Research on Stock Index Futures
---An empirical analysis of CSI 300 stock index futures

Lu Zhang (luzh11ab@student.cbs.dk)

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Abstract

With the fast expanding of stock market scale in China, the number of investors is growing, and the methods for better risk management are eagerly required. Moreover, CSI 300 stock index futures contract was first listed on China Financial Futures Exchange on April 16, 2010, which attached more and more attention of domestic and overseas investors. It ended the time period of China’s unilateral capital market. Also as we know, stock index futures hedging can be utilized by investors to manage the system risk in their investment portfolio, which will provide the reference for investors to plan their investment. The key of hedging implementation is the hedge ratio defining. Therefore, the research problems of this thesis are whether the launching of CSI 300 stock index futures can effectively play a hedging role and how it hedges. Based on the related theories of the stock index futures and hedging, the CSI 300 stock index futures hedging effect will be analyzed and estimated in the process of empirical research.

First of all, in order to understand the related economic knowledge, the definitions of stock index futures are described, the relevant economic functions are introduced, and the hedge theories are reviewed; which provides an essential theoretical basis for the empirical study. Furthermore, the development of China’s stock market and its index futures market are also reviewed, and the comparison between CSI 300 index futures contracts and other different index futures with a China concept are subsequently conducted, which confirms the necessity of this research.

Then, the correlation between CSI 300 stock index futures and spot index are analyzed. According to their closing price, their returns are calculated. Based on these data, the descriptive statistics test, the ADF test and the cointegration test are conducted to verify the relevance of CSI 300 stock index spot and futures markets, and insure there exists a long-term stability cointegration relationship between them, which is a preparation for the further empirical studies.

For the purpose of estimating the optimal hedge ratio, and evaluating the hedging effect from the point of view of returns and variance, the methods of OLS model and GARCH model are applied based on actual market data, and comparative analysis is utilized to analyze the hedging effect of CSI 300 stock index futures and H-shares index futures. Overall, it can be shown that the launch of CSI 300 stock index futures indeed played an effective hedging role to avoid the systemic risk in the stock market.
# Table of Contents

**Acknowledgement** .............................................................................................................. 1

**Abstract** ................................................................................................................................. 2

1 **Introduction** ......................................................................................................................... 5
   1.1 Background .......................................................................................................................... 5
   1.2 Research motivation ............................................................................................................ 7
      1.2.1 Theoretical significance ............................................................................................... 7
      1.2.2 Practical significance ................................................................................................... 7
   1.3 Literature Review .................................................................................................................. 7
      1.3.1 Stock index futures ....................................................................................................... 7
      1.3.2 Hedging ....................................................................................................................... 8
   1.4 Problem statement ............................................................................................................... 10
   1.5 Methodology ...................................................................................................................... 11
   1.6 Delimitations ...................................................................................................................... 11

2 **Stock index futures and hedging** ....................................................................................... 13
   2.1 Related theory of stock index futures ................................................................................. 13
      2.1.1 Concept ....................................................................................................................... 13
      2.1.2 Characteristics ............................................................................................................ 13
      2.1.3 Functions ................................................................................................................... 16
   2.2 Related theory of hedging .................................................................................................. 18
      2.2.1 Concept ....................................................................................................................... 18
      2.2.2 Economic principles .................................................................................................... 19
      2.2.3 Types .......................................................................................................................... 20
      2.2.4 The Basis Theory ....................................................................................................... 21
      2.2.5 The hedging theory .................................................................................................... 23

3 **Development of stock index futures in China** ................................................................... 26
   3.1 Development of stock market in China ............................................................................. 26
      3.1.1 Chinese stock market ................................................................................................... 26
      3.1.2 Reform of Chinese stock market ............................................................................... 27
   3.2 Development of CSI 300 index futures ............................................................................. 29
      3.2.1 Significance of CSI 300 index futures ...................................................................... 30
   3.3 CSI 300 Index and CSI 300 stock index futures ................................................................. 31
      3.3.1 Pricing CSI 300 Index ............................................................................................... 31
      3.3.2 Relation with Shanghai index and Shenzhen index ..................................................... 31
      3.3.3 Comparing with other Chinese concept stock index futures ..................................... 32
      3.3.4 Comparing CSI 300 index futures contract with H-shares index futures contract ... 35

4 **The general principle of the determination of optimal hedge ratio** .................................. 37
   4.1 Estimation models of optimal hedge ratio ........................................................................ 37
      4.1.1 Risk minimizing hedging model ............................................................................... 37
      4.1.2 Utility maximizing hedging model .............................................................................. 38
      4.1.3 Per unit risk compensation maximization ................................................................... 38
   4.2 Estimating hedging effectiveness based on risk-minimization hedging model .......... 39
      4.2.1 Econometric models for hedging .............................................................................. 39
      4.2.2 Estimating Hedging Effectiveness ............................................................................ 40

5 **Empirical analysis** ............................................................................................................... 42
   5.1 Data collection and processing ......................................................................................... 42
   5.2 Data analysis ...................................................................................................................... 43
      5.2.1 Descriptive statistics analysis ................................................................................... 43
      5.2.2 Stationary test ............................................................................................................ 46
5.2.3 Cointegration test ........................................................................... 47
5.2.4 Summary ......................................................................................... 49
5.3 Hedging Model Analysis .................................................................. 49
  5.3.1 OLS Model .................................................................................... 50
  5.3.2 GARCH Model ............................................................................... 52
5.4 Hedging effectiveness analysis ......................................................... 54

6 Conclusion and perspective ................................................................. 57
  6.1 Conclusion ....................................................................................... 57
  6.2 Suggestions for investors ................................................................. 58
  6.3 Limitations and future work ............................................................. 59

Reference .................................................................................................. 61
Appendix .................................................................................................... 64
1 Introduction

1.1 Background

From July 2007, the financial crisis, which was triggered by the U.S. subprime mortgage crisis, has spread out to the surrounding countries and eventually became the global financial crisis. Because of the global financial turmoil, the systemic risk of the capital market is further increased. The investors need a financial tool to avoid the risk and fix the future cost and profit. By using financial derivatives, it is a good choice for investors to hedge.

As a common financial instrument, the stock index futures were born in U.S. In February 1982, stock index futures was firstly created by KCBT (Kansas city board of trade), which was named as value line index future. Two months later, the Chicago Board of Trade started trading the S&P stock index futures contracts (Robert, 2006). The introduction of stock index futures in the U.S activated the financial markets, and expanded the size of the U.S. domestic futures market. Following the U.S., Australia, Britain, Canada, Japan, Singapore, Hong Kong and other countries or regions have launched their stock index futures (Zhang, 2011). In recent years, with the continuous development of the world economy, trading varieties of the stock index futures are increasing and the transaction scope is expanding. Nowadays, stock index futures play a more and more important role in the financial derivatives market.

In China, the commodity futures trading (including gold, soybeans, crude oil and etc) has started for many years. However, the introduction of stock index futures has a special significance for China, because it is a first financial futures launched in China since the mid 1990s\(^1\). Along with the appearance of some economic problems (such as the RMB appreciation, the inflationary pressures, the pressure of capital inflow and so on), many uncertainties will affect the Chinese economic development, especially the risk impact in capital market (Chen & Li, 2013). With the growth and development of institutional investors in China, the demands of using stock index futures to manage the risk of investment portfolio are growing. Before the launching of CSI 300 stock index futures, investors can only trade in Hong Kong index futures market to reduce their risk. It took China about four years to promote the CSI300 Stock Index Futures.

Finally, it came out on April 16th, 2010 and traded in the China Financial Futures Exchange\(^2\).

The official trading of CSI300 stock index futures, it provides investors a new investment instrument and a hedging tool, which enriches financial products in the futures market, and connects the securities and futures markets; also it brings the changes in market transactions and trading concepts, which leads to complexity of the investment strategies and diversity of products. Moreover, the official trading of CSI300 stock index futures brings investors become more specialized and institutional.

Since CSI 300 stock index futures were brought into operation in 2010, the opening of futures customer accounts has a steady growth and the trading is active. That is because the futures price normally match the spot price with a high degree and it shows a good control of market risk. Also among the contract months, the most actively traded futures contracts are current month, therefore the futures contracts show a good momentum of development.

On February 3rd, 2012, the China Financial Futures Exchange issued “the Administrative Measures of the China Financial Futures Exchange for Hedging and Arbitrage Trading” (revised)\(^3\). Not only it gave advices to further optimize the management of hedging, but also it introduced the systems and measures of arbitrage, which would be helpful for introducing institutional investors and sophisticated individual investors. However, the Chinese stock index futures started later than other countries, and the investors lacked the knowledge of its function, so many related things are at the exploratory stage. We can expect that only if the stock futures market performs its risk avert function fully, it can meet the requirements of investors for hedging and arbitrage, thus avoid the risk of stock market effectively.

Based on the above background related to the development of China’s stock index futures market, this thesis will give a quantitative and qualitative analysis on the hedging performance of CSI300 stock index futures by using the futures trading data in almost four years, which are the main research subjects.

\(^2\) http://www.ft.com/intl/cms/s/0/5e907942-48ef-11df-8af4-00144feab49a.html#axzz31oRZvZtm
\(^3\) http://www.lawinfochina.com/display.aspx?lib=law&id=10707&CGid=
1.2 Research motivation

1.2.1 Theoretical significance
This study combines the theories about the stock index futures and hedging with the volatility characteristics of China’s securities market; also econometric models will be adopted as tools to analyze the functions of hedging in a quantitative way. The aim is to further explore the front problem of risk management in stock portfolio investment and promote the improvement of the theoretical system of stock index futures.

1.2.2 Practical significance
In the capital market, risk is everywhere. Although it cannot be eliminated fundamentally, it can be reduced by efficient investment. For investors, it is very important to reach the goal of avoiding risk and locking returns in capital market. Based on the developing actuality of Chinese stock index futures and the analysis of the relevance between stock index futures and spot index, this paper estimates the effect of hedging and aims to provide an effective risk management tool for investors, which can help them allocate the assets rationally within the scope of risk control and enhance the efficiency of investment.

1.3 Literature Review

1.3.1 Stock index futures
Edwards (1988) examined the volatility of the stock market both before and after the start of futures trading through the empirical analysis of S&P500 index. The result shows that the introduction of futures trading does not cause the increment in stock price volatility. On the contrary, the introduction of stock index futures contracts has improved the financial market, which makes the stock market more stable.

Harris (1989) studied on S&P500 stock index futures. Through empirical analysis, the research expresses that there is a great volatility in stock index futures market. One reason is the illiquidity of the corresponding market due to the large volume of trade in a short time and another reason is that the existence of stock futures market speeds up the flow of information, which accelerate the main constituent stocks’ reaction of new information consequently.

In the study of Bessembinder and Seguin (1992), the situations before and after the introduction of S&P500 index futures from 1978 to 1989 were analyzed and
compared. It can be found out that the introduction of futures market does not increase the volatility of the spot market, but makes volatility decline in the spot market.

Lee and Ohk (1992) studied the relationship between the Hang Seng Index and its futures from 1984 to 1988. They thought that the introduction of Hang Seng stock index futures had reduced volatility of the spot market.

In order to test the impact of stock index futures on the volatility of the spot market, Mayhew (2000) used data from 25 countries (that had launched stock index futures) to do empirical research. Through his study, it can be found that only in a few countries, the volatility of the stock market may be relevant to the introduction of stock index futures; and in most of the others, the relevance is not significant.

Salil K. Sarkar (2002) did a research on the development of stock index futures contracts. He supposed that the fast development of the contracts is partly because that investors want to avoid risk in portfolios.

1.3.2 Hedging

The most important function of futures trading is hedging. In the process of hedging, the main problem is to determine the number of required stock index futures contracts. And for calculating the number of contracts, the key issue is the determination of hedge ratio.

Keynes (1951) and Hicks (1952) have firstly made a detailed exposition of traditional hedge from the view of economics. It is believed that instead of getting high profits from futures trading, the hedging aims to set off gains in one market against losses in another market (hedge ratio is assumed as 1).

However, since traditional hedging theory deviates from the actual market situation, it is found that the traditional hedge cannot completely reduce the systemic risk caused by the stock price volatility. Therefore, many researchers have proposed the methods using portfolio approach to estimate the optimal hedge ratio.

Under the condition of the minimum variance of the rate of return, Johnson (1960) firstly proposed the concept of optimal hedge ratio of commodity futures, ordinary least square regression (OLS) method and the formula for the optimal hedge ratio calculation. With the assumption of constant volatility, the MV (minimum variance) hedge ratio can be estimated using OLS.
Since Johnson (1960) proposed very early to explain hedging effect by Markowitz’s portfolio theory, it made the hedging effectiveness issue become the core issue in the research of futures market. On the basis of Johnson’s research, Ederington (1979) applied the portfolio theory to the financial futures market, using OLS model to analyze the hedge ratio of U.S. Treasury bond futures. The results indicated that the hedge ratio was always less than 1, and the effect of risk aversion was better than the situation when hedge ratio was 1. Besides, he gave the indicators of hedging effectiveness of futures market, which reflected the decline level of risk after hedging. In the classic capital market theory, it assumes that the variance of the returns is constant. But a large amount of practical data analysis shows that there is a Volatility Cluster of the returns. This characteristic would lead to heteroscedasticity. The existence of heteroscedasticity makes the covariance (between spot and futures prices) to be a variation. So the calculated hedge ratio is not constant, then the concept of dynamic hedging is put forward.

Engle brought forward the autoregressive conditional heteroscedasticity model (ARCH) in 1982. This model can capture the agglomeration effects of financial time series. The representation and development of ARCH model provide a theoretical basis and research method to estimate the dynamic hedge ratio. However, there are too many lags in the regression, which too many parameters are required to be estimated. That is why can the efficiency and accuracy of the estimation results are affected.

Subsequently, Bollerslev (1986) developed GARCH model\(^4\). This model is a good solution for the situation of excessive parameters to be estimated in ARCH model. Cecchetti et at (1988), Kroner, Sulmn (1993), Park, Switzer (1995) and Gagnon, Lypny (1995) have found that the dynamic hedge ratio was better than the constant hedge ratio, and suggested traders should always adjust their positions to reduce their risk exposure. In the research of Park and Switzer (1995), it found out that the using of GARCH model improved hedging effectiveness over the OLS model.

