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An Empirical Study of Pricing Efficiency and Arbitrage Opportunity in Hong Kong HSI Futures and Options Markets

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Abstract

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Submitted by Yang Lu
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The objective of this study is to investigate the pricing efficiency for HSI and Mini-HSI futures and options contracts, this will assist investors to avoid the volatility of the market, reduce the risk from the spot market, and test or verify the existence of arbitrage opportunities. The results suggest that the price of Mini-HSI Index futures market fails to follow the theoretical put-call-futures parity model. This paper considers about ex post and ex ante. After add transaction cost in the least linear regression, the result proved that the HSI futures market exists arbitrage opportunity even through transaction costs are considered. During January 2010 to June 2011 mispricing existed in the market.

Table of Contents

Chapter 1: Introduction

1.1 Overview

Derivative market efficiency has been addressed frequently in the research area for many years. Along with the high growth in the trading of derivative instruments in all major securities markets, the derivative market in Hong Kong has become one of the most famous trading places in the world, and also one of the most active derivative markets in Asia. There are four primary groups participate in the derivative markets, and one of the groups to be mentioned here is one, which engages in arbitraging through trading in the market. Once derivative markets open to economies, one question should be asked about their efficiency. Dimson and Mussavian (2000) mentioned that assumption of efficient markets is usually violated in reality. This study is to examine the pricing efficiency and arbitrage opportunity in Hong Kong HSI futures and options markets. This chapter will provide a brief introduction of Hong Kong index futures and options markets, and general background information related to this topic. According to the background information, then the purpose and rationale of the study will be stated. Furthermore, specific problems related to the study will be discussed.

1.2 Background Information

Derivative financial instruments are contracts that create opportunities for investors

to transfer or exchange specified cash flows at particular points of time in the future (Robert and Worapot, 2004). According to Hong Kong Exchanges and Clearing Limited (HKEx), the Hong Kong Futures Exchange (HKFE) introduced HSI futures contracts in May 1986, and HSI options contracts in March 1993. After then, the HKFE introduced a Mini-Hang Seng Index (Mini-HSI) futures contracts in October 2000, which is established for retail investors, and two years later, Mini-HSI options contracts was introduced in November 2002. After long time innovation of these HSI derivatives, these financial instruments have become symbols of Hong Kong financial market and popularly used by investors to hedge systematic risk in the stock market. Whereas, some investors kept seeking arbitrage opportunities in HSI futures and options markets, since they doubt the pricing efficiency of these relatively new financial instruments.

1.3 Purpose and Rationale of the Study

The purpose of this study is to inspect the pricing efficiency for HSI and Mini-HSI futures and options contracts to help investors avoid the volatility of the market, reduce the risk from the spot market, and test or verify the reality of arbitrage opportunities. The reason behind of examine the pricing efficiency and verify the existence of arbitrage opportunities is that if there are arbitrage opportunities existing, which means that the market is not efficient and the higher risk in the market expose to investors caused by inappropriate use of futures contracts with massive speculation. In general speaking, the speculators are the people who want to gain the

profits and also bear risks from the futures markets. By doing this, over speculation will increase the daily trading volume and activity in the secondary market. However, given the leverage effect, massive speculation will increase the volatility and the risk of the market deviated from the future's perspective. The price of futures contracts will deviate from the fair value due to massive speculation. The price deviation is the main reason for the arbitrage opportunity. People seek risk-free returns through arbitrage opportunities, and consequently drive the prices of financial instruments back to the fair value. So the arbitrage opportunities can be used as a measurement to estimate whether the derivative markets are under healthy performance or not. The Hong Kong stock market crisis in the year of 1987 is a good example of the inappropriate use of financial derivatives and massive speculation. Whether the HSI futures markets are under healthy status is a concern to all investors due to appropriate investment decisions and wealth safety. Therefore, the purpose of the study is through detecting pricing efficiency and whether arbitrage opportunities exist in HSI and Mini-HSI futures and options markets, to discover the performance of Hong Kong HSI futures and options Markets.

1.4 Statement of Problem

According to Zhang and Lai (2006), there are two problems arise when examining the efficiency of HSI and Mini-HSI futures and options in Hong Kong. First one is that those contracts are Asian derivatives, which have exercise prices equal to the average of HSI values taken every five minutes on the last trading day, the data

matching procedure in the tests will be very complicated. Another problem is the weights and distribution of stocks within the index will affect the results. To avoid directly testing the indexes will solve these two problems. Thus, this paper will perform the result through testing the validity of the put-call-futures parity relationship.

