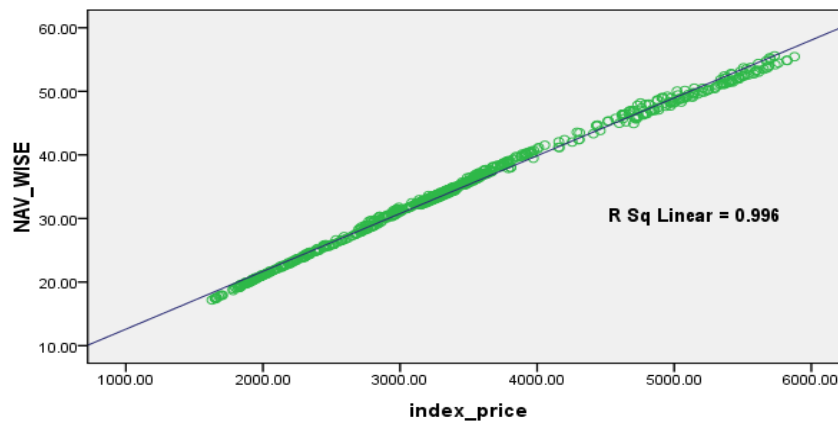


Figure 12: Scatterplot for Price Correlation

We can see from Figure 11, the performance of W.I.S.E-CSI 300 ETF is highly consistent with that of CSI 300 Index. From the Scatter Plot shown in Figure 12, we can see the numerical value of R^2 is 0.996 which is very close to 1. It indicated that the net asset value of W.I.S.E- CSI 300 ETF is highly correlated with closing price of underlying CSI 300 Index. Through calculation by SPSS, the correlation coefficient between CSI 300 Index and its tracking ETF is 0.998 with 99% confidence level (Appendix 5). It shows obviously that the CSI 300 Index and W.I.S.E-CSI 300 ETF are highly correlated in price.

● *Correlation in Yield*

We use same method as former to calculate the yield of CSI 300 Index and NAV yield of W.I.S.E-CSI 300 ETF. Then the two yields correlation drawing by scatter plot graph is showing in Figure 13 as followed:

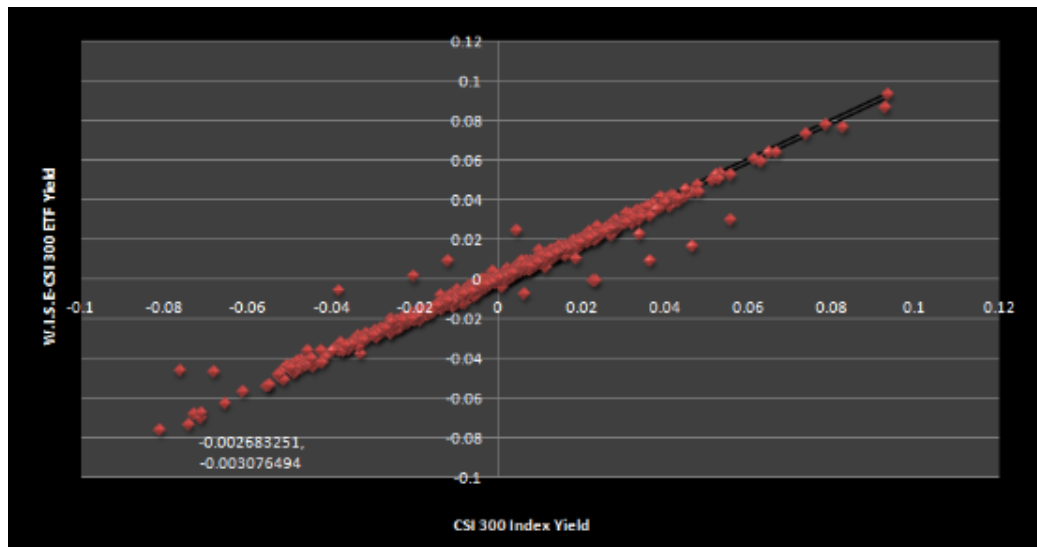


Figure13: Yield correlation between CSI 300 Index & W.I.S.E-CSI 300 ETF

According to the graph above, we can find that the yield correlation between CSI 300 Index and W.I.S.E-CSI 300 ETF is relative high. Although there are several point deviate from the line, but the correlation coefficient in Yield is still 0.989 with 99% confidence level (Appendix 3). So this is also satisfactory result for correlation. Through Regression calculation, we get R^2 equals to 0.977, and the regression equation of yield between CSI 300 Index and W.I.S.E-CSI 300 ETF is $Y=0.923X-9.808E-6$. Among them, the Index yield is independent variable. (Appendix 5)

5.2.3 Tracking Error Estimation

In the same method as in ETF portfolio, we calculate the tracking difference according to Equation 14. In Figure 14 below, There is an obvious tracking difference between CSI 300 Index and W.I.S.E-CSI 300 ETF around 18th Jan, 2008.

