THE INTRADAY PRICING EFFICIENCY OF HONG KONG HANG SENG INDEX OPTIONS AND FUTURES MARKETS

JOSEPH K. W. FUNG
LOUIS T. W. CHENG
KAM C. CHAN

INTRODUCTION

Futures and options contracts on stock indices have received warm receptions since their relatively late debut in the financial markets. There are two reasons for the success of these instruments. First, they are versatile asset management tools for institutional investors for repositioning the level of market exposures. Second, they open up new profit opportunities for professional speculators and arbitrageurs. If these market participants do a good job in monitoring the pricing behavior of the options and futures markets, then persistent mispricing should not occur. Substantial arbitrage opportunities between the two markets should not be expected.

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- *Joseph K. W. Fung is a Lecturer of Finance at the Hong Kong Baptist University.*
- *Louis T. W. Cheng is an Associate Professor of Finance at Murray State University.*
- *Kam C. Chan is an Associate Professor of Finance at the University of Wisconsin—Parkside.*

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Although there are a number of studies that treat possibilities of arbitrage opportunities or pricing efficiency of options and futures markets separately [e.g., Klemkosky and Resnick (1980), Mackinlay and Ramaswamy (1988), Yadav and Pope (1990), and Ho, Fang, and Woo (1992)], only limited research has been conducted on the joint pricing efficiency or arbitrage opportunities between index futures and index options on the same underlying stock index. Lee and Nayar (1993) is the first major study to examine arbitrage opportunities on the S&P500 index options and futures markets. Fung and Chan (1994) provided a small sample study on the S&P500 index options and futures. The results of Lee and Nayar and Fung and Chan suggest that both the index options and futures markets are jointly efficient. To date, the empirical evidence in this area is primarily in the U.S. markets; few studies are on markets outside the U.S.

The objective of this article is to examine the joint pricing efficiency of the Hong Kong Hang Seng Index Options (HSIOs) and the Hang Seng Index Futures (HSIFs) by both ex post and ex ante tests. Unlike the U.S. counterparts, HSIOs and HSIFs are Asian-type derivatives. Specifically, the exercise values of HSIOs and HSIFs are path dependent and are functions of the average value of the Heng Seng Index (HSI) taken at 5-minute intervals during the last trading day. Hence, the findings from a relatively young and different (from the U.S.) Hong Kong index options and futures markets will provide evidence on the behavior and possible arbitrage opportunities of index options and futures markets outside the U.S. The next section reviews the literature. The following two sections describe the options/futures arbitrage relationship and report the results. The last section concludes the article.

LITERATURE REVIEW

Lee and Nayar (1993), using 8-month data from November, 1989 and June, 1991, provided a transaction data test between S&P500 index options and index futures. They found that, after considering trading costs, only 9.5% of the sample received an ex post profit of 0.463 index points. However, the mispricing was corrected quickly so that no ex ante arbitrage profits could be made between the two markets. Fung and Chan (1994) further proved that the put–call–futures parity is immune to the distortional effects of stock distributions; and they applied the parity condition to study the S&P500 index options and index futures markets and also found no arbitrage opportunities.

Chiang, Ho, and Wong (1993) tested for arbitrage opportunities between the Hang Seng Index options and futures by using 68 daily observations at 3:30 P.M. and 3:45 P.M. from March to June of 1993. They observed a small profit of 2.937 (3:30 P.M.) and 1.833 (3:45 P.M.) points and concluded that the Hong Kong markets are quite efficient. However, their test only included a small number of observations and the conclusions are based on ex post tests only.

In short, only a few research studies have examined the joint market efficiency of index options and futures contracts. This article will provide additional evidence for this issue by testing the Hong Kong index options and futures markets.

PUT–CALL–FUTURES PARITY IN HONG KONG

The index futures price is related to its underlying cash index value via a cost-of-carry relationship [e.g., Cornell and French (1983)], and index call and put options prices are also tied to their underlying index according to a put–call parity relationship [Stoll (1969)]. Violations of the above relationships present opportunities to professional arbitrageurs, who stand ready to profit by simultaneously executing trades in both the cash and the options or futures markets. However, arbitrage trades involving transacting in the cash market present several difficulties to arbitrageurs. These include

1. There can be technical difficulty in simultaneously buying or selling (or shorting) the index portfolio at a set of specified prices. This problem can be worsened by the illiquidities of some securities in the index.
2. High trading costs in the cash market may render potentially profitable arbitrage trades unprofitable.
3. Short selling of stocks, in general, is subject to many institutional restrictions.
4. Stock distribution, such as dividends, from the index portfolio may affect the actual performance of the arbitrage trade.