Chapter 2: Literature Review

Researchers have done related studies with derivatives by using different methods, specifically, testing the market efficiency of index options and futures. The most famous model is the Black-Scholes option pricing model (Black and Scholes, 1971). However, this particular model does come with drawbacks. For instance, Mittnik and Rieken (2000) and Cavallo and Mammola (2000) documented that the primary shortcoming of the Black-Scholes model is that the markets and the data used for testing the arbitrage efficiency of the market are synchronized; in other words, the model tests the pricing efficiency and the markets at the same time.

The second type of methods applied for testing the arbitrage efficiency includes put-call parity. Mittnik and Rieken (2000) stated that the main assumption of this particular test is that there is no risk free arbitrage opportunity existing in the market because investors will eliminate all potentials autonomously. Consequently, the hypotheses of this test would be the market is efficient and the data are synchronized. This method has been applied for many studies; for example, Billingsley and Chance (1985), Marchand et al. (1994), Hemier and Miller (1997) investigated the index options markets in the US, and their result indicate that the arbitrage opportunities existing in the US market are either very restricted or unprofitable. Similarly, Fung et al (2004) found no evidence of existence of arbitrage opportunity in the Hong Kong market. Hemier and Miller (1997) stated that any market may have a particular

period in which it may not be efficient.

On the other side, Figlewski (1984) examined the hedging performance and basis risk within stock index futures in the US; Cornell (1985) presented empirical tests for the argument that the prices of the stock index futures contracts might be less than the predicted prices if the market is perfectly efficient and having no taxes, Chung (1991) investigated co-integration for the Greek futures markets over the period of crisis which was from 1999 to 2001; Yadav and Pope (1994) tested the arbitrage efficiency between index futures and the underlying index for the US. They proved that the probability of mispricing enhances as the market volatility increases, and thus the possibility of profitable arbitrage opportunities rises. Moreover, Chung (1991) found that the Greek futures markets are informationally more efficient than their underlying stocks, and suggested investors should consider dealing with Greek stock index futures rather than their underlying stocks.

The third family of studies for testing the pricing efficiency involves examining the relative informational efficiency of inter-markets. Fleming, et al (1996) observed that, when trading costs are taking into consideration, the index futures markets lead the options markets as well as the cash markets whereas Hentze and Seiler (2000) concluded an inconclusive result of the relationship between the lead and the lag markets. Chiang and Fong (2001) documented that the Hong Kong cash index returns leads the index option returns on account of thin trading, but in a weak

lead-lag relationship comparing to other countries.

The fourth method that is commonly used is to utilize put-call-futures parity to test the dynamic efficiency or the joint pricing efficiency of index options and index futures markets. Bodurtha and Courtadon (1987) examined the market efficiency, specifically, the importance of the effect of nonsynchronous prices and transaction costs, in the Philadelphia Stock Exchange Foreign Currency Options Market. Followill and Helms (1990) presented the Put-Call-Futures Parity tests by using the averaged 6455 contracts of daily volume in COMEX gold futures contracts. They found no evidence of existence of mispricing between the futures contracts, and the options written on these commodities in the treasury bond futures options market, the foreign currency options market, and gold futures, options markets in the US and UK. Similarly, Tucker (1991) and Lee and Nayar (1993) studied the association between the futures and options contracts and the underlying indexes, and their results showed no inefficient within these markets. Fung and Chan (1994) investigated the relationship between futures and options contracts written on the Hang Seng Index that are traded on the Hong Kong Futures Exchange, and found that the mispricing did exist during the period of 1993 to 1995 but not economically significant and profitable after taking transaction costs into consideration.

There are numerous of researches regarding to this particular subject for the Hong Kong market. For instance, Fung et al (1997) concluded that no profitable arbitrage

opportunity exists within Hang Seng Index futures or options as well as the underlying index. Similarly, Cheng et al (2000) documented that the arbitrage profits and the standard deviations of the profits increased for the index options and index futures markets in Hong Kong in both ex-ante and ex-post analysis during the Asian financial crisis period. Fung and Mok (2001, 2003) they documented that Hang Seng Index futures and options markets are jointly efficient. Moreover, Zhang and Lai's research (2006) used a longer period of data than those precedent works. They indicate that the markets are theoretically inefficient but still price efficient because the profit magnitudes are so low, even the arbitrage opportunities do exist.