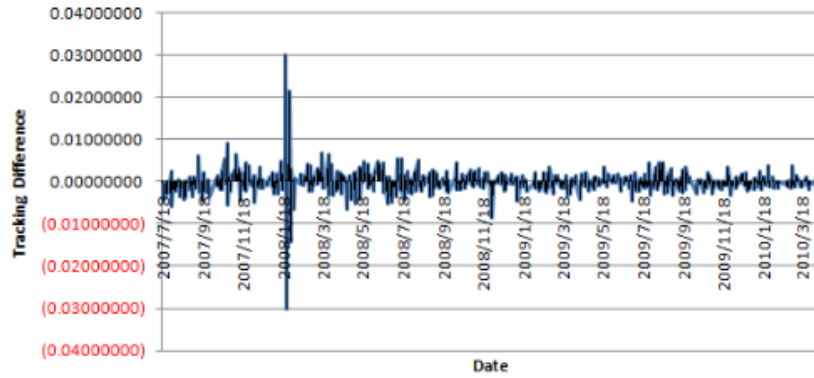


Figure14: Tracking Difference volatility between CSI 300 Index & W.I.S.E-CSI 300 ETF

To find the reason, there is a dramatic decline happened on fundamentals of A-shares between 18th Jan, 2008 to 22nd Jan, 2008, the index point decreased from 5414.47 to 4753.87 within 2 trading days. Therefore, the significant tracking difference would be result by delayed reaction of W.I.S.E-CSI 300 ETF on the unexpected drop. The accumulated tracking difference within sampling interval is account to -1.32235% and average is -0.00203%. The negative tracking difference illustrate that the yield of underlying index is higher than the yield of CSI 300 ETF. Then the tracking error between CSI 300 Index and the W.I.S.E-CSI 300 ETF is calculated as 0.39584% according to Equation 15.

5.3 Empirical Comparison for spot position construction

After the whole analysis in liquidity level, correlation and tracking error of both two spot position construction methods, we will do final decision according to empirical comparison showing in Table 9 below.

Table 9: Empirical Result Comparison

ETF name	Liquidity level (weighted turnover)	Coefficients with index yield	Average TD	Tracking Error in daily
ETF Portfolio (In Mainland China)	3.138%	0.980	0.005065%	0.36392%.
W.I.S.E-CSI 300 ETF	4.346%	0.977	-0.00203%	0.39584%

As described before, the higher turnover rate, the better for liquidity; the closer of R square number to 1 the better for correlation to underlying index, and the lower tracking error rate the better for tracking effect. We can see from Table 9 above, the liquidity level of W.I.S.E-CSI 300 ETF is better than ETFs portfolio in Mainland China. But the

ETFs portfolio is more correlated with CSI 300 Index than W.I.S.E-CSI 300 ETF, and also with lower tracking error in daily. Finally, considered all of the factors together, we think using portfolio combined with SSE 50 ETF, SZSE 100 ETF, and SSE Bonus ETF to construct the spot position is the optimal method for futures-spot arbitrage in CSI 300 stock index futures market.

Compared with the general index funds portfolio in China's mainland, W.I.S.E-CSI 300 ETF Tracker has some disadvantages. First of all, as the W.I.S.E-CSI 300 ETF listed in Hong Kong, and the CSI 300 stock index futures traded in China's mainland, then the arbitrageurs will face barriers (such as minimum investment amount provision for non-local investors by QFII) of cross-market transactions if they choose that fund to construct spot position. Secondly, foreign exchange rate risk. As the W.I.S.E-CSI 300 ETF is priced in HK\$, but its main investment in AXP is denominated in US\$, even more, the CSI 300 Index futures is traded in RMB, so the arbitrageurs must undertake foreign exchange rate fluctuate risk among three currencies. Thirdly, various trading hours in three markets will bring troubles to arbitrageurs to track updated information and make decision.

The advantages of the W.I.S.E-CSI 300 ETF are that: firstly, it is easier to do transaction than index-fund portfolio and to control tracking error. The tracking error movement of general index fund portfolio will be influenced by a lot of factors. Secondly, the W.I.S.E-CSI 300 ETF allows investor to have short position and make loan on the transaction. These features make reverse cash-and-carry arbitrage become possible. Thirdly, the W.I.S.E-CSI 300 ETF applies T+0 transaction rule. It means the investor can buy and sell the ETF in the same day. Compared with T+1 rule in mainland, the transaction barrier is smaller, and liquidity is higher for W.I.S.E-CSI 300 ETF. Last but not least, there is no circuit breaker application in Hong Kong market. In other words, there is unlimited for price increasing or decreasing. This may be a good opportunity for arbitrageurs, but there may be even worse loss. (SEHK, 2010)

In the whole point of view, it is feasible for both spot index construction method with different advantages. The ETF portfolio method in Mainland China is better to use at present. With the further changes in market environment, the barrier to construct spot index position for futures-spot arbitrage might be reduced a lot. Maybe the appearance of relevant CSI 300 ETF in mainland in the future will be the best way to track spot index. So, further researches on futures-spot arbitrage of stock index futures should follow market changes closely.

5.4 Empirical Analysis on no-arbitrage pricing model

This part we will do the empirical analysis by using new pricing model which we have defined in Chapter 3. We select CSI 300 Index futures monthly contract and use ETFs portfolio to replicate CSI 300 Index. Time horizon of our data is 20 months from July, 2007 to March, 2010.