However, Holmes (1995) used the data of FTSE-100 stock index futures from June 1984 to June 1992. By comparing the hedging effects of the traditional OLS, ECM (error correction model) and the GARCH model, the result showed that the effect of the OLS model was better than the other models. During the analysis on the hedging

\(^4\) GARCH model is the ARCH model as generalized autoregressive conditional heteroscedasticity.
performance, different researchers have obtained very different results by using various models. Over time, the researchers also found that using simple linear regression models to estimate the hedging effectiveness, and ignoring cointegration relationship between spot and futures prices, would reduce the hedging effect. Thus, they began to study the long-term equilibrium relationship between futures and spot prices. Wahab, Lashgari (1993) and Lien, Luo (1994) conducted further studies of the co-integration relationship between stock index and futures market; and concluded that when different models were applied to estimate the hedging performance, the co-integration relationship should be considered. The study of Lien (1996) summarized the impact of the co-integration relationship on the hedging performance. He pointed out that if the co-integration relationship during the estimation of hedge ratio was not considered, it would greatly reduce the hedging effectiveness; and when evaluating the hedging effectiveness, the effect of using GARCH model would be the best. Lien et al (2002) also proposed an indicator of hedging performance. This indicator was expressed by the rate of change of returns’ variances before and after hedging. It was conducive to compare the hedge effectiveness estimated by different models. Though, the literatures have been reviewed are not newly findings. However, the theories and models are already well established. The results of those researches are practical and time tested, which can be adopted to study and analyze the newly launched CSI 300 stock index futures in China.

1.4 Problem statement

1) What are the basic definitions of stock index futures and hedging? The related theories and knowledge will be briefly introduced.

2) How is the development of stock index futures in China? What are CSI 300 Index and CSI 300 index futures? In this part, the development process of stock index futures in China will be summarized and analyzed. And the comparison between CSI 300 index futures and other index futures with China concept will be presented.

3) What models can be used to obtain the optimal hedge ratio? How to estimate the hedging effectiveness? The hedge ratio and hedging effectiveness of stock index futures will be chosen as the evaluation indicators for hedging
performance, and the correlative models (OLS and GARCH) will be built to estimate the indicators.

4) How is the correlation between CSI300 index futures market and the spot market? Here, the correlation between the CSI300 index and the futures price will be investigated, and the long-term equilibrium relationship between the futures price and spot price will be discussed.

5) Based on the empirical analysis, how is the hedging performance of CSI 300 index futures compared with other index futures? In the professional econometric software-Eviews, the OLS and the GARCH models will be used to calculate the hedge ratio and the hedging effectiveness, and do a comparative analysis with the calculation results.

1.5 Methodology

- Literature study
This paper studies a broad range of economic and financial literature in order to fully understand the research focus, contents and relevant theoretical knowledge to guarantee the smooth implementation of the research.

- Empirical study
This paper makes empirical research of hedging of the CSI300 index futures. Through the relevant statistical test and regression analysis, it gives a reasonable evaluation on the hedging performance of CSI300 index futures. In the meantime, it provides some suggestions for hedgers, in order to fully reflect the practical value of this paper.

Statistical test: Using the ADF (augmented Dickey-Fuller) test and co-integration test, the empirical analysis of the correlation between CSI 300 spot price and CSI 300 index futures price will be conducted. According to equations, the long-term equilibrium relationship between the index and the CSI 300 index futures will be studied.

Regression analysis: Using the OLS and GARCH models to calculate the evaluation indicators of hedging performance of CSI300 index futures, the calculation results will be compared and analyzed.

1.6 Delimitations
The research data, which is used in this paper is daily closing price of CSI 300 index futures, is lack of specific analysis of daily high frequency data. The study is not
focused enough at a micro-level. During the research process, in order to reflect the continuity of the study period, we assume investors continually choose current month contract to roll over. However, in reality, investors often use a hedging period from 30 days to 60 days. Also this study ignores the dynamic adjustment of hedging and the required margin. In the process of empirical analysis, it is also ignored that the risk preferences of different investors will be different. So there leaves some room for further improvement.
2 Stock index futures and hedging

2.1 Related theory of stock index futures

2.1.1 Concept

Technically, stock index futures are the agreements to buy or sell a standardized value of a stock index at a specified price on a future date. The trade object is the stock index, using the changes of stock index as the standard. Stock index futures are settled in cash and not by delivery of the underlying stocks (Hull, 2011). Also, they are special kind of futures contracts by tracking the value of an underlying index. Stock index is a comprehensive reflection of the market dynamics, which is used to analyze and predict future movements of stock price for investors, or to provide the basis for investment decisions. It tracks the changes of a portfolio of stocks (Hull, 2011). There are three different ways to construct the stock market index, including price-weighted index, value-weighted averages and the value line index. The value line index is an equal-weighted arithmetic average.

Although the trading history of stock index futures is very short, they still have great influence in the stock market. Stock index futures are important institutional arrangements in the financial system to avoid market risks; also they are the most important part in the financial derivatives market and cannot be replaced (Dubofsky & Miller 2003). The essence of stock index futures is a process that investors transfer the expected risk of the stock market price index to the futures market. This risk is through buying or selling to cancel out each other when the investors have different judgments on stock market curves. Like other futures (such as currency futures, interest rate futures and other commodity futures), stock index futures are designed to meet the needs of risk-aversion, and specifically designed to manage the price risk in stock market.

2.1.2 Characteristics

Stock index futures are based on stock price index, which is the underlying asset of the financial futures contracts. So it not only has the stock characteristics, but also has the characteristics of futures and the specific features of its own.
2.1.2.1 Stock characteristics (Kolb, 2003)

From the viewpoint of the stock characteristics, since the influence factors of spot index and commodity are not the same, there are huge differences of the research methods between those two kinds of futures. In order to analyze the trend of commodity futures, investors need to have an in-depth investigation in the supply and demand situations, which affect the movement of commodity. Also, a good selection of investment platform is very important. For stock index futures, investors need to pay more attention to macro economy, e.g. the trend of industry and the trend of the heavyweights, which will have a greater impact on the spot market.

2.1.2.2 Futures characteristics

And from the viewpoint of futures’ characteristics, stock index futures and commodity futures trading are basically the same. Both of them have standardized contract terms. Except for price, the contract specifies the quantities, the maturities and method for closing the contract in advance (Kolb, 2003). As for market participants, they are traded using the standardized futures contracts. This mechanism can make sure no one will default. All futures trading are completed through the clearinghouses. They do not have OTC\(^5\) transactions. Therefore, it eliminates the counterparty risk. As similar as other futures transactions, stock index futures have the system of daily settlement or marking-to-market (Kolb, 1999). This system makes sure that traders offset the position everyday and realize each day’s profit or loss in cash. It can be inferred that stock index futures can help to stabilize the market (Zhang, 2011).

2.1.2.3 Special characteristics

In addition, as a special future contract, stock index futures have features that differ from others (Zhang, 2011; Sutcliffe, 1993), which are expressed in the following aspects:

**Underlying asset** Stock index futures’ underlying asset is represented by stock index. The value of the contract is the quoted index value multiplied by the contract multiplier.

**Delivery Method** For stock index futures, there is a cash settlement system. It is a key feature that makes stock index futures special. Since stock index futures do not

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\(^5\) OTC stands for Over-the-counter, which trading is done directly between two parties.
settle by actual stocks, contract holder needs to pay or obtain cash for the price difference to closing the deal. When it comes to physical delivery, it will involve the transfer of ownership of the underlying asset, which would produce costs in storage, transportation and other things. Physical delivery is much more complicated.

**High Leverage** By using the margin trading system, it leads a high leverage effect. Investors do not need to pay the full value of the contract, only pay margins on a certain percentage for trading. For a 15% initial margin on a futures contract, the leverage can reach 7 times. High leverage is a double-edged sword, on the one hand, it provides the chance to earn huge profit with a small capital; on the other hand, it leads a higher risk, in the event of extreme market, the losses may be even more than the investment.

**Low Transaction Cost** Compare with the spot trading, the transaction costs are lower. It includes: commission, the bid-ask spread, the opportunity cost for paying the initial margin and possible taxes. This amount is much lower than the transaction costs of trading stocks. To trade index futures, the cost calculation is based on the number of contracts. While the costs paid in stock market are considered, it computes by the amount of stocks traded.

**Easy Short Selling** There is a short-selling mechanism in most stock exchanges. However, the limiting conditions of short selling are very strict. For example, in the UK, only Market Maker can borrow stocks; while in America, investors have to borrow shares through brokers and pay a certain amount of relevant fees. At present, it does not have short selling of stocks in China. It is more attractive to have this feature in stock index futures. This mechanism helps investors reducing loss when share price dropping. Basically, short selling stock index futures is more convenient than short selling shares.

**Liquidity** Due to the existence of margin trading system, it decreases the transaction costs. At the meantime, it attracts more investors involved. In general, the liquidity of index futures market is larger than the stock market.

Based on these features, stock index futures are used as one of the most active investment tools all over the world. The features of standardization and defined maturities give stock index futures an easy way to hedge their positions.
2.1.3 Functions

As we know, stock index futures are important investment tool in financial markets. Its appearance gives a new choice for market participants to manage risks. Also it enhances the vitality and improves the liquidity of the market. As a derivative financial instrument, from the viewpoint on a macroeconomic level, its basic functions are risk aversion, price discovery and so on; from the micro-level, it has three functions as hedging, arbitrage and speculation. The other functions are derived from them. Here, we introduce its functions from the macro-level.

2.1.3.1 Risk aversion

Like other futures contracts, risk aversion is the main and basic economic function of stock index futures (Kolb, 2003). Merton Miller, the American economist said: “the features of efficient risk sharing are the fundamental elements to innovate futures, options and other derivatives.” The essence of financial derivatives is that they are tools of risk management. The function of risk transfer in futures markets is mainly implemented by hedging. From the viewpoint of the entire financial market, the realization of risk aversion of stock index futures could be conducted based on three reasons: firstly, many stock investors are facing different risks, so risk aversion can be realized through mutual beneficial deals to control the overall market risk; secondly, the prices of stock index futures and index generally change in the same direction, if investors establish the opposite positions in two markets, when the stock price changes, he must benefit from one market and have loss in another market, the profit and loss can be fully or partly offset; thirdly, stock index futures is a standardized trading in the market in the field, there are a large number of speculators who are willing to take risks in order to obtain profits, they transfer the price risk from stock holders through rapid and frequent trading, so that this function of stock index futures can be achieved also in this aspect.

2.1.3.2 Price discovery

The function of price discovery is to reflect the price of supply and demand in the futures markets and other public auction trading system. Stock index futures are the revealing of information about future cash market prices through the futures market (Kolb, 1999). In practice, due to the low margin requirement and cheap transaction

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When the relationship between spot and futures does not hold, the futures are incorrectly priced and that results in arbitrage opportunities. It is not common in the market.
costs, the futures market has an excellent liquidity. Once there is information affect investors’ expectation on the market, it will soon be revealed in the market, and quickly passed to the spot market, which makes price for spot market tend toward equilibrium. By many investors’ bidding in the public and efficient futures market, it is conducive to form the stock price that reflects the true value of stock better. There are two reasons which make the futures market have a price discovery function: one is that there are many participants in the trading and the price formation contains information on price expectation from different participants; the other is that since stock index futures have advantages with low transaction costs, high leverage, high speed of instruction execution and etc., investors prefer to adjust positions in the futures market after receiving new market information, which makes futures price react even faster.

The existence of price discovery function links the stock index futures market and the spot market closely together. As shown in Figure 2.1 and Figure 2.2, which represent the trend changes of the spot market price (CSI 300 index) and stock index futures market price (IF index) from April 16, 2010 to December 31, 2013\(^7\). Through the comparison of the two figures, it can be obviously found that the close linkage of price changes between the stock index futures market and the spot market, which demonstrates the existence of price discovery function.

![Figure 2.1 Trend of CSI 300 Index](image1)

![Figure 2.2 Trend of CSI 300 index futures](image2)

### 2.1.3.3 Asset allocation

Asset allocation refers to choose among a variety of assets and to determine how much of one’s portfolio to place in safe assets versus in risky assets (Bodie, Kane, and Marcus, 2011). It will involve the issue of risk control. Nowadays, investors have lots

\(^7\) Data obtained from China Financial Futures Exchange (CFFEX)
of investment choices, such as stocks, bonds, real estate, commodities and so on. However, most of the investment cannot get rid of systemic risk. The most obvious example is the subprime crisis after 2007. When the whole environment was bad, almost all the investment facing losses; but in futures market, many investors who are in the short positions have made bundles of money; such as George Soros, based on his experience during this period, he has published a book called “The new paradigm for financial markets: the credit crisis of 2008 and what it means”.

The transaction costs involved in establishing and liquidating futures positions are much lower than taking actual spot positions, so that many institutional investors consider the stock index futures as a flexible asset allocation tool (Bodie, Kane, and Marcus, 2011).

Asset allocation function shows specifically in the following areas: First, due to the introduction of short-mechanism, the investment strategy of investors changes from the single mode (waiting stock price rise) into the mode (a two-way investment), which makes the investors’ funds can also be something even in the downward market trend, rather than passively unused; Second, the stock index is a stock portfolio itself; it conforms with the basic principle of investment diversification, and reduces significantly the risk compared to the specific stock trading, which is particularly conducive to the development of institutional investors, portfolio investment promotion and risk management; Third, through the trading of stock index futures, it can adjust the proportion of various types of assets in the portfolio, increase the market liquidity and improve the efficiency of capital using. When investors want to increase or decrease the amount of the financial asset holdings, they can just buy or sell stock index futures contracts corresponding to the asset.

2.2 Related theory of hedging

2.2.1 Concept

Hedging is undertaken to reduce the price risk of a cash or forward position by taking a position in the futures instrument to offset the price movement of the cash asset (Daigler, 1993). In a broader sense, it uses futures as a temporary substitute for the cash position. So, hedging can be regarded as a management tool. When it is suitable for an organization, it helps to reduce risk and improve working capital potions. Its effectiveness can be evaluated quantitatively. Its ability to reduce price level risk serves as economic justification. Hedging should always be viewed as risk reducing
but not eliminating, thus it is required that the remaining risk should be identified and monitored (Chance & Brooks, 2008).