Chapter 3: Methodology

3.1 Models used for the study

According to Tucker (1991, pp. 351-53), the put-call futures parity states that:

$$F = X + (C - P)e^{r(T-t)} \qquad (1)$$

Where

F= the theoretical fair price of stock index futures,

T= the expiration date of index call and put options,

r= the risk-free interest rate,

C= index call (European style) option prices,

P= index put (European style) option prices,

X= the exercise price of the index put and call options.

The model shows that the relationship between futures position and a call and put option position with the same strike price.

If the equation is not equal from both sides, arbitrage opportunities exist. There are two strategies can be used in arbitrages, which are:

1. Hold-to-expiration strategy
2. Early unwinding strategy

The first strategy states that all the contracts should be held to expiration. The second strategy states that taking opposite positions when settling the contracts before expiration. Mostly, those investors who want to optimally seize the arbitrage opportunity prefer to use the early unwinding strategy than the hold-to-expiration

strategy. However, in this case scenario, the first strategy is a lot simpler to deal with for testing purpose. Thus, this paper assumed that speculators would hold the contracts until expiration.

Interpret ε as the price difference between the market futures contract and the theoretical price indicated in the Equation. The pricing errorε, which also stands for the arbitrage profit by taking the proper long or short positions without transaction costs. Therefore, arbitrage trade occurs whenever ε is non-zero. In practice, an arbitrage trade is profitable only if the pricing error, ε, is larger than the total arbitrage cost. Thus, mispricing of futures contracts generates arbitrage opportunity only when ε is greater than the total cost of arbitrage.

Test for put-call-futures parity

According to Fung (1997), regression analysis is performed with the method of Ordinary Least Squares for the above equation, which is rewritten as:

$$Fe^{-r(T-t)} = \alpha + \beta\left(C_i - P_i + X_i e^{-r(T-t)}\right) + \omega_i \qquad (2)$$

Where,

ω_i = random error term

When market is efficient, no mispricing occurs;

α should be statistically no different from zero;

β = coefficient

This should be indifferent from 1;

And also the regression supposed to give high illustrative power. However, a failure of any of these conditions will lead to violated of put-call-futures parity, and arbitrage opportunities should occur at this point.

Ex post simulation tests

Ex post tests assume trading of futures and options at prices with which signals occur. Any violating Equation 2 means mispricing and arbitrage trading can be done at these related prices. If the Ex post profits are larger than the cost of arbitrage, then arbitrage opportunities exist.

Ex ante simulation tests

Ex ante simulation tests are not like ex post tests. Orders are usually completed at the next available set of prices in the real world. The existence of difference between the prices shows an arbitrage opportunity and prices create risks. Berg (1996) claims that profits measured from ex post trading rule may be violated because such rule may not be applicable in reality; and therefore the reported mispricing might not actually exist. To find out the risks, ex ante simulation tests will be presented in this paper.

3.2 Data Sources

Time series transaction data of HSI options and futures, and the Mini-HSI options and futures are acquired from the Hong Kong Exchange Limited for the period January 2010 to June 2011.