5.4.1 Determination of parameters in the model

Before the empirical analysis, we have to determine the specific numerical value of each parameter in the new pricing model. We set Chinese mainland one-year deposit rate as the risk-free interest rate r and the value is 2.25%. Generally, the dividend payment period in China is from May to July, but these payouts are not regular and frequent. On the other hand, because we focus on futures monthly contract and the D_{Tt} is the present value of dividend in contract period, so we need to calculate D_{Tt} in each month. Actually, investors could receive dividend just only in a few months and the value of that is quite small relative to the value of index futures. Therefore, we set D_{Tt} as 0. However, if the time period is three months or more, the dividend should be not left out. For trading cost, there is no stamp duty on the trading of ETF, investors just pay some trading commission when they buy or sell ETF and the cost of trading commission is 0.3% in Chinese financial market, so the C_{st} is 0.3%. CSI 300 Index futures contract has stipulated transaction fee is 30 RMB per unit and the transaction cost is equal to transaction fee divide by HS_t . because H is 300 in CSI 300 Index futures so the C_{ft} is $30/300 \times S_t$ which is the same as $1/10 \times S_t$. In order to prevent market manipulation, the constituent stocks of CSI 300 Index are specially selected from market. Aggregate market value of total 300 constituent stocks account for about 75% of the whole market value and the weight of Top 5 heavyweight constituent stocks reached 14% of all 300 stocks, so it is almost impossible to control the index trend by trading of several stocks. From another point of view, the liquidities of both CSI 300 Index and CSI 300 Index futures are very abundant that means trading from individuals has little or no effect of the whole CSI 300 Index. As the result, the impact cost of individual trade approach to 0 and we regard C_{sl} , C_{ss} , C_{fl} , and C_{fs} are 0 in our model. The margin level of CSI 300 Index futures monthly contract is 10%, so the M_1 is 10%. The determination of M_2 is complex; it depends on volatility of index futures. Because the volatility of index futures was quite high in our sample interval and the test run of margin trading require even higher reserve ratio, so we set the value of M_2 as 50% which is also equal to official's recommendation from CFFEX. We select one year loan interest rate as C_l . For effect of tracking error on yield, we determine it by using \overline{TD} amount in Table 9. If the time to maturity is n days, then the tracking error affecting is $\overline{TD} \times n$, so the S_e is equal to $\overline{TD} \times (T-t) \times S_t \times H$. Because the test run of margin trading was just operated at the end of March and the cost of loan securities was tentatively set as 9.68%, so we give the value 9.68% to C_{ls} before formal rules of margin trading published.

After determine each parameter, the upper and lower limits were calculated according to Equation 10 & 11 (Page 29).

$$\text{Upper limit: } \frac{[301.8 \times S_t - 0.015174 \times S_t \times (T-t)] 1.00006^{(T-t)}}{300 - 180 \times [1.00014^{(T-t)} - 1] - 60 \times 1.00006^{(T-t)} / S_t}$$

$$\text{Lower limit: } \frac{[298.119 \times S_t - 0.015174 \times S_t \times (T-t)] 1.00006^{(T-t)}}{300 + 180 \times [1.00014^{(T-t)} - 1] + 60 \times 1.00006^{(T-t)} / S_t}$$

5.4.2 Empirical analysis by applying new pricing model

In this segment, we will use our new pricing model to analyze selected sample interval. Our objectives are to check reliability of model and compare results with previous researches.

The sample interval is from 17th July, 2007 to 31st March, 2010. In this period China's securities market experienced a large fluctuation that provide a good chance to examine the function of model. We input the data and draw a line graph of index futures price and no-arbitrage limits in Figure 15 below:

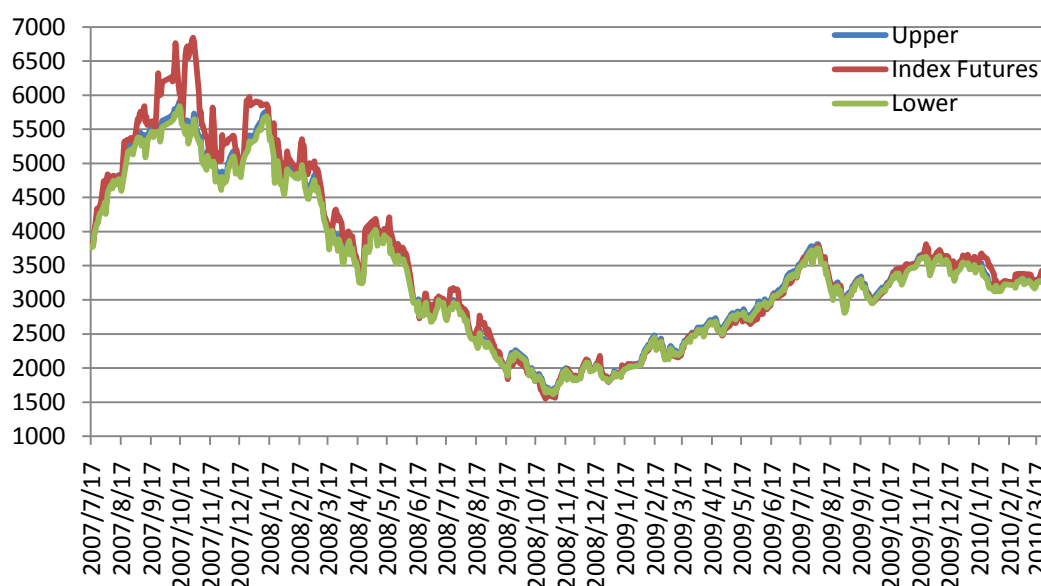


Figure 15: Arbitrage opportunity with upper and lower limit

From Figure 15 we can find that, the September 2008 was important demarcation point of index futures arbitrage. Before it, we can see many opportunities of cash and carry arbitrage especially from August 2007 to February 2008. This period just was the golden age of China's securities market, large fund inflow into market and CSI 300 Index went up to more than 6000 point. The expectations of higher price lead to overvalue of index futures which reflected in graph is prices of index futures above upper limit very significantly and no point under lower limit. However, after September 2008, market quotations took a sudden turn and become worse rapidly with the onset of the financial crisis. The opportunities for cash and carry arbitrage were less and less even appeared prices under lower limit. This situation was better until the end of 2009.