2.2.2 Economic principles
Generally speaking, a hedge is simply the purchase (sale) of a futures market position as a temporary substitute for the security of the sale (purchase) in the cash market. Hedgers in the futures market will always take an opposite position to the cash position held. In a hedge, risk is reduced to the extent that the gain (loss) in the future position offsets the loss (gain) on the cash position. To achieve the function of hedging, it is based on the following economic principles:

- The price in the cash market and the price in the futures market will generally change in the same direction. Although the spot market and futures market are two completely separate markets, the economic factors and the economic environment that affect the spot price and the futures price are similar. Therefore, theoretically speaking, the price-changing tendency in both markets is the same. Hedgers can achieve the purpose of hedging based on this principle.

- As the futures contract nears delivery, the spot and futures prices will converge; as expiration approaches, the futures price equals or is very close to the spot price. Because of above principle, futures prices should equal to the spot prices on the maturity date. Once the prices are not equal, there will be risk-free arbitrage trading opportunities existing for traders. Then, the arbitrageurs will quickly take advantage of this spread that would equalize the prices. The arbitrageurs can restrict the fluctuation of price.

- Hedging transfers the spot prices as the basis risk in futures market, which can reduce the risk in spot market. Typically, hedging is the shifting of risk from hedgers to speculators or to the marketplace. Hedging reduces the gain potential as well as the loss potential (Chance&Brooks, 2008). More specifically, it is the process, which transforms the potentially more hazardous price level risk into the more manageable basis risk.

8 These apparent mispricing lead to the presence of “arbitrageurs,” who aim to exploit the resulting profit opportunities, but whose role remains controversial.
2.2.3 Types

There are two types of hedges, i.e. the short hedge and the long hedge; also known as sell and buy hedges.

A short hedge is a hedge that involves a short position in futures contracts in order to offset adverse price changes in a long cash position (Hull, 2012). When the investors forecast a decline in the price of stocks, the investors can execute a short hedge with a future contract to “lock-in” the price of stock portfolio that will be purchased in the future. So, by selling stock futures short, the investors on the futures side, could partially or totally offset the loss on the long cash stock position as its price declines.

Typically, organizations that maintain inventories (such as securities trading firms, refiners, or commodity producers) tend to be short hedgers. They sell futures or enter sale agreements to protect inventory or portfolio values.

As for long hedging, it is usually considered to be taking futures positions as substitute for a short cash position (Blank, Carter and Schmiesing, 1991). A long hedge is initiated when futures contracts are purchased in order to “lock-in” a price now and prevent the risk of price variability. Long hedges can be used to manage an existing short position. For example, if a hedger knows he will buy some amount of stock in the future, he can buy stock index futures immediately in the futures market. Thus, he can lock in the current value and only pay a small amount for the margin deposit.

According to the different purpose of hedging, it can be divided as the positive hedging and the passive hedging (Gregoriou, 2011).

- Positive hedging

The objective of positive hedging is to maximize revenues. Through the predictions on the stock market trends, it can choose hedging strategy wisely to avoid systemic risk. When the portfolio manager is facing greater systemic risk, he can use the positive hedging to hedge the systemic risk of the portfolio. However, this is just a temporary choice, after the release of risk, it will close the position.

- Passive hedging

The passive hedging sets its goal as the risk-averse, regardless of the revenue increment due to its operation. It does not involve stock market forecast. The purpose is to reduce or even completely avoid the systemic risk in the spot market. For this
purpose, what matters is not the profit made through the stock index futures, but the certainty of stock price in the spot market by holding stock index futures.

2.2.4 The Basis Theory

The basis defines the quantitative relationship that exists between the physical position and the hedge instrument (Koziol, 1990). Basis is the difference between the spot price and the futures price of the same commodity or asset (Schwarz, Hill and Schneeweis, 1986). The basis is decreasing over time as expiration nears. The convergence of prices eventually drives the gross basis\(^9\) to zero (Cusatis & Thomas, 2005). Basis is an important index that the hedger should concern. The changing trends of basis affect the hedge effectiveness of stock index futures directly. Its change provides important criteria for the investors, which can have the rational asset allocation and choose the right hedging strategy. The basis in a hedging situation can be expressed as follows:

\[
\text{Basis} = \text{Spot price of asset to be hedged} - \text{Futures price of contract used}
\]

There will be a different basis for each delivery month for each contract. Moreover, this relationship should be acceptably stable. This does not mean that the basis cannot fluctuate but rather it should not do so in an erratically volatile manner.

2.2.4.1 Basis risk

In general, hedging should follow the four basic principles:

- **Opposite trading direction**
  
  It requires holding the opposite positions in the spot and futures markets. It is the most important one. Only following this rule, investors can gain in one market, and offset the loss in another market.

- **Same or relevant variety of trade**
  
  When creating a hedging portfolio, the futures should be consistent with the chosen spot goods. In this way, it can create a close relationship between the futures price and the spot price. They will have the same price trend.

- **Same transaction amount**
  
  It requires the futures contracts have the same value of underlying assets in the spot market; otherwise, there will face greater risk.

- **Same or similar month**

\(^9\) Gross basis is measured as the difference between the two prices at the close of each business day.
It would be better that the delivery month of futures contract is the same with the time of buying or selling assets in the spot market. It can improve the effect of hedging. However, in the real situation, the perfect hedging hardly ever happens, since any change of factors that affects the spot price or the futures price will induce the change of basis. Basis change leads to the uncertainty of hedging effectiveness, which is called basis risk.

2.2.4.2 Affecting factors of basis risk
For stock index futures, the affecting factors of basis risk are mainly reflected in the following aspects (Dubofsky & Miller, 2003):

- Change of supply and demand in constituent stocks
  When the demand of constituent stocks is greater than the supply, the spot price would be lower than the futures price. It will drive the basis change to the opposite direction.

- Changes in interest rates
  Assume the stock yield of a company has not changed, if the interest rate rises, the price of stock index futures will be greater than the spot price. The basis will increase in reverse direction. If the market interest rate decline, the spot price will be more than the futures price, the basis is said to strengthen.

- Changes in stock yield
  If the company's stock yield rises, then the basis is said to strengthen. Conversely, when the stock yields drop, the basis is said to weaken.

- Policy factors
  If monetary policy or fiscal policy changes in the economic development, then the exchange rate, interest rate, inflation rates and other economic indicators will be affected. Consequently, the futures price and the spot price are going to be influenced.

In hedging, the trader still faces basis risk. However, the change range of basis is smaller than the price change in the futures market or the spot market. Traders can reduce their investment risks by using basis risk to replace price risk in the futures market or the spot market. Rational traders tend to choose this way to hedge.

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10 Stock yield is the dividend per share divided by its current price per share
2.2.5 The hedging theory

With the economic development and the improvement of financial market, the futures market has been discussed with much interest. The futures market is successful, which is mainly owing to the investors’ needs for hedging. Therefore, many researchers have been studying the theory of hedging. From a global perspective, the hedging theory has gone through a process evolving from the traditional to the modern. According to hedgers’ attitudes towards risk and hedgers’ motivation towards the profit from futures operation, there are four approaches to hedging, as summarized by Gray and Rutledge (1971): to eliminate the risks with price fluctuations; to reduce the risks associated with price fluctuations; to profit from movements in the basis; to maximize expected returns for a given risk or minimize risk for a given expected return. Ederington (1979) classified hedging theory as: traditional hedging theory, Working’s hypothesis and portfolio approach to hedging.

- Traditional hedging theory

Hedgers can do the opposite operations in the stock market and the futures market. They can hold the same amount but the opposite positions in these two markets to transfer the price risk. This is the so-called “traditional hedging theory”. Due to the existence of arbitrage activities and the needs of the supply-demand, Keynes (1951) and Hicks (1952) thought that the price of stock portfolio and the price of stock index futures have the same movement and the same fluctuation range, which means, the optimal hedge ratio is 1. Thus, on the expiration day, the gains (losses) in futures market are just balanced by the losses (gains) in stock portfolio, to achieve the purpose of perfect hedging.

In theory, the function of hedging is to use basis risk replace the price risk. During hedging, only when the price difference is zero and the basis risk is zero, the perfect hedging can be achieved. However, in fact, despite the high relevance between stock portfolio and stock index futures, their price movements are not entirely the same. The price difference is not zero. Therefore, there is basis risk when use the traditional hedging strategy. It cannot completely eliminate the risk.

- Working’s hypothesis

This theory holds that the hedging behavior of investors is with characteristic of selectivity, not marketability. In real trading of stock index futures, there is basis risk. So the gains from futures market may not be able to fully compensate for the losses in
the spot market. To overcome the basis risk, Working (1960) proposed the selective hedging to avoid basis risk. This method considers investors’ goal is profit-maximization. Under this assumption, hedgers concern about the changes of relative prices between stocks and futures, which are the changes of basis. They will engage in hedging transactions when the expected basis changes.

When using this strategy for hedging, the expression of gains and losses appears as shown below:

$$\text{Max} E(R) = h E\left[ X_s (S_{t+1} - S_t) - X_f (F_{t+1} - F_t) \right] + (1 - h) E\left( S_{t+1} - S_t \right)$$

(2.1)

where $E(R)$ denotes the expected returns, $S_{t+1}$ and $S_t$ are the spot prices at time $t+1$ and $t$; $F_{t+1}$ and $F_t$ are the futures prices at time $t+1$ and $t$; $\left[ X_s (S_{t+1} - S_t) - X_f (F_{t+1} - F_t) \right]$ is expected basis changes, $h$ is the optimal hedge ratio.

To achieve profit maximization, when $\left[ X_s (S_{t+1} - S_t) - X_f (F_{t+1} - F_t) \right]$ is positive, hedgers will choose traditional hedge strategy ($h=1$). Instead, if $\left[ X_s (S_{t+1} - S_t) - X_f (F_{t+1} - F_t) \right]$ is negative, there is no hedging which means $h=0$.

However, the hedging effectiveness of this type of models cannot be estimated. Under this method, whether it makes hedging decisions or not depends on the expectation of moving direction of basis. So it is called as Selective Hedge.

Working’s hypothesis was seen as the speculation of basis that it can gain risk-free return through the “buy low and sell high” of basis. Hedgers only take hedging operations when they think there is a profit opportunity. Therefore, hedging is one way of speculation; also it is not speculating on price, but on basis.

- Portfolio approach to hedging

Johnson (1960) believed the selective hedging is a strategy of arbitrage. The optimal hedging ratio is either 0 or 1. Thus, it has lost the original meaning of hedging function. Johnson (1960) and Ederington (1979) proposed using Markowitz's portfolio theory to explain the hedging theory.

Generally speaking, basis risk is less than price risk. For investors, the futures market is an investment market. The purpose of entering the market is to obtain maximum benefits with minimum risk. Investors think they can build a portfolio, which includes both stocks and futures contracts and trade in the market. By doing the opposite operations in futures market, hedgers can make a negative correlation between the
assets in spot market and the assets in futures market. So that the portfolio can obtain a satisfy combination of return and risk.

Therefore, in addition to do hedging selectively, the amount of buying and selling futures contracts is not necessarily consistent with the amount of spot transactions. Hedgers can adjust and change the amount of futures trading anytime, according to their purpose and the relationship between futures price and stock prices any time to select an optimal hedge ratio.

Portfolio theory is an important part of the modern hedging theory. By combining stocks and futures as a portfolio, it stresses that the optimal hedging ratio is not 0 or 1. Moreover, it avoids risks rationally through simulation to estimate the effective hedging ratio. And it fully considers the profits and risks of the existence of portfolio to illustrate the relevant hedging purposes.
3 Development of stock index futures in China

It can be seen from former chapters, the stock index futures is already one of the basic derivative financial instruments in mature markets, and the foreign investors have a deep understanding on it. However, it is the first time that China release stock futures contracts. The investors in China may not have relatively sufficient knowledge, and normally the kinds of stock index futures products are not the same in different countries. Moreover, different products have their own characteristics in different market environments. To deeply understand the characteristics of stock index futures in a specific environment, we must fully understand the relevant knowledge of the subject matter and its trading mechanism. In this chapter, the development of stock market and stock index futures in China and its related knowledge about CSI 300 will be focused.

3.1 Development of stock market in China

Due to the complexity of the Chinese economy and the imperfection of China’s capital markets, the implementation of stock index futures in China has undergone many ups and downs.

3.1.1 Chinese stock market

Chinese Stock Market has undergone a substantial development since its establishment in the early 1990’s. The large increases in share prices and market capitalization mainly benefit from the liberalization of market and the improvement of investor protection. The Chinese stock market is a typically immature and emerging capital market. There are many disparities between the Chinese stock market and mature capital markets of developed countries and regions, such as their backgrounds of establishment, modes of operation and developing processes. The regulatory roles and the national macroeconomic policies on these two types of markets are also very different, e.g. the development of the Chinese capital markets has been mainly driven by the central government.

When talking about China’s stock market, it has to include both the stock markets in the Mainland China as well as in the Hong Kong Special Administrative Region, because the HK market has become an integral part of the overall China market. The organized stock market in Mainland China is composed of two stock exchanges, the

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11 China Stock Market Handbook
Shanghai stock exchange (SSE) and the Shenzhen stock exchange (SZSE). Since 1992, the Chinese stock market has boomed and become one of the worldwide largest in a relatively short lapse of time. The stock market in China averaged 1680.01 index points from 1990 until 2014, reaching an all-time high of 6092.06 index points in October of 2007\(^\text{12}\). Starting from 53 in 1992, the number of firms listed on SSE and SZSE increased 50 times to 2,532 in 2013 (see Figure 3.1). After the rally in 2007, the Chinese stock market reached a market capitalization of over 30 trillion Yuan. This volume overstepped China’s nominal GDP for the first time\(^\text{13}\).

![Number of listed firms, 1992-2013](image)

\textit{Source: CSRC.}

### 3.1.2 Reform of Chinese stock market

In recent years, with the continuous reform of the financial markets in depth, the marketization of interest rates in China makes the demands of risk management tools increase rapidly, especially for the financial institutions. Also, non-tradable shares reform, which is a special appearance during the development of corporate system and capital market, has been implemented in the Mainland of China. And Chinese government resolutely carries out reform of the shareholder structure in listed companies and resolves this longstanding institutional problem that hindered the development of the securities market, which hopefully build a good environment for the development of stock index futures.