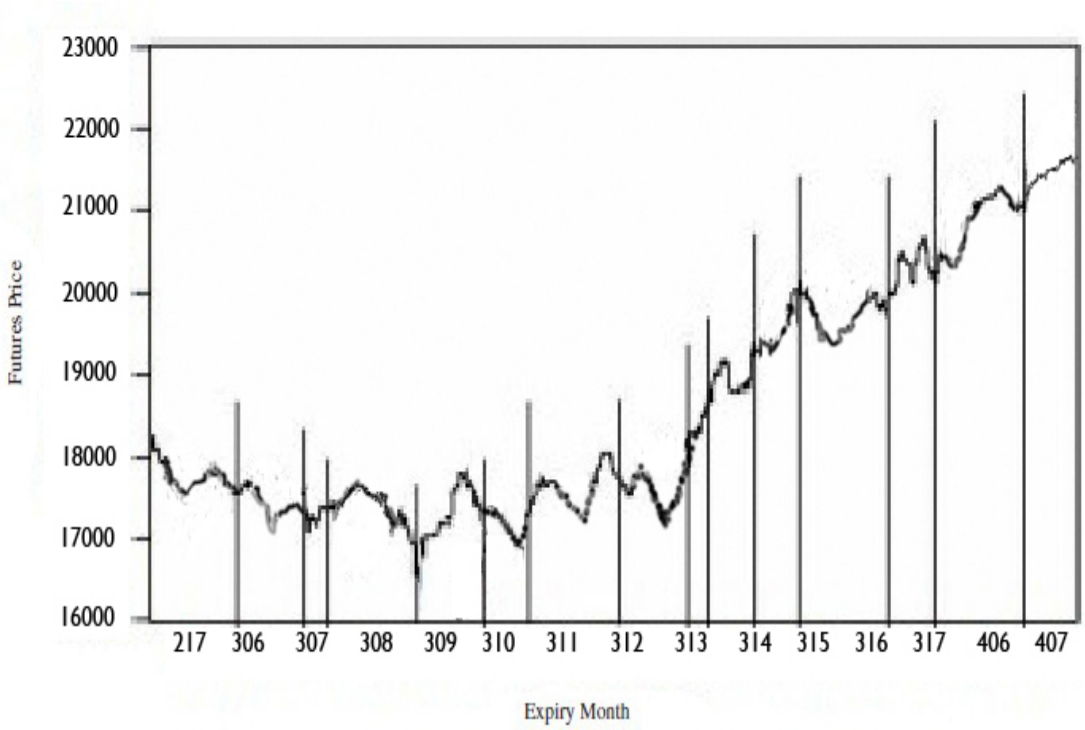

Fig. 1. Movement of HSI futures price from January 2010 to June 2011

As shown in Figure 1, a trend of movement of HSI futures price from January 2010 to June 2011, which gives an idea of that what happened in the market. The sample is gathered to show particular market situations during these periods.

3.3 Data Summary

The following is the summary of the volatility of the daily return of the Mini-HSI as well as the absolute daily return of Mini-HSI. The volatility of Mini-HSI is used as the proxy of the market volatility.

Table 1. Market volatility of Mini-HSI

		Number of days when			
	Std. dev.	ki⩾1%	ki⩾2%	ki⩾3%	ki⩾4%
Month-by-month					
Jan-10	0.009457	6	1	0	0
Feb-10	0.007767	7	1	0	0
Mar-10	0.014003	4	1	0	0
Apr-10	0.015579	8	3	0	0
May-10	0.008676	7	2	1	1
Jun-10	0.009904	9	2	0	0
Jul-10	0.015432	4	1	0	0
Aug-10	0.008456	6	0	0	0
Sep-10	0.001124	8	3	1	0
Oct-10	0.013581	6	3	1	0
Nov-10	0.011254	2	2	1	1
Dec-10	0.004562	8	1	0	0
Jan-11	0.011202	4	1	0	0
Feb-11	0.014534	6	2	0	0
Mar-11	0.007964	5	1	0	0
Apr-11	0.014517	7	3	1	0
May-11	0.015423	2	0	0	0
Jun-11	0.019573	5	3	1	0

Note: Std.dev. is the standard deviation of the daily return of Mini-HSI and is used as the proxy of market volatility. Ki is the daily return of Mini-HSI

Chapter 4: Test Results

4.1 Put-Call-Futures Parity

As shown in table 2, the R^2 of the test results of the joint pricing efficiency for Hong Kong Mini-HSI futures and options markets are very close to 1 and able to explain more than 99% of the variation in all the regressions. The range of β values fluctuates from 0.992134 to 0.998173 for the period of January 2010 to June 2011. The t-statistics shows that all α values are statistically different from 0 and all β values are statistically different from 1, which means that the equality relationship of the equation (1) is statistically not satisfied. Therefore, the arbitrage opportunities indeed exist. Among all regressions, only two intercepts are negative whereas others are positive, ranging from 5.661385 to 186.3368, which suggests that an encouraging relationship of mispricing in most situations.

Generally speaking, the circumstance of mispricing for Hong Kong Mini-HSI happens more considerably in some specific periods, for instance, the 2nd quarter and the 4th quarter of 2010. It can also be observed from the table 1 in which the two days of the absolute daily return, exceeding 4% appear in May and Nov of 2010. The following is regression results for Mini-HSI.