The result of calculation also show that the degree of price overvaluation decreased with coming of maturity day and lots of cash and carry arbitrage opportunities appeared compare with that of reverse cash and carry arbitrage. However, relative to mature index futures market, the opportunities of cash and carry arbitrage are overmuch and that of reverse cash and carry arbitrage are too little. We consider this abnormality was caused by several reasons:

- CSI 300 Index futures were traded in a simulation system at this period. Although it has a high degree of simulation, the trend does not reflect the true market perfectly.
- A fairly large number of participants in mock trading are speculators; the behavior of them exacerbated fluctuation of market and mispricing of futures. Lack of arbitrage and hedging trading lead to future's price could not efficient regress to its value.
- Because the margin trading was not allowed in China's financial market, so investors were accustomed to make long position and lack of short position awareness. It also, to a certain extent, made the index futures were overvalued.

Furthermore, compare with previous study on futures-spot arbitrage, we add new parameters into the model and find out some opportunities that investors could implement reverse cash and carry arbitrage. Wu (2008) analyzed the no-arbitrage band by using modified interval pricing model and she draw a conclusion that arbitrage opportunities existed in 55% of total trading days and all of them are cash and carry arbitrage opportunities because there was no price below lower limit of band in the mock trading system. However, index futures market is simulative but the CSI 300 Index is operated formally. Therefore, we think it is impossible that no reverse arbitrage opportunity in China's index futures market. The result from our model attests this opinion; although futures' prices were wildly overvalued the reverse arbitrage opportunity still appeared at financial crisis period especially in the bottom of both futures' prices and CSI 300 Index.

In order to make the comparison, we use the interval pricing model to analyze the same data sample. Firstly, we input the data into interval pricing model to examine whether and how many opportunities could be found by it. Details show in figure 16.

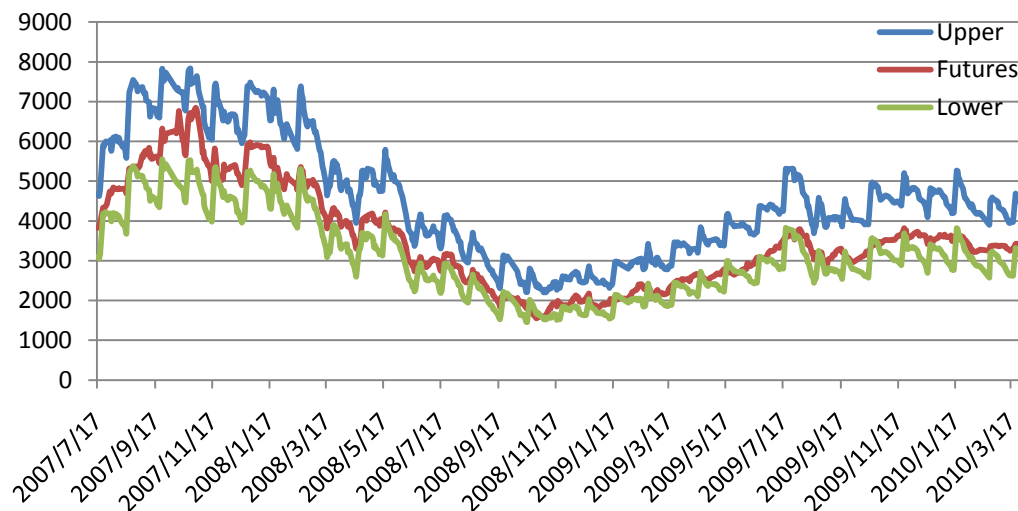


Figure16: Arbitrage opportunities found by interval pricing model

In Figure16, we find that almost all the futures' prices fall into the no-arbitrage band. More specifically, there is no cash-and-carry arbitrage opportunity in this period and

also a few points reach or less than lower limit. The reason of this phenomenon is the quite large band between upper limit and lower limit, average difference is 1413 which almost equal to half of futures' prices. From another point of view, this result also proves that the less parameter considered the wider no-arbitrage band appeared. Overall, this simple interval pricing model makes a wide no-arbitrage band that basically no arbitrage opportunity could be implemented.

Then, we make a comparison between interval pricing model and our new pricing model by using mispricing ratio method. Mispricing ratio could measure the degree of future's price deviate from no-arbitrage band, the bigger absolute value, the more profit obtained. Generally, we can use following formula to calculate mispricing ratio (Equation 17):

Equation 17: Mispricing ratio

$$\text{Mispricing Ratio}_t = \begin{cases} \frac{F_t - F_{\text{Upper}}}{F_{\text{Upper}}} & (F_t > F_{\text{Upper}}) \\ 0 & (F_{\text{Lower}} < F_t < F_{\text{Upper}}) \\ \frac{F_t - F_{\text{Lower}}}{F_{\text{Lower}}} & (F_t < F_{\text{Lower}}) \end{cases}$$

Where F_t is the price of future at time t and F_{Upper} , F_{Lower} are defined as upper limit and lower limit. If the mispricing ratio is greater than zero, investors could make cash-and-carry arbitrage; if it is less than zero, reverse cash-and-carry arbitrage should be operated. Figure 17 illustrate the mispricing ratio of these two models. MPR1 means mispricing ratio of interval pricing model and MPR2 refer to mispricing ratio of new pricing model. The outcome is very significant, new pricing model find much more arbitrage opportunities than that from interval pricing model. What is more, vast majority of these opportunities are cash-and-carry arbitrage. However, there is no cash-and-carry opportunity found by interval pricing model, because less parameters and wide band result in much undiscovered mispricing futures. In addition, the average rate of return gained by new pricing model is also much more than that of interval pricing model.