Basically, China's shares are divided into state shares, legal person shares, individual shares and foreign shares. And the state shares and legal person shares cannot

\(^{12}\) Data obtained from Shanghai Shenzhen Stock Exchange.

circulate, but individual shares and foreign shares can be traded on the Shanghai and Shenzhen Stock Exchange. Most legal persons are actually state entities, so the legal person shares and state shares are known as state-owned shares (Luo, 2011).

The stock market enables companies to become openly exchanged, or even increase extra funds with regard to growth selling off stocks. However, the non-tradability of state-owned shares led to many problems, which limited the development of stock market. Firstly, state assets were “dead”, which would be less valuable; secondly, property rights of enterprises could not be clearly defined among individual investors; thirdly, capital mobility and economic restructuring were hindered; and lastly, the development of a secondary stock market was obstructed (Ma, 2008). Thus, it could be expected that if the proportion of state ownership in Chinese enterprises could decrease further, the development of stock market would be better. However, from 1997-2004, there were only minor changes in the relative size of the state-owned shares (Ma, 2008).

A breakthrough occurred in late April 2005. Under the guidance of the State Council, the China Securities Regulatory Commission (CSRC) launched the Equity Division Reform among Chinese listed companies. The CSRC explained that the reform was designed to address the problem of non-tradability of the large amount of state-owned shares, instead of cashing them in. It is a historical residual problem from the period before the companies went public. The coexistence of non-tradable state-owned shares and tradable individual shares has resulted in a “dualistic” market consisting of “different types of equities, different prices, and different rights” (Ma, 2008). In late 2006, Shang Fulin, chairman of the CSRC, announced that the reform “had basically been accomplished.” In 2008, there were a total of 1656 listed companies have finished the reform or in the reform process in Shanghai stock market and Shenzhen stock market. It has reached 98.6% of the listed companies who should have implemented the reform.

Technically, the reform was to correct the system error, and to resume original feature, to make non-circulating stocks to become circulating stocks, to realize the same stock has same price, right and profit. The reform sought to remove the problems regarding the split share structure and the negative effects of dividends on

the A-share investors. During the reform period from 2005 to 2008, the smooth progress of the split share structure reform fundamentally solved the problem of dividing interests and prices among the state-owned shares, institutional shares and tradable shares in a company’s share structure. And it enabled equal rights to the trading of and earnings on shares among all categories of shareholders (OECD).

It can be seen that promoting the non-tradable share reform has a great practical significance to build up market confidence and bring steady growth of investment. Also owing to this reform, the market foundation is strengthened. China’s shares are now valued by the market mechanism that creates the basis for common interests of all shareholders. On the other hand, the quality of listed companies is also getting promoted. The internal control mechanism of brokers and futures companies has being gradually perfected. All these advantages have created a favorable environment for the introduction of stock index futures.

3.2 Development of CSI 300 index futures

In order to better reflect the price fluctuation and general performance of China A-share market, China Securities Index 300 (CSI 300), designed and managed by China Securities Index Co., Ltd, was launched on April 8, 2005. The mock trading\(^{16}\) of CSI 300 index futures was put into operation by the China Financial Futures Exchange (CFFEX) on 30\(^{th}\) October 2006. Till April 2007, the Regulation on the Administration of Futures Trading was issued by the State Council\(^{17}\), which cleared the way for the trading of stock index futures. By the end of 2006, it was more than doubled in less than two years. The exchange and market participants expected the CSRC agreed to implement the real trading of stock index futures from 2007. But the stock market was on a tear. The CSRC was afraid of the introduction of stock index futures might cause the stock market bubble. So the approval was withheld by CSRC. Since the outbreak of the global financial crisis in 2008, the regulators feared that the futures might aggravate the bear market. The year 2008 was a bad year for all capitalist markets especially the SSE. Its benchmark recorded its biggest annual loss of more than 65%. It fell from 5265 points in January 2008 to 1834 points in December 2008\(^{18}\). Hence,

\(^{16}\) The difference between mock trading and real trading is that the money is not real.
\(^{17}\) http://www.lawinfochina.com/display.aspx?lib=law&id=5948&CId=
\(^{18}\) Data obtained from Yahoo Finance, http://finance.yahoo.com/q?s=000001.SS
the mock trading was not changed to a real one but continued by CFFEX in year 2008, 2009 and into 2010.

Finally in 2010, with the Chinese economy on a steady growth path and a stable stock market, the green light came after about four years of preparation and experience; and on April 16, 2010, the CSI 300 stock index futures was launched on CFFEX, which marks a very important milestone in the development of China’s financial market and risk management.

So far, the launching of CSI 300 stock index futures has been regarded as a success. Over the first three months of trading, a moderate average monthly trading volume was more than 6 million contracts, with a value exceeding 5 trillion Yuan (USD 800 billion). Its trading value was larger than the value of stocks traded on the two exchanges in the same period (Zhang, 2011). By the end of 2013, the trading volume of CSI 300 stock index futures accumulated to 195 million contracts with notional value 141 trillion Yuan (USD 22.67 trillion)\(^9\).

### 3.2.1 Significance of CSI 300 index futures

There are two main significances of the introduction of CSI 300 stock index futures:

First, it provides investors with a hedging tool to avoid loss of assets. Due to the positive correlation of trading volume between the stock market and the stock index futures market, it attracts a large number of arbitrageurs and hedgers to participate. Thus, it increases the market liquidity.

Secondly, according to its function of price discovery, large amounts of money will flock to the blue-chip stocks, which have a good performance in the market. This situation provides a favorable external financing environment for the good performance firms. It is conducive to accomplish the optimal allocation of resources and restructure the stock market.

From the view of whole, the overall situation of China stock index futures showed a healthy development during the last three years. However, it is not as mature as compared with the markets in developed countries. Therefore, in the developing process, it needs to constantly improve and keep the prosperous development of the stock index futures market.

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\(^9\) China Financial Futures Exchange, www.cffex.com.cn
3.3 CSI 300 Index and CSI 300 stock index futures

3.3.1 Pricing CSI 300 Index

China Securities Index (CSI) 300 is an index that consists of 300 stocks with the largest market capitalization and liquidity from all the A-share listed companies. As the first equity index launched by the two exchanges together, CSI 300 Index was created with the base point at 1000 on December 31, 2004. The candidate constituents of CSI 300 index should have good performance without serious financial problems (or laws and regulations breaking events) and with no large price volatility, which can represent strong evidence of manipulated\(^\text{20}\).

CSI 300 index is calculated using a Paasche\(^\text{21}\) weighted composite price index formula and is weighted by adjusted shares\(^\text{22}\). For pricing CSI 300 index, no adjustment is required for dividend payment and the index is allowed to fallback naturally. But for total return index and net total return index, the divisor will be adjusted before the ex-dividend date.\(^\text{23}\)

3.3.2 Relation with Shanghai index and Shenzhen index

The most important indices for A-shares\(^\text{24}\) in SSE and SZSE are the Shanghai stock exchange composite index and the Shenzhen stock exchange component index.

The Shanghai SE Composite Index is a major stock market index which tracks the performance of all A-shares and B-shares listed on the Shanghai Stock Exchange, in China. It is a capitalization-weighted index. And the Shenzhen Stock Exchange Component Index is a Capitalization Weighted Index. The constituents consist of the 40 top companies that issue A-shares on Shenzhen Stock Exchange.\(^\text{25}\)

The correlation between the CSI 300 index and the Shanghai Composite Index has been 97% at the beginning. Though the CSI 300 index do not have a clearly relevance with the Shenzhen Index; by the end of 2013, the total market capitalization of CSI 300 Index is 14.14 trillion Yuan and its free float market capitalization is 5.19 billion

\(^\text{21}\) Paasche index uses quantities for each period as weights and compares current prices to base period prices at current purchase levels.
\(^\text{22}\) Formula and table can be found in Appendix A.
\(^\text{24}\) RMB-denominated ordinary shares for domestic residents and institutions to invest in are called A-shares for short.
\(^\text{25}\) Both of the two indexes are not required for index adjustment when dividend payment happened.
Yuan, which has about 59.56% coverage of the total stock market capitalization and 51.88% coverage of the tradable market cap of A-share market, respectively.\textsuperscript{26} Due to its high coverage of the market cap and good representation, the CSI 300 index has achieved market recognition. Also, the distribution of the weights of the mainly constituent stocks in CSI 300 index is dispersed. The listed companies are classified into 10 sectors\textsuperscript{27}. The industrial distribution of the constituent stocks is balanced (see Figure 3.2). Meanwhile, the top 10 constituents stocks of the index have a weight of 22.64%; the top 20 constituents stocks of the index have a weight of 32.77\%\textsuperscript{28}.

![Figure 3.2 Weights and classification of Industries in CSI 300 index](image)

The characteristics of high market coverage and decentralized weight of constituents determine that CSI 300 index cannot be manipulated. They will not be affected by the periodical fluctuations. It can have a good hedging effect and meet demand of risk management from investors. So it is the most suitable index as the underlying index in both the Shanghai and the Shenzhen stock markets.

### 3.3.3 Comparing with other Chinese concept stock index futures

Along with the acceleration of opening-up in China, the economy has increased stably and appreciation in RMB is expected, both of which attract the investors’ attention from abroad. At the same time, more and more Chinese enterprises list themselves overseas. There are increasing demands in risk management tools of stocks for investors.

\textsuperscript{26} [http://www.cffex.com.cn/gyjys/jysdt/201312/t20131204_17446.html](http://www.cffex.com.cn/gyjys/jysdt/201312/t20131204_17446.html)


Under this background, the Hong Kong stock exchange (HKEx), Singapore stock exchange (SGX) and Chicago Mercantile exchange (CME) have launched a series of stock index futures with Chinese Concept before the CSI 300 index futures. They have attracted a large number of investors to participate in. Since the day of introducing CSI 300 index futures, it is facing the competition with the overseas Chinese concept stock index futures. Generally speaking, the more relatively homogeneous products and the better the alternative emerge, the stronger competition is between each other.

- H-shares index futures

Hong Kong Exchange launched H-shares index futures on Dec. 8 2003. It is a first overseas Chinese concept stock index future. Its underlying index is Hang Seng China Enterprise Index (HSCEI). It is a market capitalization-weighted stock index. It tracks the performance of Mainland China enterprises with H-share listings in Hong Kong. The 40 stocks that have the highest combined market capitalization ranking are selected as constituents of the H-shares Index. Compared with CSI 300, through the analysis of the constituents of the HSCEI, there is an overlap of most heavyweights stocks in the two indexes (see Appendix B). This indicated that CSI 300 and HSCEI are highly correlative.

- Mini H-shares index futures

Mini H-shares index futures would meet the needs of customers who have a smaller risk capital. The underlying index is HSCEI, as well as the standard H-shares Index futures contract. The smaller contract size allows both experienced and novice investors to participate in the performance of the H-shares market in a graduated scale.

- E-mini FTSE/Xinhua China 25 Index futures

CME listed E-mini(R) futures on the FTSE/Xinhua(R) China 25 Index. The FXI China 25 index is composed by 25 of the largest Chinese companies listed on the Hong Kong Stock Exchange and has a total market capitalization of about USD 241 billion. Due to the constituents of the index including red chips, which have not returned to A-share market, the correlation between FXI China 25 index and CSI 300 index is weaker.

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31 Risk capital refers to funds used for high-risk, high-reward investments.

• **SGX FTSE China A50 Futures**

Denominated in U.S. dollar, the SGX A50 Futures are the only offshore futures tracking the China A-shares market. It is based on the FTSE China A50 Index, which tracks the performance of the largest 50 companies by full market capitalization on the Chinese stock market.\(^{33}\) The index offers the optimal balance between representativeness and tradability for China’s A Share market. The constituents of CSI 300 index covered the all constituents of FTSE China A50 index.

<table>
<thead>
<tr>
<th>Exchanges</th>
<th>Name of stock index futures</th>
<th>Substitutability</th>
<th>Competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKEX (Hong Kong Stock Exchange)</td>
<td>H-shares index futures</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>Mini H-shares index futures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E-mini FTSE/Xinhua China 25 Index futures</td>
<td>Weak</td>
<td>Weak</td>
</tr>
<tr>
<td>SGX (Singapore Exchange)</td>
<td>SGX FTSE China A50 Futures(^{34})</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>CME (Chicago Mercantile Exchange)</td>
<td>E-mini FTSE/Xinhua China 25 Index futures</td>
<td>Weak</td>
<td>Weak</td>
</tr>
</tbody>
</table>

*Note. Substitutability here stands for if CSI 300 index futures can be replaced by other futures.*

Based on the above analysis, the H-shares index futures is a strong competitor of CSI 300 index futures. Due to the index design and its requirement from the stock market, CSI 300 index has its own competitive advantage. The trading volume and trading value related to the constituent stock of CSI 300 index futures are far more than them related to the constituent stock of H-share index futures (Fang, 2008). Apparently, it is clear that investing in the Mainland China stock market makes a number of fund companies, insurance companies, QFII\(^{35}\) and other institutional investors have a great demand to hedge the stock risk. In addition, as mentioned before, CSI 300 Index could be a good representative in terms of market scale, liquidity, and industry group of A-share market.

For the introduction of CSI 300 Index, it is not only able to reflect the operating conditions and the trend of price volatility of China’s A-share market comprehensively and truly, but it also provides some reference value to the stock investment of the investors. Meanwhile, it establishes the foundation for the launching


\(^{34}\) SGX A 50 futures has law issues with the two stock exchanges in China.

\(^{35}\) QFII: Qualified Foreign Institutional Investor.
of CSI 300 stock index futures.

3.3.4 Comparing CSI 300 index futures contract with H-shares index futures contract

Some features of CSI 300 index futures contract\(^{36}\) and H-shares index futures contract\(^{37}\) can be seen in Table 3.2.