Table 2. Put-Call-Futures Parity Regression Results for Mini-HSI by quarter

	N	α (t- value)	β (t- value)	Adjusted R^2
Overall	87531	157.25412 (37.0459)	0.995178 (-51.5741)	0.993485833
By quarter				
1st quarter 2010	14623	17.42688 (-2.5692)	0.998173 (-4.2665)	0.990728
2nd quarter 2010	16665	48.46123 (27.9676)	0.992134 (-33.2587)	0.999662
3rd quarter 2010	10256	30.19747 (-4.5699)	0.992933 (-5.3354)	0.990325
4th quarter 2010	13788	62.40895 (7.5562)	0.995462(-8.4421)	0.998755
1st quarter 2011	15236	22.65214 (8.3256)	0.998033 (-5.6899)	0.991029
2nd quarter 2011	16963	5.661385 (7.3356)	0.997655 (-5.6477)	0.990416
January effect				
Dec 2010 and Jan 2011	9856	186.3368 (14.5347)	0.998877 (-16.8605)	0.99121

Note: The null hypothesis of α and β are: ***α=0, β=1*** *. The significance level of t-statistics is 1%*

Also, as seen from table 2, it is very clear that the January effect exists within the Mini-HSI market. The very large intercept is pointed as 186.3368 and the*β* coefficient of 0.998877 is also statistically different from one of the period from January 2010 to June 2011. Figure 2 demonstrates the fluctuation of Mini-HSI futures prices to reflect the January effect.

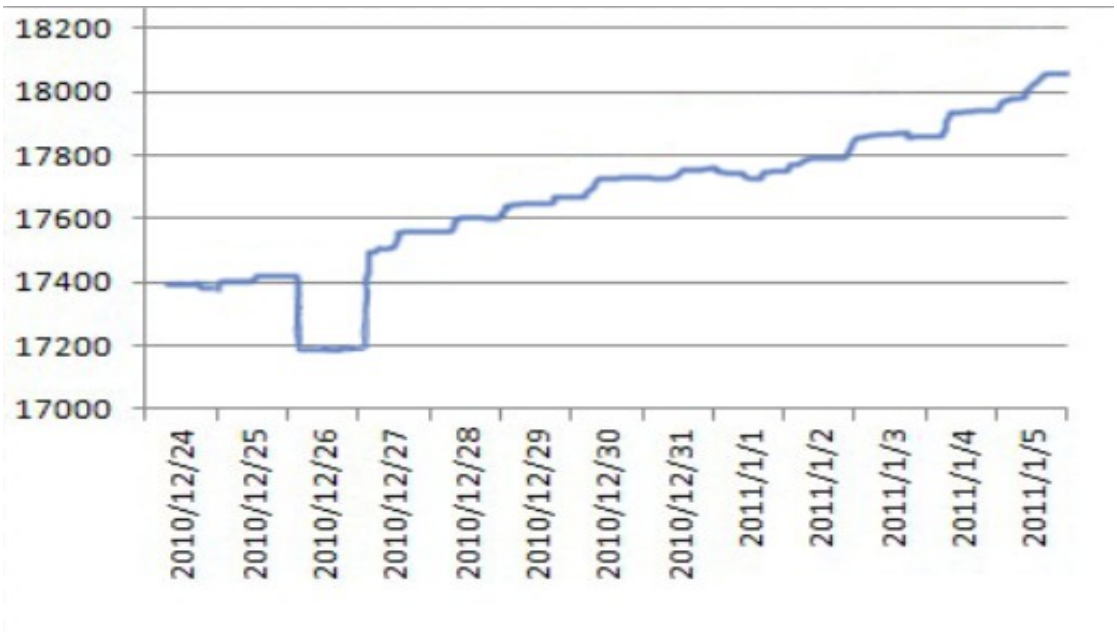

Figure 2 Mini-HSID prices reflect January effect

In conclusion, the regression results of Mini-HIS infer that Put-Call-Futures parity theoretically does not persist because all coefficients are statistically different from expectations. Moreover, theoretically, the options and futures markets for Mini-HSI are jointly inefficient due to the rejection of the null hypothesis in all circumstances. The results are very similar to the latest study of the Hong Kong Mini-HSI market by Zhang and Lai (2006) which contradicts all the previous researches on the joint pricing efficiency of Hong Kong future and options market.