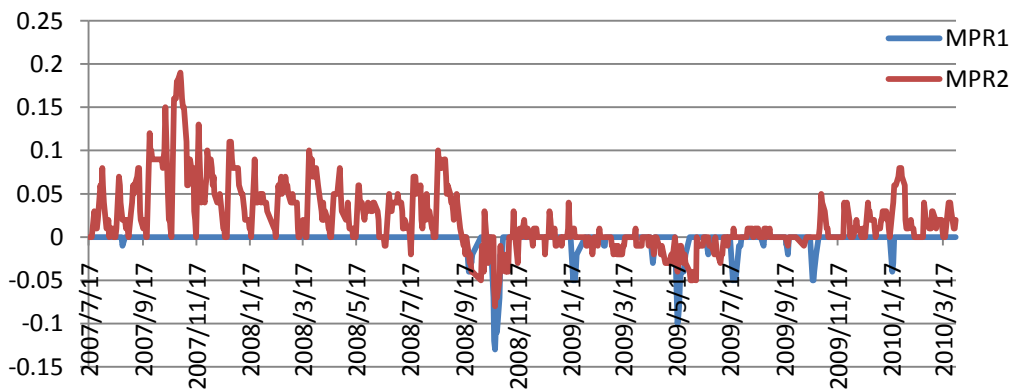


Figure17: Mispricing ratio of two pricing models

5.4.3 Analysis on formal trading of CSI 300 Index futures

CSI 300 Index futures was launched formally on 16th April 2010, we select the first month data from 16th April, 2010 to 17th May, 2010 as the sample to analyze arbitrage under the realistic situation (Figure 18).

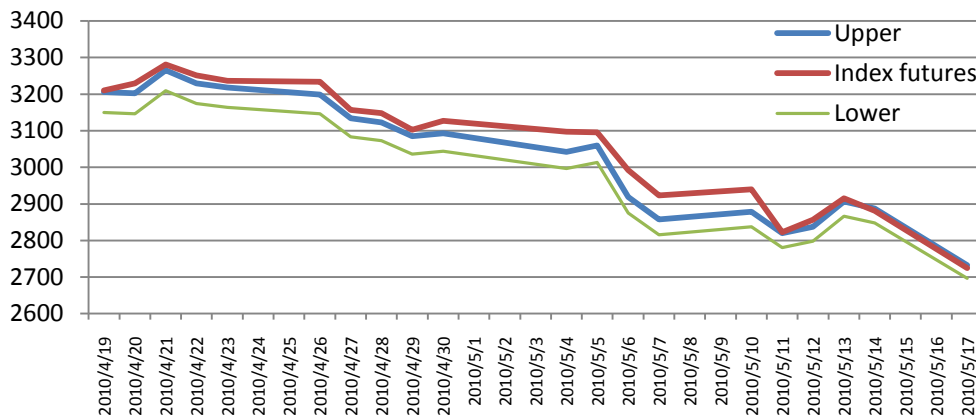


Figure 18: Arbitrage opportunity from 16th April, 2010 to 17th May, 2010

The Figure 18 typically reflects the performance of stock index futures at its initial stage. Empirically, at the first several months following formally launched, investors could find lots of opportunities to make arbitrage in the major stock index futures market like S&P 500, FTSE 100, and Nikkei 225. CSI 300 Index futures market has the quite same performance of them. We can find that the future's price was over upper limit almost all the period and the spread of them were significant at 26th April and 6th May. That means investors could obtain profit by arbitrage at almost every day particularly at those two days. Another obvious trend is that the spread between future's price and upper limit was decreasing and tend to zero after 10th May. Because the 21st May is settlement day of this monthly contract and future's price would regress to its value with the coming of contract maturity. In a word, the new model could reflect the realistic situation of CSI 300 Index futures and make the no-arbitrage band more accurate than the interval price model.

5.4.4 Practice of optimal arbitrage strategy on 6th May, 2010.

In this part, we illustrate how to use this arbitrage strategy and how much profit will be obtained in one futures contract trading. Initially, we calculate the mispricing ratio of formal trading data, the ratio of each day present in Figure 19:

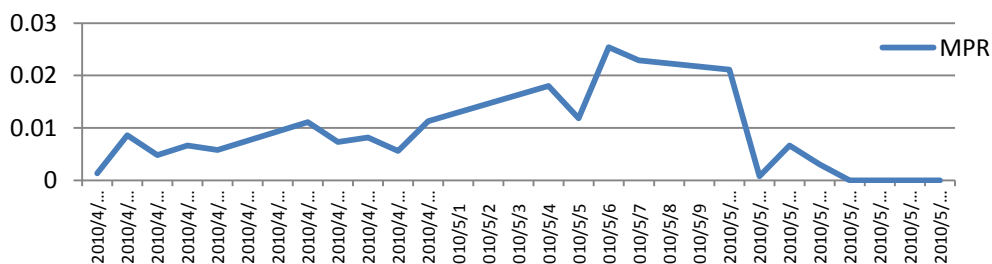


Figure 19: Mispricing ratio of formal trading data

Obviously, the highest mispricing ratio appears on 6th May, in order to make a clear process we choose this day to make the practice. At that day, CSI 300 Index was 2896.86 and the price of monthly future contract is 2992.60, so investors need to borrow 897780 RMB (2992.60×300) to buy spot index which is a portfolio of SSE 50 ETF, SZSE 100 ETF, and SSE Bonus ETF by weighted in 0.369, 0.403, and 0.19 respectively. Meanwhile, they should sell one index futures contract with the delivery price of 2992.60. Then, at the settlement day 21st May, 2010, the CSI 300 Index was 2768.79. So, for spot index, the investors lose $897780 - 897780 \times (2768.79/2896.86) = 39690.80$ RMB; for index futures contract, they can obtain $(2992.60 - 2768.79) \times 300 = 67143$ RMB; the interest of borrowing money was $897780 \times (5.31\%/12) = 3972.68$. In summary, the investors could earn $67143 - 39690.80 - 3972.68 = 23479.52$ RMB risk-free profit. The rate of return of this arbitrage was 2.6% which was much higher than one month deposit rate 0.18%.

Chapter VI

Quality Criteria

In this chapter we reflect on the validity, reliability and generalizability of our research work. These are three criteria for estimating the quality of the research. They show whether the procedure results have been achieved by applying rigorous scientific standard.

6.1 Validity

Bryman & Bell (2007) defined validity in quantitative research as “the issue of whether or not an indicator that is devised to gauge a concept really measures that concept” (Bryman & Bell, 2007, p165). In other words, the validity is used to estimate whether the whole study procedure is correspond with your research objectives; Whether the instruments you choose is measuring what you designed to measure; and whether the collected data is relevant and persuaded enough to interpret your research result.

In this research, the authors get research question through huge amount of literature review. After determining the guiding research question of how to build up futures-spot arbitrage strategy for China’s Stock Index Futures investment, we divided the guiding question into two specific research questions contain replication method to track CSI 300 Index and optimal pricing model for futures contract in futures-spot arbitrage. These are most significant items in doing futures-spot arbitrage in stock index futures market. Following that, the literature review and theoretical framework parts also do separate from these two parts.

For replication method, we choose liquidity level, correlations to underlying index and tracking error as the instruments in order to investigate the performance of different replication methods. The liquidity level (we choose turnover rate as the measurement) and correlation (which we chose NAV of ETF and close price of CSI 300 Index as measurements) are used to estimate the performance of each ETF replication method; tracking error is used to estimate the tracking effect of different replication methods. For stock index futures pricing model, we discussed plenty of pricing model theories which has high reputations in financial field, and choose no-arbitrage interval pricing model as our research instrument. It can be used easily to confirm the no-arbitrage interval, and to find arbitrage opportunities from the figures. In this point of view, we can say that our research procedure is close correspond with study objectives, and we choose appropriate instrument to measure what we designed to measure. This research has relative high validity.

One point which may influence the validity of the research should be mentioned here. We choose simulation market data to do main analysis because the real trading data of stock index futures in China just available for 1 month. It is not enough for our research. These simulation market data would influence the validity of research result in some extent. But the simulation trading was running under strong supervision of relevant institution, and the trading system was used real names in transaction. This is to ensure the validity of the simulation data.

6.2 Reliability

The term reliability refers to “the extent to which the data collection techniques or analysis procedures will yield consistent findings” (Saunders et al., 2009, p.156). It means if the research measures is reliable, then researcher can get same result as first time if use same measures second time under same circumstance.

In this research, for first specific research question: we used NAV of each ETF and close price of CSI 300 Index to estimate the correlation and tracking error of different replication methods. The data is collected from CFFEX, SSE and Yahoo Finance. These are all public data sources and widely available to all of the researchers. In addition, we found lots of professional researchers select same data as we did to test the similar topic through literature review in China. Then we have confidence that if other researchers select same period of data, they will get same or similar result as ours. For second specific research question, the situation is similar as mentioned above. We collect futures price from CFFEX, and CSI 300 Index close price from SSE. But we modified the no-arbitrage pricing model in theoretical framework. In this part, we discuss possible factors and quantify each of them by considering specific situation in China. Different researchers have different choice for factors. For instance, some researchers will choose U.S 10 years Treasury bond rate as the free-risk rate, but we used China’s one year deposit rate as the risk-free rate through calculation (Damodaran, 2009, p.109). Then the result will have little bit difference.

6.3 Generalizability

Generalization is a criterion item which intends to assure readers that the theory derived from research is applicable in general situation. The generalization is sufficient in this research paper. The reasons are that: first of all, the measurements we choose to estimate the performance of ETF can be used in the entire situation if other researchers want to do same estimation. Secondly, the modified no-arbitrage pricing model is universally applicable for different research period. But the specific factors consideration (i.e. we use one year deposit rate as the risk-free rate) limit the use of this modified model in other countries. We also tested the arbitrage strategy by using real trading data in stock index futures market. The result is satisfactory. Because of these, we can say that the generalizability of our research is sufficient.

Chapter VII

Conclusion

The purpose of this thesis is to establish an optimal futures-spot arbitrage strategy for investment on China's CSI 300 Index futures. After doing the comparative analysis on liquidity level, correlation to underlying index, and tracking error of each ETF, we select the ETFs portfolio combined with SSE 50 ETF, SZSE 100 ETF, and SSE Bonus ETF as the replication method to track CSI 300 Index. The combination was organized in 0.369, 0.403, 0.19 weight respectively. Then we build a no-arbitrage pricing model based on interval pricing model to ascertain upper limit and lower limit. In addition, the empirical analysis also supports that by using no-arbitrage pricing model and ETFs portfolio investors could find out arbitrage opportunities and replicate CSI 300 Index more precisely. Therefore, the optimal arbitrage strategy of CSI 300 Index investment is that: apply ETFs portfolio to replicate CSI 300 Index and determine cash-and-carry or reverse cash-and-carry arbitrage by using no-arbitrage pricing model, then do the futures-spot arbitrage through spot index and mispricing index futures.