Table 3.2 Comparison between two contracts

<table>
<thead>
<tr>
<th>Contract</th>
<th>CSI 300 index futures</th>
<th>H-shares index futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying Index</td>
<td>CSI 300 Index</td>
<td>Hang Seng China Enterprises Index (HSCEI)</td>
</tr>
<tr>
<td>Contract Multiplier</td>
<td>CNY 300</td>
<td>HK$ 50</td>
</tr>
<tr>
<td>Unit</td>
<td>Index point</td>
<td>Index point</td>
</tr>
<tr>
<td>Tick Size(^{38})</td>
<td>0.2 point</td>
<td>One index point</td>
</tr>
<tr>
<td>Contract Months</td>
<td>Current month, next month, next two calendar quarters</td>
<td>Spot month, next calendar month, next two calendar quarter months</td>
</tr>
<tr>
<td>Pre-Market Opening Period</td>
<td>None</td>
<td>8:45 am - 9:15 am &amp; 12:30 pm - 1:00 pm</td>
</tr>
<tr>
<td>Trading Hours</td>
<td>09:15 am - 11:30 am, 1:00 pm - 3:15 pm</td>
<td>9:15 am - 12:00 noon, 1:00 pm - 4:15 pm &amp; 5:00 pm - 11:00 pm(^{39})</td>
</tr>
<tr>
<td>Trading Hours on Last Trading Day</td>
<td>09:15 am - 11:30 am, 1:00 pm - 3:00 pm</td>
<td>Expiring contract month closes at 4:00 pm on the Last Trading Day</td>
</tr>
<tr>
<td>Limit Up/Down</td>
<td>+/-10% of settlement price on the previous trading day</td>
<td></td>
</tr>
<tr>
<td>Margin Requirement</td>
<td>12% of the contract value</td>
<td>Initial HK$ 31,400 per lot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintenance HK$ 25,150 per lot</td>
</tr>
<tr>
<td>Last Trading Day</td>
<td>Third Friday of the contract month, postponed to the next business day if it falls on a public holiday</td>
<td>The Business Day immediately preceding the last Business Day of the Contract Month</td>
</tr>
</tbody>
</table>


\(^{38}\) Tick size means Minimum fluctuation

\(^{39}\) Hong Kong Exchanges and Clearing Limited (HKEx) has introduced After-Hours Futures Trading (AHFT) since 8 April 2013, which means the trading is still open from 5 pm to 11 pm. But AHFT is not applicable on last trading day and the pre market opening period.
From the Table 3.5, it can be seen that the multiplier of CSI 300 index futures is 300 Yuan. The tick size is 0.2, which means for a minimum change of value is 60 Yuan (=0.2*600). As for H-shares index futures, its minimum change value is HK$ 50.

In daily trading, for CSI 300 index futures contracts, it opens at 9:15 am and closes at 3:15 pm. The trading hours almost remain the same between the CSI 300 index futures and the spot market. This kind of time arrangement is conducive to realize the price discovery function of stock index futures, which can make investors easily adjust their hedging strategies based on the information about the current assets and prices. Based on these data, they can control risk effectively.

For H-shares Index futures, it is available from trading from 5:00 pm to 11:00 pm (after-hours trading) in addition to the regular trading sessions: 9:15 am to 12:00 noon and 1:00 pm to 4:15 pm. This arrangement can attract more investors from Europe or US because it enables investors can hedge or adjust their positions during the European and US business days.

The margin requirement of H-shares index futures is a fixed amount per lot, which differs from CSI 300 index futures charging on a certain percentage of the contract value. When the index goes up, the margin requirement of CSI 300 index futures will also rise.

On Last trading day, both of them close 15 minutes earlier than usual. There is a limitation of the daily price volatility for CSI 300 index futures. It cannot increase higher or decrease lower than 10% of settlement price on the previous trading day.
4 The general principle of the determination of optimal hedge ratio

4.1 Estimation models of optimal hedge ratio
The alternative hedging strategy searching and the optimal hedge ratio modeling are the focuses of financial risk management applied to financial futures. The theory of hedging and portfolio investment points out that hedging is actually one kind of portfolio investment. It is an investment choice on the combination of spot market asset and futures market asset. Since it is a portfolio investment behavior, we must consider the expected return and risk. Based on the portfolio theory, investors divide the ways of determining hedge ratios into three types. According to investors’ different purposes of holding the positions and risk appetites, the three types are: risk minimization hedging, utility maximization hedging and per unit of risk compensation maximization. Among them, the risk minimization model has been widely used.

4.1.1 Risk minimizing hedging model
Hedgers who applied this model are regarded as the absolute risk-averse investors. They wish to minimize their risks (by considering their variance-return position) through hedging. Johnson (1960) was the first to propose the minimum variance hedge. The number of futures contracts, which are required to hedge a certain spot position, is based on minimizing the variance of the hedged portfolio (Carol & Andreza, 2007). The optimal hedge ratio is defined as the ratio of the size of position taken in the futures market to the size of the spot position, which minimizes the total risk of portfolio.

Equation 4.3 shows the hedger’s spot-futures portfolio return. After hedging, the changing situation of the investment portfolio can be written as:

\[
\Delta S = S_2 - S_1 \\
\Delta F = F_2 - F_1 \\
R = \Delta S - h\Delta F
\]

where \(S_1\) and \(S_2\) are the spot prices in logarithms at time \(t_1, t_2\); \(h\) is the hedge ratio; \(F_1\) and \(F_2\) are the logged futures prices at time \(t_1, t_2\); \(R\) represents the return on a hedged portfolio.

---

40 Portfolio investment hedging theory proposed by Johnson (1960) and Ederington (1979)
Equation 4.4 shows the variance of a hedges portfolio, which is given by:

$$\text{Var}(R) = \text{Var}(\Delta S - h\Delta F) = \sigma_s^2 + h^2 \sigma_f^2 - 2h\rho \sigma_s \sigma_f$$  \hfill (4.4)

where $\sigma_s^2 = \text{Var}(\Delta S)$ and $\sigma_f^2 = \text{Var}(\Delta F)$ are the variances of the returns on spot and futures positions, respectively; $\text{Cov}(\Delta S, \Delta F)$ represents the covariance of returns between spot and futures positions, and $\rho = \frac{\text{Cov}(\Delta S, \Delta F)}{\sigma_s \sigma_f}$ represents the correlation of assets returns (Lien, 2008).

The minimum variance (MV) hedge ratio can be given as follows:

$$h = \rho \frac{\sigma_s}{\sigma_f} = \frac{\text{Cov}(\Delta S, \Delta F)}{\sigma_f^2}$$  \hfill (4.5)

When $h = 1$, it provides a “perfect” hedge (known as ‘naïve hedge’). There is a perfectly correlation between the spot market and the futures market, and also the volatilities are equal, i.e. the spot and futures prices move with the same varying amount; when $h < 1$, it cannot erase the risk completely and is considered as imperfect hedging; when $h = 0$, it stays at un-hedged.

### 4.1.2 Utility maximizing hedging model

Investors that aim to maximize expected utility, by taking into account returns, take risks and preferences towards risk (the degree of risk aversion). When regarding the problem of opportunity cost, the degree of risk aversion for the hedger plays an important role (Manolis & Ilias, 2008). For investors who more focus on increasing returns through investment and maximize their own utility (i.e. they are not entirely risk-averse), this hedging model is designed for them to analyze the hedging effect. It targets to maximize the expected return of the hedged portfolio (from the spot and futures positions), which is subjected to the expected risks (variances) that it faces (Manolis & Ilias, 2008). Utility function describes the investors’ preferences regarding risks, composed by two factors\(^{41}\): first, the amount they are willing to invest in, which is objective factor; second, investors’ personal choices and preferences, are subjective factors.

### 4.1.3 Per unit risk compensation maximization

To maximize the risk compensation per unit, this hedge strategy introduces risk-free asset. It aims to increase the risk compensation, which means increasing the risk per

\(^{41}\text{Formulas can be found in Appendix C.}\)
unit can provide the more risk compensation of units. This model can make investors with different risk appetites obtain their corresponding returns under different risk levels. Investors who dislike risks request a higher risk compensation per unit than those who favor risks.

Comparing with former two methods, though unit risk compensation maximization takes care of both risk and return, its calculation is complicated; and it introduces the risk-free asset, this is not easy to be put into operation for investors. Besides, the utility function for utility maximization hedging is difficult to construct accurately. When facing different investors, the applied utility functions are not the same. Through utility maximization model to determine the optimal hedge ratio, it does not have the general meanings. The rear two of introduced three methods both have the disadvantage of pre-determined the utility function, which is subjective to some extent. Economics assumes that the rational investors are the investors who are risk-averse. For them, the main purpose of hedging is to avoid risk of the spot market. The risk-minimizing MVHR has a strong applicability. As a consequence, this thesis chooses the risk-minimization model to do a further research.

4.2 Estimating hedging effectiveness based on risk-minimization hedging model

4.2.1 Econometric models for hedging

- Model 1: OLS

This is the simplest model of the ordinary least squares (OLS) regression, which is a linear regression of changes in spot prices on changes in futures prices. OLS estimation of the following equation provides the best linear unbiased estimate of the MVHR if the assumptions of the classical linear regression model hold (Jason Laws, John Thompson, 2005).

The appropriate hedge ratio will be the slope estimate (i.e. \( \beta \)) in a regression, where the dependent variable is a time series of spot returns and the independent variable is a time series of futures returns. The MV constant hedge ratio can be estimated from the following expression:

\[
\Delta S_t = \alpha + \beta \Delta F_t + \xi_t
\]  

(4.6)

\(^{42}\) Formulas can be found in Appendix D.

\(^{43}\) The number of units of the futures asset to sell per unit of the spot asset held
Here, $\Delta S_t$ and $\Delta F_t$ represent the changes in the logarithm of spot and futures prices at time $t$, respectively; $\alpha$ is the intercept term, which is considered as the average basis change of hedging; $\xi_t$ is the error term from OLS estimation; the optimal hedge ratio is equivalent to the slope coefficient, $\beta$.

- Model 2: GARCH

Numbers of empirical studies show that the time series of the return on assets always show “volatility clustering”. In case of financial price and return volatility has significantly heteroskedasticity feature. Generalized autoregressive conditional heteroskedasticity (GARCH) model can deal with these problems. GARCH model is more usable in return volatility estimation field. According to Bollerslev (1986), GARCH(1,1) specification adequately fits many economic time series. A GARCH(1,1) model is chosen because there is substantial evidence on the model’s adequacy, especially on characterizing the dynamics of the second moment of financial asset prices. GARCH(1,1) model assumes that the conditional heteroskedasticity of the current return on assets is not only related to the residual squares in last period, but also related to the conditional heteroskedasticity of last period. GARCH(1,1) model describes the relationship between futures price and spot price as follows:

\[
\Delta S_t = \alpha + \beta \Delta F_t + \epsilon_t \quad (4.7)
\]

\[
\epsilon_t \sim N(0, \sigma_t^2) \quad (4.8)
\]

\[
\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 \quad (4.9)
\]

where $\epsilon_t$ denotes an error term; $\sigma_t^2$ is the conditional variance on day $t$; $\alpha_0$, $\alpha_1$ and $\alpha_2$ represent the parameters from the GARCH(1,1) estimation; The regression coefficient $\beta$ is the optimal hedge ratio $h$.

### 4.2.2 Estimating Hedging Effectiveness

In the above contents, two estimation models have been discussed to derive optimal hedge ratios. The performance of the hedging strategies can be examined by finding the hedging effectiveness of each strategy. It can be inferred that the un-hedged portfolio is constructed as the composition of shares holding same proportion in the spot price index; the hedged portfolio is constructed with the combination of both the spot and the futures contract held (Figlewski, 1984).

The hedge ratios estimated from each strategy determine the number of futures
contract. Hedging effectiveness is calculated by the reduction in variance of the hedged portfolio compared to that of the un-hedged portfolio in each forecasting horizon. The returns of the un-hedged and the hedged portfolios can be simply expressed as:

\[ R_u = S_{t+1} - S_t \]  
\[ R_h = (S_{t+1} - S_t) - h^* (F_{t+1} - F_t) \]

where \( R_u \) and \( R_h \) are returns on un-hedged and hedged portfolios. \( S_t \) and \( F_t \) are logged spot and futures prices at time \( t \), respectively; \( h^* \) is the optimal hedge ratio. Similarly, the variances of the un-hedged and the hedged portfolios are expressed as:

\[ \text{Var}(R_u) = \text{Var}(\Delta S_t) \]  
\[ \text{Var}(R_h) = \text{Var}(\Delta S_t) + h^2 \text{Var}(\Delta F_t) - 2h \text{Cov}(\Delta S_t, \Delta F_t) \]

The effectiveness of hedging \((h_e)\) can be measured by the percentage reduction in the variance of a hedged portfolio as compared to the variance of an un-hedged portfolio (Ederington, 1979). The variance reduction can be calculated as:

\[ h_e = \frac{\text{Var}(R_u) - \text{Var}(R_h)}{\text{Var}(R_u)} \]

\( h_e \) reflects the reduction degree of the hedged spot’s risk compared with the un-hedged ones. The greater the reduction in the variance is, the better the hedging effectiveness becomes. This gives us the percentage reduction in the variance of the hedged portfolio as compared to that of the un-hedged portfolio. When the futures contract completely eliminates risk, we obtain \( h_e = 1 \), which indicates a 100% reduction in the variance; whereas we obtain \( h_e = 0 \), when hedging with the futures contract does not reduce risk.

Therefore, a larger value of \( h_e \) indicates better hedging performance. Then, in order to check if the more advanced time-varying hedge ratio performs better than the constant hedge ratio, the performances of these hedge ratios estimated from the OLS model and the GARCH model can be compared.
5 Empirical analysis

5.1 Data collection and processing

A. Time Series Data

In this thesis, the daily closing price of CSI 300 index is adopted as the spot price. In the stock index futures trading, there are four kinds of contracts, i.e. the current month contract, the next month contract and the next two calendar quarterly month contracts. So there are four trading data from the contracts each day. And the expiration day is the third Friday of the contract month. It is always the nearby contract that is the most liquid and active in terms of trading volume. To avoid thin trading and expiration effects, and to obtain the possible most frequent return observations for the time series tests, the data from the nearby futures contract is used and roll over to next nearest contract one week before the expiration of the current contract. So the daily closing price of CSI index futures contract is adopted as the futures price.

To compare the different market situations, the H-shares index futures is selected within the same time period for comparison and for the convenience of foreign investors, and the MSCI China A index is adopted as another benchmark index because it is denominated in US dollars.

All the data are collected from the China Securities Index Co. and Bloomberg, covering the time period from April 16, 2010 (officially released) to December 31, 2013. After the exclusion of non-trading days the daily time series for the whole sample consists of 899 observations. For analysis, all price series are transformed into natural logarithms. Data series are analyzed by using Eviews5.1.