4.2 Ex-Post Tests

The paper utilizes ex post tests to examine the profit position in violation of the put-call-futures parity regression models after taking transaction costs into consideration. For the simplicity of comparison, the mispricing magnitude is only represented by α. Table 3 demonstrates the descriptive statistics of the profitable position of arbitrage in terms of index points and a monthly basis.

Table 3. Descriptive statistics for ex post arbitrage profits (index points) by month

	N	Mean	Std. dev.	Median	Maximum	Minimum
Overall	87531	9.6094	17.6487	5.9663	265.9952	0.0000
Jan-10	4612	5.4638	4.3332	4.3118	29.0678	0.0000
Feb-10	4231	5.6533	5.1673	4.0212	38.0143	0.0003
Mar-10	5780	8.4587	7.2566	5.9983	40.9427	0.0018
Apr-10	5250	12.0729	18.6528	5.5299	185.2067	0.0029
May-10	5556	9.5963	9.4717	6.9665	69.9869	0.0002
Jun-10	5859	6.4873	4.7602	5.0029	30.2562	0.0005
Jul-10	2046	7.7015	4.7806	6.9753	24.9957	0.0132
Aug-10	3663	8.3363	22.5082	4.7928	245.6698	0.0001
Sep-10	4547	5.6728	4.9343	4.2366	30.8975	0.0000
Oct-10	4996	8.0022	6.2367	5.9971	34.0258	0.0000
Nov-10	5023	9.8899	8.0557	7.8897	49.0005	0.0004
Dec-10	3769	12.6485	10.6571	10.0000	62.0180	0.0000
Jan-11	4987	7.8559	6.3138	5.0058	42.5656	0.0006
Feb-11	5064	28.1004	37.4007	10.0106	185.0067	0.0018
Mar-11	5185	6.9628	5.763	5.0004	39.9923	0.0009
Apr-11	7063	13.0568	11.5561	10.0028	44.2336	0.0000
May-11	3029	7.5688	6.2568	6.0258	32.2323	0.0007
Jun-11	6871	6.5399	6.0221	5.9887	36.9632	0.0029

Note: No transaction costs are considered when the statistics are calculated

As seen from the table above, the lowest put-call-futures trio matched observation is 2046 in July 2010, and the highest is pointed in 7063 and observed in April 2011. The mean profits fluctuate from 5.4638 points in January 2010 to 28.1004 points in February 2011. The standard deviations of profit range from 4.3332 points in January 2011 to 37.4007 points to February 2011. Therefore, the arbitrage opportunities indeed exist and have a wide range.

However, as shown in table 5, after considering transaction costs (estimated), the mean profit for non-members is 29.6723 index points, whereas that for members is 10.7711. After considering transaction costs as well as spread costs, the trio profit

margin decreased significantly for both members and non-members. In general, the most profitable arbitrage opportunities appear in January 2010 and February 2011.

Furthermore, Panel B in table 4 describes the short-arbitrage trade, especially, short futures, long call, and short put, whereas Panel C in the table introduces long-arbitrage trade in which long futures, short call, and long put. Obviously, there are more long-arbitrage trade opportunities (30775) existing in the market than short-arbitrage trades (26253). Furthermore, the mean profits for non-members in both long- and short- arbitrage trades are considerably higher than that for members.

Table 4: Descriptive statistics for arbitrage profits in index points in mini- HIS under *ex post* tests

	Arbitrage profits in index points		
	Overall	Members	Non-members
Panel A: all ex post trades			
Mean	11.9697	10.7711	30.6578
Standard deviation	19.1087	16.0669	40.5088
Median	5.9665	5.8962	12.0064
Maximum	236.4062	236.4062	221.0667
Minimum	0.0070	0.1966	0.007
Number of observations	57067	52068	4076
In percentages	93.05	89.66	7.03
Panel B: Short arbitrage trade			
Mean	8.6631	8.2563	16.6524
Standard deviation	12.7642	4.7554	26.018
Median	6.6696	6.6676	6.1443
Maximum	184.6620	184.662	162.0019
Minimum	0.0070	0.2364	0.007
Number of observations	26253	23337	1252
In percentages	42.81	39.68	1.79
Number of signals	27336		
Panel C: Long arbitrage trade			
Mean	13.0039	11.1765	34.8391
Standard deviation	23.8187	81.0796	59.0775
Median	6.7008	5.8864	5.2345
Maximum	236.4062	236.4062	221.0667
Minimum	0.0283	0.1684	2667
Number of observations	30775	28635	2566
In percentages	51.06	47.29	4.96
Number of signals	31156		