For CSI 300 Index replication, the spot position could be constructed by ETFs portfolio in Mainland China or single W.I.S.E CSI 300 ETF in Hong Kong. Compare to W.I.S.E-CSI 300 ETF, the ETFs portfolio has stronger correlation, higher liquidity, and lower tracking error. Therefore, ETFs portfolio could provide the better tracing effect of CSI 300 Index than single ETF. On the other hand, as the W.I.S.E is listed in Hong Kong, the investor should consider the risk of exchange rate between RMB and HKD. As a result, before appearance of specific CSI 300 ETF in Mainland China, ETFs portfolio would be our best choice to track CSI 300 Index.

For no-arbitrage pricing model, because ordinary interval price model ignored some important affecting factors in China's financial market, so this model could not estimate the no-arbitrage band accurately. Therefore, we added some crucial affecting factors of China's futures market into the model and rebuilt it to a new no-arbitrage pricing model based on the relationship of yield. The significant improvement of the new no-arbitrage pricing model is the discovery of reverse cash-and-carry arbitrage opportunities which were not found in previous studies on the same sample interval. Moreover, the new no-arbitrage pricing model clearly illustrates plenty of arbitrage opportunities and convergence character of CSI 300 Index futures in the first month after formally launched. Consequently, this no-arbitrage pricing model consider more affecting factors of China's futures market and fit CSI 300 Index futures arbitrage very well.

The main contribution of this thesis is that we introduce the replication method for futures-spot arbitrage in stock index futures market in China by considering offshore ETF: W.I.S.E-CSI 300 ETF Tracker. In addition, we find out the optimal replication method for China's spot market in arbitrage, and estimate exact weight of each ETF in

replication portfolio, what can be convenient for investors.

Furthermore, we got new pricing model modified from no-arbitrage pricing model by considering specific factors in China's stock index futures market. The empirical results of this new model are satisfactory. The new pricing model supports us to find out reverse cash-and-carry arbitrage opportunities in trading. Then the institution arbitrageurs, corporations and fund managers might be beneficiaries of this new pricing model. Meanwhile, the researcher could consider applying this model in further analyzing in China's stock index futures market.

In summary, our research provides a practical futures-spot arbitrage strategy for investment on China's stock index futures. At the end of thesis, we intend to make some suggestions for further research. Initially, we focus on daily price in empirical study, but many investors build arbitrage strategy based on minute even second price. The close price also could not reflect whole day's trend of index futures, so set the sample interval by minute based would be the better choice which provides the more clear and precise result. On the other hand, we assume the constituent stocks of CSI 300 Index are not changed before build the model, actually, CFFEX would examine and audit them semiannually. Therefore, the further research could take constituent stocks change into account. Furthermore, we only analyze one month of actual CSI 300 Index futures data at last, it not sufficient to estimate and forecast arbitrage opportunities in the realistic situation, this problem can only be solved over time. For this reason, the further research could use a large time period to retest our arbitrage strategy and make the arbitrage analysis on formal market. Accordingly, we recommend these as the concerns for the future research..

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Appendix 1 Details for the trading of CSI 300 Index future in China

CSI 300 Index futures (Unit in RMB)	
Exchange	China Financial Futures Exchange
Settlement	Cash settled
Trade Unit	300 yuan times the CSI 300 Index
Point Value	30 yuan
Tick Value	60 yuan
Contract Months	The current and next month as well as two following months in the quarterly cycle
Last Trading Day	The third Friday in the contract month
Price Limits	10 % above or below the previous day's settlement price
Ticker Symbol	IF
Note: The contract is electronic only—no open outcry	

(Source: China Securities Index Co., LTD, 2007)

Margin:

The margin rate of CSI 300 Index futures is equal to 10 percent of futures value at present. The CFFEX has right to modify this margin rate in terms of market situation such as risk level and fluctuation. If the intraday close price of CSI 300 Index futures is 3000 point, then investors have to pay $3000 \times 300 \times 10\% = 90000$ RMB at the beginning of next trading day.

Price fluctuation limits:

The maximum change of CSI 300 Index futures price is 10 percent of close price at previous trading day. But at the settlement day, there is no limitation on price's fluctuation. Because the settlement price is not calculated by average price of index futures but the weighted average price of spot index. Therefore, in order to ensure the price of index futures regress to spot index, the exchange allow the price change more than 10 percent at the last trading day.

Contract listed month:

CSI 300 Index futures has four listed contract which are contract of current month, contract of next month, contract of next three months, and contract of next six months. For example, if current month is July, the investors could trade futures contracts with expire date at July, August, September, and December. The CFFEX uses IF1007,

IF1008, IF1009, and IF1012 to represent them. The IF means CSI 300 Index futures contract and 1007 means July, 2010.

The last trading day:

The last trading day of each futures contract is the third Friday at the expired month. The last trading day also is settlement day of contract, and close price at that day will be the settlement price of futures. If the settlement day is national holiday, then CFFEX would do the settlement at next trading day.