B. Returns Calculation

To analyze the relationship of price volatility between spot market and futures market, in this paper, the concept of returns is utilized. The returns of stock index futures prices and spot prices are defined as follows:

\[
R_{f,t} = \Delta F_t = \ln \frac{F_t}{F_{t-1}}
\]

\[
R_{s,t} = \Delta S_t = \ln \frac{S_t}{S_{t-1}}
\]

44 The trading volume of futures contracts decreases sharply when they approach their settlement days.
45 MSCI (Morgan Stanley Capital International) China A index captures large and mid cap representation across China securities listed on the Shanghai and Shenzhen exchanges. It has 463 constituents.
where, $R_f$, represents the logarithm of futures price return at time $t$, similarly, $R_s$, represents the logarithm of spot price return at time $t$, $F_t$ is the logarithm of futures price at time $t$ while $S_t$ is the logarithm of spot price at time $t$, $F_{t-1}$ is the logarithm of futures price at time $t-1$ while $S_{t-1}$ is the logarithm of spot price at time $t-1$.

5.2 Data analysis

5.2.1 Descriptive statistics analysis

- Correlations

First, it is important to know the degree of the correlation between the spot market and the futures market. According to the data processed by EViews 5.1, the correlation can be obtained as follows. It is obvious that the spot prices of CSI 300 index are strongly correlated with the futures contract prices. Same as the H-share index futures, its spot price has a highly correlation with its futures price. And the selected benchmark MSCI China A index, it is also highly correlated with CSI 300 index futures. The positive correlations among them indicate their prices move in the same way with each other.

Table 5.1 Correlation between the spot and futures

<table>
<thead>
<tr>
<th></th>
<th>CSI 300 index</th>
<th>MSCI China A index</th>
<th>HSCEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSI 300 index futures</td>
<td>0.998964</td>
<td>0.994918</td>
<td>0.821706</td>
</tr>
<tr>
<td>H-shares futures</td>
<td>0.812444</td>
<td>0.804698</td>
<td>0.998649</td>
</tr>
</tbody>
</table>

- Price movements

Next, as noted in Figure 5.1, in general, the spot prices of CSI 300 index moved largely in step with CSI 300 index futures prices, as well as the situations of the HSCEI & H-shares index futures. It is further illustrated they are highly correlated and probably have a long-term equilibrium relationship. Though the price movements of MSCI China A index keep a same trend with CSI 300 index futures, there exists a deviation between those two. Thus, it may not track the status of CSI 300 index futures as well as CSI 300 index.
Figure 5.1 Price movements of CSI 300 index and CSI 300 index futures
(From April 16, 2010 to Dec. 31, 2013)

Figure 5.2 MSCI China A index & CSI 300 index futures

Figure 5.3 HSCEI & H-shares futures

*Note*: Index futures prices ($\ln F$) and spot index prices ($\ln S$) are in logarithms.
**Daily return time series**

Then, the statistical characteristics of the prices, the daily return time series of the spot and futures can be analyzed subsequently.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CSI 300 index futures</td>
<td>$R_s$</td>
<td>-0.00041</td>
<td>0.049256</td>
<td>-0.06516</td>
<td>0.014095</td>
<td>-0.17387</td>
<td>4.868073</td>
<td>135.0981</td>
</tr>
<tr>
<td></td>
<td>$R_f$</td>
<td>-0.00042</td>
<td>0.055972</td>
<td>-0.07381</td>
<td>0.014407</td>
<td>-0.1032</td>
<td>5.712327</td>
<td>276.8534</td>
</tr>
<tr>
<td>H-shares index futures</td>
<td>$R_s$</td>
<td>-0.000166</td>
<td>0.078161</td>
<td>-0.065196</td>
<td>0.015551</td>
<td>0.060165</td>
<td>4.895751</td>
<td>135.0125</td>
</tr>
<tr>
<td></td>
<td>$R_f$</td>
<td>-0.000165</td>
<td>0.066803</td>
<td>-0.064206</td>
<td>0.015917</td>
<td>0.053236</td>
<td>4.041905</td>
<td>41.04241</td>
</tr>
<tr>
<td>MSCI China A index</td>
<td>$R_s$</td>
<td>-0.000377</td>
<td>0.048490</td>
<td>-0.064489</td>
<td>0.014076</td>
<td>-0.234146</td>
<td>4.608230</td>
<td>104.9800</td>
</tr>
</tbody>
</table>

*Note.* Spot prices and Futures prices are the logged prices. Daily logarithmic returns for spot and futures assets are used.

As seen from the table, the mean and standard deviation of returns of spot and futures are very close (CSI 300 index futures and H-shares index futures). All the means are negative, indicating that within the period of investigation, both the futures prices and the spot prices showed a downward trend.

For the standard deviation of the futures price returns, it is relatively larger than the spot price returns. This situation is mainly because the transaction cost is comparatively lower in futures market and the reaction of information is sensitive. The fluctuation interval of CSI 300 index is from -0.06516 to 0.049256, while the range of CSI 300 index futures is from -0.07381 to 0.055972. The volatility in futures market is reasonably large.

To test the data series for Skewness and Kurtosis, a measure of the weight in the tails of a probability density function can be conducted.

The skewnesses of the return series in CSI 300 index, CSI 300 index futures and MSCI China A index are generally negative, which means that the longer tail was to the left. The skewnesses of the return series in HSCEI and H-shares index futures are positive, which indicates the longer tail was to the right.

Excess kurtosis (i.e. measured kurtosis - 346) of all the return series is relatively large and always positive, which implies fatter tails. These two measures provide evidence...

---

46 3 is the normal distribution.
that the all the return series are not normally distributed and have an obvious peak and fat tails.
In addition, J-B statistic test are further proved that all the return series do not comply with the normal distribution. Figures in the Appendix E show the histograms.
We can get the daily return fluctuation as shown in Figure 5.4, where the daily returns of the index spot and index futures have a characteristic of volatility clustering. And the futures prices is more volatile than the spot prices, which indicates the existence of an arbitrage possibility.

Figure 5.4 Line Graph of daily returns on CSI 300 index and CSI 300 index futures

5.2.2 Stationary test
Since, in most cases, the economic indicator series are non-stationary series. For the estimation of optimal hedge ratio, using non-stationary data may lead to spurious regressions and invalid conclusions (Cotter and Hanly, 2006).
In order to prevent false regression problems, it is desirable that the series involved are stationary. Stationary means that the series will remain stable at different time points, i.e., the mean and the covariance of a series are time-independent. To test for stationarity, ADF unit root test\(^\text{47}\) is carried on each of the sample series. The results of the series \(R_s\), \(R_f\) are given in Table 5.3.

\(^{47}\)Augmented Dickey-Fuller (ADF) test is adopted.
Table 5.3 ADF test

<table>
<thead>
<tr>
<th>Null Hypothesis: $R_s$ has a unit root</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-30.29874</td>
<td>0</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.437418</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.864549</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.568426</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Null Hypothesis: $R_f$ has a unit root</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-30.95061</td>
<td>0</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.437418</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.864549</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.568426</td>
<td></td>
</tr>
</tbody>
</table>


From the Table 5.3, it can be seen that the t-statistics of ADF test of $R_s$ and $R_f$ are smaller than the critical values at 1% level, 5% level and 10% level. The two series in the 1% significance level mean we can have at least about 99% confidence level to reject the null hypothesis. So, the time series data do not have a unit root. In other words, the series of daily returns shows that both of them are stable.

Application of the ADF test on the daily returns series of CSI 300 index and CSI 300 index futures indicates that both series are stationary at levels.

Then, similar tests can easily be applied on HSCEI, H-shares index futures and MSCI China A index, the results shows that all three return series are stationary at levels

5.2.3 Cointegration test

Cointegration allows us to draw the reposeful relation between two or multiple series (Gao, 2009). Sometimes, the time series are not stable themselves. But the linear combination between different time series can be stationary.

The prerequisite for establishing hedge models is the existence of a long-term equilibrium relationship between the variables. Therefore, it is necessary to run the cointegration test of the variables. Johansen (1988) cointegration test are used here to examine the spot and futures prices series.

\[^{48}\text{Results are given in Appendix F.}\]
Table 5.4 Johansen Cointegration Tests

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r \leq 0^* )</td>
<td>0.035494</td>
<td>35.82759</td>
<td>15.49471</td>
<td>0</td>
</tr>
<tr>
<td>( r \leq 1 )</td>
<td>0.003929</td>
<td>3.519401</td>
<td>3.841466</td>
<td>0.0606</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r \leq 0^* )</td>
<td>0.035494</td>
<td>32.30819</td>
<td>14.2646</td>
<td>0</td>
</tr>
<tr>
<td>( r \leq 1 )</td>
<td>0.003929</td>
<td>3.519401</td>
<td>3.841466</td>
<td>0.0606</td>
</tr>
</tbody>
</table>

Note. Trace test indicates 1 co-integrating equation at the 0.05 level. Max-eigenvalue test indicates 1 co-integrating equation at the 0.05 level. *Denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values.

Table 5.4 shows that both the trace statistics test and the maximum eigenvalue statistics test reject the hypothesis of no-cointegration. The results suggest the presence of one cointegrating vector between the spot and futures market prices at 5% level respectively.

The Johansen test provides evidence that cash prices and futures prices series are cointegrated for each case. The result implies that there is a well-defined long-run relationship between the spot and futures prices.

**Reasons for co-integration relationship**

Why CSI 300 index and CSI 300 index futures have such a co-integration relationship? One of main reasons is that CSI 300 index is designed as the underlying asset of the stock index futures contracts. Therefore, the two subjects cannot be completely divorced from each other. Although they may deviate from each other temporally, caused by some economic factors, but the deviation will eventually disappear and their prices trend will be the same.

So due to the existence of arbitrage, the index price will tend to perform in line with the futures price eventually. If there exists irrational basis, then arbitrageurs can gain the return of price spread through operating in a reverse direction in the two markets. Similarly, either the index prices or the futures prices have the abnormal fluctuations, speculators can benefit through related operations. The basic reason is that no matter
how the speculative action and arbitrage are conducted in the market, the supply and demand can tend towards equilibrium, and the unreasonable price spread or basis will tend to be reasonable until the market is unprofitable.

So it can be inferred that the futures price can be regarded as the spot price at a particular moment in the future. With the approaching of the settlement date, the position-holding cost of stock index futures will be gradually reduced and the price spread between the cash and futures is getting narrow.

5.2.4 Summary
This section is mainly to prepare for the hedging model analysis. Based on above arguments, the following conclusions can be obtained:
1) According to the statistical analysis, the CSI 300 index and the CSI 300 index futures return series show the characteristics of non-normality, fat tail and volatility clustering.
2) Based on the ADF test, it indicates that the return series of CSI 300 index futures and spot are stationary time series. These results suggest that regressions can be applied on the returns series.
3) The results of the co-integration analysis showed that there exists co-integration relation between CSI 300 index futures price and CSI 300 index prices. Such a co-integration correlation between the stock market and the futures market has laid the foundation for the realization of hedging function. So we expect the CSI300 index futures to be an effective tool to hedge risk in spot market in China.

5.3 Hedging Model Analysis
From the previous analysis, the CSI 300 index prices and CSI 300 index futures prices have a strong correlation and exist a long-run equilibrium relationship. These features provide the favored conditions for hedging by CSI 300 index futures.

In this section, the hedging effectiveness of CSI 300 index futures will be further analyzed on the basis of the previous conclusions. Based on the universality and continuity of data analysis, we assume that investors invest in the constituent stock of the CSI 300 index and the ratios of stock share holdings are same as the weights of the constituent stocks in the CSI 300 index (the same assumptions of investing in H-shares index futures and MSCI China A index). Here, different econometric models are adopted to calculate the hedge ratios and hedging effectiveness. And the results
obtained from CSI 300 index futures, H-shares index futures and the selective benchmark MSCI China A index will be compared.

### 5.3.1 OLS Model

First, EViews 5.1 is used to draw the scatter diagrams of returns series. As shown in Figure 5.5, the logged price change of CSI 300 index has a strong linear relation with the logged price change of CSI 300 index futures.

According to Equation 4.6 given in Chapter 4, the model can be built as follows:

\[
R_s = \beta_0 + \beta_1 R_F + \xi_t
\]  

(5.3)

where \( R_s \) and \( R_F \) are the log-returns of the spot and futures; \( \beta_0 \) is the intercept term of the regression function; \( \beta_1 \) is the slope of the regression function, which is the minimum variance hedge ratio \( h \); \( \xi_t \) is the residual term.

OLS Regression is conducted in EViews 5.1, and the results are given as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-Statistic</th>
<th>Prob.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.10831</td>
<td>0.9138</td>
<td>Non-Significant</td>
</tr>
<tr>
<td>( R_F )</td>
<td>96.4907</td>
<td>0.0000</td>
<td>Significant</td>
</tr>
</tbody>
</table>

From Table 5.5, it is known that the constant term C, its Prob. equals to 0.9138, which is not significant at the 5% level, so the constant term can be deleted from the regression equation. The results of this new OLS regression can be obtained and shown as Table 5.6:
Table 5.6 Results on OLS Regression without constant term

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF</td>
<td>0.934463</td>
<td>0.009675</td>
<td>96.58787</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

The new regression equation is written as:

\[ R_s = 0.934463R_f + \xi_t \]  

(5.4)

where, \( \xi_t \) is the residual term.

Here the coefficient of \( R_f \) is the estimated hedge ratio, which \( h=0.934463 \).

The same procedure may be easily adapted to obtain OLS model for H-shares index futures:

\[ R_s = 0.919544R_f + \xi_t \]  

(5.5)

The estimated hedge ratio \( h=0.919544 \).

For MSCI China A index, its hedge ratio is 0.922966. The regression output for all regressions can be found in Appendix G.

As indicated above, from all the three results, the hedge ratio \( h \) is higher than 0.9. Thus, it can be concluded that the hedge ratios estimated from OLS method provide approximately 90% variance reduction for the contracts of CSI 300 index futures and H-shares index futures, which indicates that the hedge provided by these contracts in futures markets are effective.

5.3.1.1 Discussion on the results

1) Significance of regression coefficients

It can be seen from Table 5.6, t-Statistic of \( R_f \) is 96.58787 with the Prob.=0.0000, which shows the regression coefficient is significant at the 5% level.

2) Fitting degree

The determination coefficient \( R^2 = 0.912211 \), it indicates a good fitting degree of the equation, which means the returns of CSI 300 index futures and CSI 300 index are highly relevant.