Note: These percentages are the numbers of observations against the total number of observation of 87531

4.3 Ex-Ante Tests

Table 5 presents the results of ex-ante tests for Mini-HSI futures and options markets. Interestingly, dislike the ex-post analysis, only non-members can earn profit of 13.9808 index points in long-arbitrage trades. Non-members suffer 15.4682 index points in short-arbitrage positions, whereas members would suffer 5.7765 index

points and 19.9956 index points in short- and long- arbitrage trades, respectively.

Table 5. Descriptive statistics for total ex post arbitrage profits from inefficiency in mini-HIS for members

	Arbitrage profits in index points		
	Overall	Members	Non-members
Panel A: all ex post trades			
Mean	-2.7677	-4.4996	6.6689
Standard deviation	26.5508	19.0462	44.9686
Median	-0.6335	-2.1879	-0.9488
Maximum	0.48923	52.2653	162.7009
Minimum	-188.4688	-188.4688	-71.3302
Number of observations	24962	20708	3687
In percentages	42.2203	35.534	6.1877
Panel B: Short arbitrage trade			
Mean	-6.7334	-5.7765	-15.4682
Standard deviation	27.8434	15.7964	20.0002
Median	-0.6295	-0.4001	-13.8966
Maximum	53.6281	53.6281	29.0053
Minimum	-188.4590	-188.459	-62.3652
Number of observations	11334	9871	796
In percentages	17.37	15.78	1.24
Panel C: Long arbitrage trade			
Mean	-13.6978	-19.9956	13.9808
Standard deviation	30.1054	16.5521	49.9952
Median	-19.6910	-20.6534	20.0135
Maximum	162.0694	162.0694	28.9966
Minimum	-71.3302	-71.3302	-71.3302
Number of observations	13509	11011	2566
In percentages	22.77	18.01	4.97

Note: These percentages are the numbers of observations against the total number of observation

Chapter 5: Conclusion

Through the above analysis, the price of Mini-HSI Index futures market fails to follow the theoretical put-call-futures parity model. The result further illustrated some previous researches on HSI Index that made an assumption about put-call futures parity theory is not supported in this maturity financial Asian market. This paper considers about ex post and ex ante. After adding transaction cost in the least linear regression, the result proved that in the HSI futures market arbitrage opportunity exists even through transaction costs are considered. Especially in ex post situation, arbitrage profit is greater than ex ante significantly.

Although it has enough previous research papers and numerical analyses to illustrate arbitrage profits exist in the relatively more volatile periods, only high frequency trading can really generate attractive arbitrage activity. Not every investor could be arbitrageurs even through in a market fluctuation

This study found that the Mini-HSI future submarkets are not efficiency enough to follow the put-call futures parity theory. During January 2010 to June 2011 mispricing existed in the market.

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Appendix: Trading Fees and Commissions

	Mini-HSI options	Mini-HSI futures	HSI options	HSI futures
Exchange fee	HK$2.00	HK$3.50	HK$10.00	HK$10.00
SFC levy	0.20	0.20	1.00	1.00
Investor compensation levy	0.10	0.10	0.50	0.50
Special levy	NA	NA	NA	NA
Total per contract per side	2.30	3.80	11.50	11.50
Exercise/settlement fee	2.00	2.00	10.00	10.00

Commission 1% of contract value with minimum of HK$30 or HK$50 for Mini-HSI options before 1 April 2003; 1% of contract value with minimum HK$30 or HK$100 before 1 April 2003; HK$60 (day trade) and HK$100 (overnight) for HSI futures before 1 April 2003; HK$12 (day trade) and HK$20 (overnight) for Mini-HSI futures before 1 April 2003. Commissions for all the four products are negotiable on 1 April 2003 thereafter. Options that are designated cabinet bids shall not attract a minimum commission as they have no contract value.

Sources: “fees and Charges” on the website Hong Kong Exchange Ltd.: http://www.hkex.com.hk