Appendix 2 Previous studies: the impact of index futures trading on spot market volatility

Name	Year	Data Type- Index Future unless otherwise noted	Method	Change in Volatility
Edwards	1988	S&P 500	Variance ratio test	Decrease
Harris	1989	S&P 500	OLS	Increase (not proved conclusively)
Antoniou, Holmes	1993	FTSE 100	GARCH	Increase
Oehley	1995	All Share indices and gold	Various	No conclusive effect
Butterworth	2000	FTSE 250 Index Futures, Daily Log Returns	GARCH	Increase
Yu, Shang-Wu	2001	S&P 500, FTSE 100, Nikkei 225, Hang Seng Index, Australian AOS	GARCH	Increase except FTSE and Hang Seng
Chang and Wang	2002	Taiwan Index Futures (Introduction of 2 types)	GJR Model	Increase (one futures) no effect from other
Mukhopadhyay, Kumar	2003	NSE Nifty (India)	GARCH	No effect/Decline in Persistent Volatility
Darrat, Otero, Zhong	2003	Mexico Stock Index	EGARCH	Increase
Illueca, Lafuente	2003	Spanish Stock market	GARCH	No effect
Bae, Kwon, Park	2004	Korean KOPSI 200	OLS	Increase
Spyrou	2005	Athens Stock Exchange	GARCH	No effect
Alexakis	2007	FTSE/ASE-20	GJR-GARCH	Increase

(Source: Carlson & Li, 2008)

Appendix 3: Yield Correlation between CSI 300 Index and W.I.S.E-CSI 300 ETF (Regression Analysis)

Variables Entered/Removed^b

Model	Variables Entered	Variables Removed	Method
1	Index_yield ^a		. Enter

a. All requested variables entered.

b. Dependent Variable: ETF_yield

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.989 ^a	.977	.977	.00347398

a. Predictors: (Constant), Index_yield

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.338	1	.338	2.802E4	.000 ^a
	Residual	.008	649	.000		
	Total	.346	650			

a. Predictors: (Constant), Index_yield

b. Dependent Variable: ETF_yield

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.808E-6	.000		-.072	.943
	Index_yield	.923	.006	.989	167.402	.000

a. Dependent Variable: ETF_yield

Appendix 4: Regression analysis of different portfolio combinations

● For SSE 50 ETF + SZSE 100 ETF

Variables Entered/Removed ^b			
Model	Variables Entered	Variables Removed	Method
1	Yield_100, Yield_50 ^a		. Enter

a. All requested variables entered.

b. Dependent Variable: Yield_index

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.988 ^a	.976	.976	.00373

a. Predictors: (Constant), Yield_100, Yield_50

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	
1	(Constant)	-5.737E-5	.000		-.398
	Yield_50	.442	.014	.453	31.577
	Yield_100	.521	.013	.558	38.944

a. Dependent Variable: Yield_index

● For SSE 50 ETF + SSE Bonus ETF

Variables Entered/Removed ^b			
Model	Variables Entered	Variables Removed	Method
1	Yield_bonus, Yield_50 ^a		. Enter

a. All requested variables entered.

b. Dependent Variable: Yield_index

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.981 ^a	.961	.961	.00477

a. Predictors: (Constant), Yield_bonus, Yield_50

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	
1	(Constant)	.000	.000		.595
	Yield_50	.495	.019	.508	26.561
	Yield_bonus	.453	.018	.494	25.839

a. Dependent Variable: Yield_index

Appendix 4: Regression analysis of different portfolio combinations

- For SZSE 100 ETF + SSE Bonus ETF

Variables Entered/Removed ^b			
Model	Variables Entered	Variables Removed	Method
1	Yield_bonus, Yield_100 ^a		. Enter

a. All requested variables entered.

b. Dependent Variable: Yield_index

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.980 ^a	.961	.961	.00482

a. Predictors: (Constant), Yield_bonus, Yield_100

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.551E-5	.000		-.513	.608
	Yield_100	.547	.021	.586	26.040	.000
	Yield_bonus	.375	.021	.409	18.157	.000

a. Dependent Variable: Yield_index

- For SSE 50 ETF + SZSE 100 ETF + SSE Bonus ETF

Variables Entered/Removed ^b			
Model	Variables Entered	Variables Removed	Method
1	Yield_bonus, Yield_50, Yield_100 ^a		. Enter

a. All requested variables entered.

b. Dependent Variable: Yield_index

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.990 ^a	.980	.980	.00340

a. Predictors: (Constant), Yield_bonus, Yield_50, Yield_100

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.592E-5	.000		-.197	.844
	Yield_50	.369	.014	.378	25.988	.000

Yield_100	.403	.016	.432	25.467	.000
Yield_bonus	.190	.016	.207	11.718	.000

a. Dependent Variable: Yield_index

Appendix 5: Correlation between CSI 300 Index & W.I.S.E-CSI 300 ETF

Correlations in Price

		index_price	NAV_WISE
index_price	Pearson Correlation	1	.998**
	Sig. (2-tailed)		.000
	N	652	652
NAV_WISE	Pearson Correlation	.998**	1
	Sig. (2-tailed)	.000	
	N	652	652

** . Correlation is significant at the 0.01 level (2-tailed).

Correlations in Yield

		Index_yield	ETF_yield
Index_yield	Pearson Correlation	1	.989**
	Sig. (2-tailed)		.000
	N	651	651
ETF_yield	Pearson Correlation	.989**	1
	Sig. (2-tailed)	.000	
	N	651	651

** . Correlation is significant at the 0.01 level (2-tailed).



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