3) Durbin-Watson

The D.W. statistic of the regression equation is 2.74226. It deviated from the standard (D.W.=2), which implies the autocorrelation existing in the random error series. Also it can be seen from Figure 5.6, for certain time periods, the fluctuation of the residual term is small, at other times, its volatility is high, which indicates the residual may exist conditional heteroscedasticity. The Appendix G shows a summary of these tests.
5.3.1.2 Test OLS residual

Then, the test of the heteroscedasticity is required on the random error sequence of the linear regression. If the serial data of the random errors have obvious heteroscedasticity phenomena, then the GARCH model should be used to calculate the hedge ratio.

The results of ARCH LM test are shown as below:

Table 5.7 results on Residual test

<table>
<thead>
<tr>
<th>ARCH Test</th>
<th></th>
<th>Prob. F(1,895)</th>
<th>0.0000</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
<td>30.48008</td>
<td>Prob. Chi-Square(1)</td>
<td>0.0000</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>29.5421</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Table shows that F-statistic=30.48008, Probability=0.0000, which means the F-statistic reject the null hypothesis; LM statistics Obs*R-squared=29.5421, the distribution probability of $\chi^2$ is 0, clearly less than the 5% significance level. All of these indicate that there exists the ARCH effect in the random error sequence of the regression equation.

The results of OLS model imply that there are auto-correlations and ARCH effect of the random error sequence, which would affect the validity of OLS model. Therefore, the GARCH model is introduced to estimate the hedging ratio.

5.3.2 GARCH Model

According to the equations in Chapter 4, the results are given as follow by using EViews 5.1:
Table 5.8 Results on GARCH(1,1) Regression

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>2.01E-05</td>
<td>0.000119</td>
<td>0.169236</td>
<td>0.8656</td>
</tr>
<tr>
<td>RF</td>
<td>0.953208</td>
<td>0.008036</td>
<td>118.6189</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

In which, the z-Statistic of the constant term C is 0.169236, Prob.=0.8656. It is found to be insignificant at the 5% level, which cannot explain the regression equation well. It was therefore excluded from the final estimations.

Then the model is written as: \( R_s = \beta R_F + \xi_t \).

Based on the new model, the new results on GARCH(1,1) regression is shown in table below:

Table 5.9 Results on GARCH(1,1) Regression (without constant term)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF</td>
<td>0.953181</td>
<td>0.008039</td>
<td>118.5769</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>1.81E-06</td>
<td>6.36E-07</td>
<td>2.840641</td>
<td>0.0045</td>
</tr>
<tr>
<td>RESID(-1)^2</td>
<td>0.113521</td>
<td>0.027379</td>
<td>4.146245</td>
<td>0</td>
</tr>
<tr>
<td>GARCH(-1)</td>
<td>0.782801</td>
<td>0.054495</td>
<td>14.36471</td>
<td>0</td>
</tr>
</tbody>
</table>

The GARCH(1,1) model is written as:

\[
R_s = 0.953181 R_F + \xi_t
\] (5.6)

\[
\sigma_t^2 = 1.81 \times 10^{-6} + 0.113521 \sigma_{t-1}^2 + 0.782801 \sigma_{t-1}^2
\] (5.7)

where the coefficient of \( R_F \) is the estimated hedge ratio of CSI 300 index futures, that \( h=0.953181 \).

The model of H-shares futures is:

\( R_s = 0.930577 R_F \)

Its hedge ratio \( h \) is 0.930577.

When using MSCI China A index as benchmark, its hedge ratio \( h \) is 0.943561. Tables in Appendix H show the results for all the regressions.

5.3.2.1 **Discussion on the results**

1) Significance of regression coefficients

It can be seen from above table, the probability of z-Statistic is 0, which means the regression coefficient of \( R_F \) is significant at the 5% level.

\[\text{footnote}{49}\] Results are shown in Appendix H.
2) Fitting degree

From the results on GARCH regression, the $R^2$ is 0.911845, which implies a good fitting degree of the model, the returns between the spot index and index futures have a high relevance. Also it shows the close relationship between the stock market and the stock index futures market.

3) Durbin-Watson

The D.W. statistic in the regression results is 2.760423, which indicates it has autocorrelation (by comparing with the standard).

5.3.2.2 Test GARCH residual

Table 5.10 Results on ARCH Test

<table>
<thead>
<tr>
<th>ARCH Test:</th>
<th>F-statistic</th>
<th>Prob. F(1,895)</th>
<th>Obs*R-squared</th>
<th>Prob. Chi-Square(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.130382</td>
<td>0.077186</td>
<td>3.126443</td>
<td>0.077032</td>
</tr>
</tbody>
</table>

Looking at the Table 5.10, the distribution probability of $\chi^2$ is 0.077032, higher than the 5% significance level. So, there is no ARCH effect in the random error sequence.

Based on the above results, the GARCH(1,1) model can better capture the serial correlation of the random error and heteroscedasticity in the regression equation.

5.4 Hedging effectiveness analysis

Through the establishment of different models, it has derived the different optimal hedge ratios. In order to test the hedging effectiveness by using the obtained ratios, this section will estimate the performance and make a comparative analysis. In Chapter 4, it has introduced how to estimate the hedging effectiveness. To calculate with the formula, it is required to know the following data: the variance of the returns of spot prices, the variance of the returns of futures prices, the covariance of both returns, and the hedge ratio.

Table 5.11 Covariance Matrix

<table>
<thead>
<tr>
<th>CSI 300 index &amp; CSI 300 index futures</th>
<th>$R_S$</th>
<th>$R_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_S$</td>
<td>0.000198</td>
<td>0.000194</td>
</tr>
<tr>
<td>$R_F$</td>
<td>0.000194</td>
<td>0.000207</td>
</tr>
</tbody>
</table>
As the table shows, the variances of CSI 300 index and its futures can be obtained: 
\[ \text{Var}(R_U) = 0.000198, \text{Var}(R_H) = 0.000207, \text{Cov}(R_S, R_F) = 0.000194. \]

According to the Equation of \( h_e \), the results appear by computation as shown below:

Table 5.12 Results on hedging effectiveness

<table>
<thead>
<tr>
<th>Criteria</th>
<th>OLS</th>
<th>GARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSI 300 index futures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( h )</td>
<td>0.934463</td>
<td>0.953181</td>
</tr>
<tr>
<td>( \text{Var}(R_U) )</td>
<td>0.000198</td>
<td>0.000198</td>
</tr>
<tr>
<td>( \text{Var}(R_H) )</td>
<td>1.61851E-05</td>
<td>1.62365E-05</td>
</tr>
<tr>
<td>( h_e )</td>
<td>0.918256953</td>
<td>0.917997708</td>
</tr>
<tr>
<td>H-shares(^{50})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( h )</td>
<td>0.919544</td>
<td>0.930577</td>
</tr>
<tr>
<td>( h_e )</td>
<td>0.886601542</td>
<td>0.886696399</td>
</tr>
<tr>
<td>MSCI China A index(^{51})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( h )</td>
<td>0.922966</td>
<td>0.943561</td>
</tr>
<tr>
<td>( h_e )</td>
<td>0.890084348</td>
<td>0.889629689</td>
</tr>
</tbody>
</table>

As seen in the above table, compared to the variance of returns in an unhedged position, the results in a hedged position have drastically reduced by using CSI 300 index futures. Both models can decrease the systematic risk efficiently. It also reveals that the optimal hedge ratios estimated from GARCH model are slightly larger than those estimated from OLS model for both index futures markets. The dynamic hedge ratio \( h=953181 \) based on GARCH model is better than the static hedge ratio \( h=0.934463 \) based on OLS model.

From the view of the effect of risk aversion, CSI 300 index futures indicates higher hedging effectiveness. It is shown that the hedging effectiveness of CSI 300 index futures (0.917997708) was higher than that of H-shares index futures (0.886696399). It is also shown that CSI 300 index futures provides more effective hedge for the two hedge ratio estimation models compared to H-shares index futures.

The results also indicate that OLS model performs more effectively in Chinese index futures market. But one of the basic assumptions of OLS model is that the financial time series have the same variance. However, GARCH model dose not have such

\(^{50}\) The results are provided in Appendix I.  
\(^{51}\) The results are provided in Appendix I.
assumptions. It can be applied to the case that financial time series have heteroscedasticity. Theoretically, GARCH model has a strong applicability of related analysis in the financial markets and using this model to estimate the hedge ratio is better.

In general, the hedging effectiveness for index futures using different models is above 90%, which indicates that the index futures can help investors to hedge risk in spot market to a large extent. In this case, CSI 300 index futures contracts can be suggested as effective tool for hedging risk.
6 Conclusion and perspective

The purpose of this study is to explore the impact of the introduction of stock index futures on Chinese stock market, and empirically test the CSI 300 index futures.

6.1 Conclusion

At the beginning of this study, it outlines the basic theory of stock index futures and hedging, and briefly describes the development of Chinese stock index futures market. From the perspective of the development, CSI 300 index future has maintained a steady growth during its initial of operation in China. Then, by selecting the transaction data in the market, processing and analyzing them empirically, the correlation between CSI 300 index futures and spot index has been verified. Two tests, i.e. the stationarity test and cointegration test, have been mainly adopted during the verification. Thereafter, the two commonly used models (OLS and GARCH) are introduced to estimate the optimal hedge ratio, and the hedging effectiveness of CSI 300 index futures are analyzed and evaluated at the same time. Taken together, the following conclusions have been made:

1) Results from the stationarity test and the cointegration test

The logarithm price series of CSI 300 spot and futures are stationary at the first order difference, which means both returns series are stationary time series. Then, this paper confirms the existence of a long-term equilibrium relationship between the CSI 300 index and index futures through the co-integration test. This conclusion demonstrates the existence of co-movement between the stock market and the stock index futures market. For the further explanation, it is that the prices in two markets influence each other and the fluctuant prices will show a convergence trend eventually. This long-term equilibrium relationship provides a prerequisite for hedging.

Meanwhile, the stock index futures prices have been more volatile than the spot prices. Consequently, there exists arbitrage space in the market price, which indicates the risk-averse ability of stock index futures need to be further strengthened.

2) Hedge ratio and Hedging effectiveness

In order to evaluate the efficiency of hedge, the determination of the optimal hedge ratio is firstly required, and OLS method and GARCH(1,1) model are both adopted. Through the calculation by EViews, the estimated hedge ratio based on GARCH model is 0.953181, which is slightly higher than 0.934463 obtained from OLS model.
Both ratios are close to perfect hedge \( (h = 1) \). The hedging effectiveness of the two models is around 0.92, which indicates the CSI 300 index futures can hedge 92% risk of the spot. The results in this study show that the error term of OLS is auto-correlated and has ARCH effect. So OLS model cannot accurately analyze the hedge effect of CSI 300 index futures, but GARCH(1,1) model can overcome the limitations of the traditional method of OLS. GARCH model can provide a more accurate analysis of the hedge effect of stock index futures, where the hedge ratio is 0.953181 and the hedging effectiveness is 0.917998. Through the comparison analysis between CSI 300 index futures and H-shares index futures, CSI 300 index futures is more efficient than H-shares index futures. And CSI 300 index is more correlated with CSI 300 index futures than MSCI China A index. To choose the benchmark as indicating hedging effect, the stock portfolio should be better built to effectively track the CSI 300 index trend.

In conclusion, the evaluation results support the view that the CSI 300 index futures provides investors with better risk-management tool. CSI 300 index futures have a great hedge effect. Hedge by using CSI 300 index futures can effectively reduce risks and ensure the stability of returns. However, when choosing a specific hedging model, it takes into account the characteristics of the underlying asset and the investors’ risk tolerance, thus it is able to get the most satisfactory hedge effect.

6.2 Suggestions for investors

Based on the above analysis and discussion in this thesis, some suggestions can be given to investors:

1) Selection of the hedged underlying

When investors chose the hedged underlying, the stock portfolio should be highly correlated with the futures’ underlying, and the holding period of futures contracts needs to correspond to the same period of risk-taking in the stock market. Only high correlation between the spot asset and the CSI 300 index futures can ensure a great hedge effect. Although the basis will tend to be 0 as the settlement date approaches, if the hedging period is inconsistent with the delivery day, the basis risk still appears. Therefore, investors should make the hedging period remain the same or close to the futures contract maturity date.

2) Selection of the hedging model
The selection of model for estimating hedge ratio has been already analyzed. In practice, investors should note that they could accurately estimate the optimal hedge ratio by choosing a different model depending on the market conditions and their investment preferences. In this paper, in order to choose the model, it is assumed the investor is risk averse and wants to achieve risk minimization. If the investors who favor risks, the conclusions through empirical analysis of this study are not applied to them. Those investors should use other premise, such as expected utility maximization.

In general, if the market is volatile, for long-term hedging operations, it is suggested to use GARCH model or OLS model to estimate the optimal hedge ratio. Although OLS model has the stringent assumptions, it is still very widely applied in practice. For long-term hedge, investors also need to timely adjust the hedge ratio and the positions structure of the portfolio according to the change of market conditions, in order to improve the efficiency of hedging and reduce the risk of portfolios.

6.3 Limitations and future work

In this paper, during the analysis of hedging effectiveness of CSI 300 index futures, there are still several shortages, which need to be further improved and perfected.

1) The scope of the study

Since the introduction time of CSI 300 index futures is short, there is a limited amount of collected data. In the empirical analysis of this study, it has drawbacks of insufficient sample data and short time period, so the conclusions may not be generally applicable. In the actual situation, the market is closed on holidays. So the data is non-continuous, which makes the advantages of GARCH model cannot be fully achieved. Also, size of the sample will affect the accuracy of the empirical results.

The stock market is constantly changing. The daily frequency data can better characterize the trading behavior of investors and the trading changes. For further work, based on the research of daily closing prices of stock index futures, it should more carefully study the data change trends per hour or per minute intraday, estimate the hedge effect in a short time, and draw the appropriate conclusions.

This paper studies the hedging effects of CSI 300 index futures, mainly from the view on macroscopic. It did not give specific investment programs for particular investors. They can replicate the movement of CSI 300 index through invest in stock portfolio
and use the hedge ratio obtained from this paper, to achieve an effective risk management.

2) The determination of hedging models

In the aspect of model determination, it did not take into account the transaction costs, the market impact costs and the opportunity costs, which can affect the hedge ratios. The hedging performance is sure to be affected accordingly. In this study, it is based on ideal conditions, which has the prerequisite of sufficient capital, no time and money consuming of adjusting positions. While in the real investment, it needs to consider the increased cost caused by adjustment positions, time consuming and many other factors, which can further impact the hedging model choice of investors. To improve the model, the cost factor should be considered as a variable in it. In addition, different investors have different risk preferences. It should carefully consider the hedgers’ expected returns and risk preferences, and set the related risk preference coefficient, which makes the model can reflect risk tolerance of different investors.

3) Margin management

During the process of hedging, investors also need to concern the risks of the variation margin and mark-to-market. Due to the implementation of the margin and the daily settlement system in stock index futures trading, once an unfavorable change happened in the futures market, its equity may fall below the minimum margin maintenance and the investor will receive a margin call. If investors cannot be able to make up the margin, the Exchange will execute mandatory liquidation for under-margin positions. Accordingly, investors should fully estimate the number of margin and prepare money for a rainy day.
Reference

Book
Tiemei, Gao (2009), *Econometrics analysis and modeling: application and example in Eviews*. Tsinghua University press.

Journal


Appendix

A. Pricing CSI 300 index

The formula is:

\[
\text{Adjusted market value} = \sum (\text{Price} \times \text{Adjusted No. of shares})
\]

To reflect the price fluctuation of the real negotiable shares in the market, CSI indices adopts free float shares to calculate index exclusive of non-negotiated shares\(^{52}\) such as strategic holdings, government holdings, etc. CSI 300 uses category-weighted method to adjust constituents’ shares. CSI will grant certain inclusion factor to the total A shares according to the percentage of free float shares in total A shares, which aims to insure index stability.

\[
\text{Negotiable Market Cap Ratio} = \frac{\text{Free Float}}{\text{Total A Shares}}
\]

\[
\text{Adjusted Shares} = \text{Total A Shares} \times \text{Inclusion Factor}
\]

Category-weighted Method of CSI 300 is indicated by the following table:

<table>
<thead>
<tr>
<th>Negotiable Market Cap Ratio (%)</th>
<th>≤ 10</th>
<th>(10,20]</th>
<th>(20,30]</th>
<th>(30,40]</th>
<th>(40,50]</th>
<th>(50,60]</th>
<th>(60,70]</th>
<th>(70,80]</th>
<th>≥ 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion Factor (%)</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

For example, a stock with a negotiable market share ratio of 7%, which is below 10%, will have an inclusion factor equals to its negotiable market capitalization ratio. A stock with a negotiable market share ratio of 45% will belong to category (40,50]. The corresponding inclusion factor is 50%, i.e. 50% of total market share, will be used for index calculation.

B. Table. Top 10 constituents in CSI 300 index (at the end of 2013)

<table>
<thead>
<tr>
<th>Constituent code</th>
<th>Constituent Name</th>
<th>Weight</th>
<th>Industry</th>
<th>Constituents in HSCEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>601318</td>
<td>Ping An Insurance (Group) Company of China Ltd</td>
<td>3.85%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
<tr>
<td>600036</td>
<td>China Merchants Bank Co Ltd</td>
<td>3.46%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
<tr>
<td>600016</td>
<td>China Minsheng Banking Corp Ltd</td>
<td>3.36%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
</tbody>
</table>

\(^{52}\) Non-negotiated shares: Long term holdings by founders, families and senior executives; Government holdings; Strategic holdings: shares held by strategic investors for long-term strategic interests in lock-in period; Frozen shares; Restricted employee shares; Cross holdings
<table>
<thead>
<tr>
<th>Stock No.</th>
<th>Company Name</th>
<th>Return (%)</th>
<th>Industry</th>
<th>Risk-Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>601166</td>
<td>Industrial Bank</td>
<td>2.23%</td>
<td>Financials</td>
<td>No</td>
</tr>
<tr>
<td>600000</td>
<td>Shanghai Pudong Development Bank Co Ltd</td>
<td>2.03%</td>
<td>Financials</td>
<td>No</td>
</tr>
<tr>
<td>600837</td>
<td>Haitong Securities Company Limited</td>
<td>1.76%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
<tr>
<td>600030</td>
<td>CITIC Securities Co Ltd</td>
<td>1.69%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
<tr>
<td>000651</td>
<td>Gree Electric Appliances Inc of Zhuahai</td>
<td>1.51%</td>
<td>Consumer</td>
<td>No</td>
</tr>
<tr>
<td>000002</td>
<td>China Vanke Co Ltd</td>
<td>1.50%</td>
<td>Financials</td>
<td>No</td>
</tr>
<tr>
<td>601288</td>
<td>Agricultural Bank of China Co Ltd</td>
<td>1.24%</td>
<td>Financials</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: data obtained from the annual report of CSI 300 in year 2013 & Hang Seng Indexes 

C. Utility Maximizing Hedging Model

If we assume the wealth of the investor at time $t_0$ is $W_0$, $\Delta S$ and $\Delta F$ are the returns of spot and futures from time period $t_0$ to $t_1$, $h^*$ is the hedge ratio, then the wealthy of investor at time $t_1$ is $W_1$, i.e.

$$W_1 = W_0(1 + \Delta S - h\Delta F) \quad (5.8)$$

If we assume the expected utility function as $U(W)$, the investor maximizes the following expected utility function, which specifies the trade-off between expected wealth and the volatility of the wealth,

$$\max E[U(W_1)] = \max E\left[U\left(W_0(1 + \Delta S - h\Delta F)\right)\right] \quad (5.9)$$

where $\Delta S$ and $\Delta F$ are normally distributed, optimizing the Equation $\max E[U(W_t)]$ with respect to $h$ yields the following utility maximizing hedge ratio:

$$h^* = \frac{\text{Cov}(\Delta S, \Delta F)}{\text{Var}(\Delta F)} + \frac{E\left[U\left(W_0(1 + \Delta S - h\Delta F)\right)\right]}{E\left[U\left(W_0(1 + \Delta S - h\Delta F)\right)\right]} E(\Delta F) \quad (5.10)$$

where the first component in Equation $h^*$, $\frac{\text{Cov}(\Delta S, \Delta F)}{\text{Var}(\Delta F)}$, represents the minimum variance hedge ratio (MVHR) based on the risk minimizing. When $E(\Delta F) = 0$, the utility maximizing hedge ratio equals the risk-minimizing hedge ratio, that is, the hedge ratio generates the minimum portfolio variance and also the hedge ratio maximize the investors’ utility. However, in most situations, $E(\Delta F) \neq 0$, due to the basis risk, there is a speculative motivation to trade (Lien and Tse, 2002). Some speculators may use basis to increase their utilities. Thus, the Equation $h^*$ can be
distinguished as two components: the first part is the MVHR, whereas the second one represents the speculative component.

D. Per Unit Risk Compensation Maximization Model

In the investment portfolio, it includes spot asset, futures asset and risk-free asset. We assume the risk-free return rate is $r_f$, $R_i$ represents the yield of portfolio $i$, $\sigma_i$ is the standard deviation of $R_i$, in order to obtain the risk compensation per unit maximization, it must make $\max \frac{E(R_i) - r_f}{\sigma_i}$ true. To get the optimal hedge ratio:

$$h = \frac{\left[ E(R_f) - r_f \right] \sigma_s^2 - \rho \sigma_s \sigma_f \left[ E(R_i) - r_f \right]}{\left[ E(R_f) - r_f \right] \sigma_f^2 - \rho \sigma_s \sigma_f \left[ E(R_i) - r_f \right]} = \frac{\lambda - \rho}{(1 - \lambda \rho) \pi}$$ (5.11)

where, $\lambda = \frac{\left[ E(R_f) - r_f \right] \sigma_f}{\left[ E(R_i) - r_f \right] \sigma_s} \pi = \frac{\sigma_f}{\sigma_s}$.

E. Descriptive statistics (histogram statistics) on return serials

- CSI 300 index & CSI 300 index futures

- HSCEI & H-shares index futures
- **MSCI China A index**

F. ADF test results

- **HSCEI**

  Null Hypothesis: HKRS has a unit root  
  Exogenous: Constant  
  Lag Length: 0 (Automatic based on SIC, MAXLAG=20)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-29.99425</td>
</tr>
</tbody>
</table>

Test critical values:  
1% level: -3.437418  
5% level: -2.864549  
10% level: -2.568426

- **H-shares index futures**

  Null Hypothesis: HKRF has a unit root  
  Exogenous: Constant  
  Lag Length: 0 (Automatic based on SIC, MAXLAG=20)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-30.32618</td>
</tr>
</tbody>
</table>

Test critical values:  
1% level: -3.437418  
5% level: -2.864549  
10% level: -2.568426

- **MSCI China A index**

  Null Hypothesis: MSCIRS has a unit root  
  Exogenous: Constant  
  Lag Length: 0 (Automatic based on SIC, MAXLAG=20)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Test critical values:  
1% level: -3.437418  
5% level: -2.864549  
10% level: -2.568426
G. Results for OLS regression

- CSI 300 index & CSI 300 index futures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURNF</td>
<td>0.934463</td>
<td>0.009675</td>
<td>96.58787</td>
<td>0</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.912211</td>
<td>Mean dependent var</td>
<td>-0.000406</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.912211</td>
<td>S.D. dependent var</td>
<td>0.014095</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.004176</td>
<td>Akaike info criterion</td>
<td>-8.117675</td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.015645</td>
<td>Schwarz criterion</td>
<td>-8.112329</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>3645.836</td>
<td>Durbin-Watson stat</td>
<td>2.74226</td>
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</tr>
</tbody>
</table>

- HSCEI & H-shares index futures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKRF</td>
<td>0.919544</td>
<td>0.011023</td>
<td>83.41929</td>
<td>0</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.885803</td>
<td>Mean dependent var</td>
<td>-0.000166</td>
<td></td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.885803</td>
<td>S.D. dependent var</td>
<td>0.015551</td>
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</tr>
<tr>
<td>S.E. of regression</td>
<td>0.005255</td>
<td>Akaike info criterion</td>
<td>-7.658096</td>
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<tr>
<td>Sum squared resid</td>
<td>0.024772</td>
<td>Schwarz criterion</td>
<td>-7.65275</td>
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<tr>
<td>Log likelihood</td>
<td>3439.485</td>
<td>Durbin-Watson stat</td>
<td>2.960006</td>
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</table>

- MSCI China A index & CSI 300 index futures

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURNF</td>
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<td>0.010692</td>
<td>86.3256</td>
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<tr>
<td>R-squared</td>
<td>0.892486</td>
<td>Mean dependent var</td>
<td>-0.000377</td>
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</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.892486</td>
<td>S.D. dependent var</td>
<td>0.014076</td>
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<tr>
<td>S.E. of regression</td>
<td>0.004615</td>
<td>Akaike info criterion</td>
<td>-7.917779</td>
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</tr>
<tr>
<td>Sum squared resid</td>
<td>0.015645</td>
<td>Schwarz criterion</td>
<td>-7.912433</td>
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<tr>
<td>Log likelihood</td>
<td>3556.083</td>
<td>Durbin-Watson stat</td>
<td>2.538252</td>
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</tbody>
</table>
H. Results on GARCH regression

- CSI 300 index & CSI 300 index futures

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURNF</td>
<td>0.953181</td>
<td>0.008039</td>
<td>118.5769</td>
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</table>

Variance Equation

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.81E-06</td>
<td>6.36E-07</td>
<td>2.840641</td>
</tr>
<tr>
<td>RESID(-1)^2</td>
<td>0.113521</td>
<td>0.027379</td>
<td>4.146245</td>
</tr>
<tr>
<td>GARCH(-1)</td>
<td>0.782801</td>
<td>0.054495</td>
<td>14.36471</td>
</tr>
</tbody>
</table>

- HSCEI & H-shares index futures

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKRF</td>
<td>0.930577</td>
<td>0.007325</td>
<td>127.0326</td>
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</table>

Variance Equation

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3.87E-07</td>
<td>1.13E-07</td>
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<tr>
<td>RESID(-1)^2</td>
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<tr>
<td>GARCH(-1)</td>
<td>0.857277</td>
<td>0.019724</td>
<td>43.46261</td>
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<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKRF</td>
<td>0.885676</td>
<td>Mean dependent var</td>
<td>-0.000166</td>
</tr>
<tr>
<td>GARCH(-1)</td>
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<td>S.D. dependent var</td>
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</tr>
<tr>
<td>S.E. of regression</td>
<td>0.005267</td>
<td>Akaike info criterion</td>
<td>-8.084297</td>
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</tbody>
</table>
### Calculated results for hedging effectiveness

#### HSCEI & H-shares index futures

<table>
<thead>
<tr>
<th></th>
<th>HR$_S$</th>
<th>HR$_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR$_S$</td>
<td>0.000242</td>
<td>0.000233</td>
</tr>
<tr>
<td>HR$_F$</td>
<td>0.000233</td>
<td>0.000253</td>
</tr>
<tr>
<td>Var(U)</td>
<td>OLS</td>
<td>GARCH</td>
</tr>
<tr>
<td>Var(H)</td>
<td>0.000242</td>
<td>0.000242</td>
</tr>
</tbody>
</table>

#### MSCI China A index & CSI 300 index futures

<table>
<thead>
<tr>
<th></th>
<th>MSCIR$_S$</th>
<th>R$_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCIR$_S$</td>
<td>0.00198</td>
<td>0.000191</td>
</tr>
<tr>
<td>R$_F$</td>
<td>0.000191</td>
<td>0.000207</td>
</tr>
<tr>
<td>Var(U)</td>
<td>OLS</td>
<td>GARCH</td>
</tr>
<tr>
<td>Var(H)</td>
<td>2.17633E-05</td>
<td>2.18533E-05</td>
</tr>
</tbody>
</table>

### Other Calculations
- **Sum squared resid**: 0.0248
- **Schwarz criterion**: -8.062915
- **Log likelihood**: 3633.849
- **Durbin-Watson stat**: 2.972524

**Dependent Variable**: MSCIRS

**Method**: ML - ARCH (Marquardt) - Normal distribution

**Date**: 05/12/14  **Time**: 21:39

**Sample (adjusted)**: 1 898

**Included observations**: 898 after adjustments

**Convergence achieved** after 12 iterations

**Variance backcast**: ON

**GARCH** = C(2) + C(3)*RESID(-1)$^2$ + C(4)*GARCH(-1)