Moreover, arbitraging between cash and index futures markets or between cash and index options markets entails an additional risk to the arbitrageur due to the peculiar delivery terms of Asian derivatives. Specifically, the exercise values of average price options or average price futures are path dependent and are functions of the average value of a particular variable [see Bouaziz, Briys, and Crouhy (1994) and Curran (1994)]. For the case of Hong Kong, the value of the asset for the settle-

TABLE I

A Conceptual Illustration of the Put–Call–Futures Parity Condition

Panel (A): Short Hedge Arbitrage

Transactions Undertaken	*Cash Flows Today (at t)*	*Cash Flows at Expiration (at T)* $S_T > X_j$	*Cash Flows at Expiration (at T)* $S_T < X_j$
Short a futures contract at F_i	0	$F_j - S_T$	$F_j - S_T$
Borrow $F_i e^{r(t-T)}$	$+F_j e^{r(t-T)}$	$-F_j$	$-F_j$
Long call	$-C_j$	$S_T - X_j$	0
Short put	$+P_j$	0	$-(X_j - S_T)$
Lend $X_j e^{r(t-T)}$	$-X_j e^{r(t-T)}$	$+X_j$	$+X_j$
	$F_i e^{r(t-T)} - (C_i - P_i + X_i e^{r(t-T)})$	0	0

Panel (B): Long Hedge Arbitrage

Transactions Undertaken	*Cash Flows Today (at t)*	*Cash Flows at Expiration (at T)* $S_T > X_j$	*Cash Flows at Expiration (at T)* $S_T < X_j$
Long a futures contract at F_i	0	$S_T - F_j$	$S_T - F_j$
Lend $F_j e^{r(t-T)}$	$-F_j e^{r(t-T)}$	$+F_j$	$+F_j$
Short call	$+C_j$	$-(S_T - X_j)$	0
Long put	$-P_j$	0	$X_j - S_T$
Borrow $X_j e^{r(t-T)}$	$+X_j e^{r(t-T)}$	$-X_j$	$-X_j$
	$(C_j - P_j + X_j e^{r(t-T)}) - F_j e^{r(t-T)}$	0	0

Note: Ignore margin deposits and different rates of lending and borrowing.

ment of the HSIFs and the HSIOs is based on the average of the quotations of the HSI taken at 5-minute intervals during the last trading day. Such delivery terms may drive a wedge between the value of the cash index itself and the stipulated settlement value of the index on the expiration day of the contract when the arbitrage portfolio has to be unwound.

Along the cost-of-carry and put–call parity relationships, Tucker (1991, pp. 351–353) proved the general put–call–futures parity condition by substituting the cash index position with a futures position into the put–call parity. Table I is a payoff table constructed to illustrate the following put–call–futures parity condition:

$$F_j e^{r(t-T)} = C_j - P_j + X_j e^{r(t-T)} \tag{1}$$

where

F_j = stock index futures price of transaction j

C_j = index call option price with any exercise price

TABLE II

Contracts Specifications of HSIFs and HSIOs

	Hang Seng Index Futures (HSIFs)	*Hang Seng Index Options (HSIOs) Calls and Puts*
Underlying index	Hang Seng Index (HSI)	Same
Contract multiplier	HK$50 per index point	Same
Quotation	Whole index points	Same
Minimum fluctuation	One index point (HK$50)	Same
Exercise style	Irrelevant	European style options, exercisable only on expiration day
Maximum fluctuation	300 points per trading session above or below the last closing. No limit on the spot month	N.A.
Trading hours	Two trading sessions 10–12:30 and 14:30–16:00 (closing at 15:45 before 1 July 1994)	Same
Delivery months	Spot month, the next calendar month, and the next two calendar quarter months	Same
Last trading day/expiration day	The business day preceding the last business day of the month	Same
Settlement day	The first business day after the last trading day	Same
Final settlement price	An average of quotations for the HSI taken at 5-minute intervals during the last trading day	Same
Settlement method	Cash	Same

P_j = index put option price with the same exercise price as the index call option

X_j = the common exercise price of the call and put options

T = the common expiration day of index futures, index call, and index put options

r = continuously compounded risk-free rate of return from day t to T

To illustrate the put–call–futures arbitrage opportunities between HSIO and HSIF markets, the following actual Hong Kong newspaper quotes from November 9, 1995 are used:

1. The November HSI futures was trading at 9420 on November 9, 1995.
2. The November 9800 call was trading at 51 index points.
3. The November 9800 put was trading at 430 index points.

Both HSI futures and options contracts have a multiplier of HK$50 per contract. The two contracts expire at the same time on the same date; the same method is used to calculate the settlement values. Table II lists

the contract specifications of the two instruments. Most of the trading features are the same for both contracts. The commonly used risk-free rate by the traders is the 1-month Eurodollar rate, which was 5.7188% on that day. The time to expiration was 20 days. The left-hand side of eq. (1) is equal to 9390.52 points, which is slightly larger than the right-hand side (9390.34). The profit is 0.18 index point before transaction cost. Thus, the arbitrageur should short the index futures at 9420 points; short the put at 9800 points; and long the call at the same exercise price to lock in a riskless profit of 0.18 index point (or HK$9). However, after adjusting for transaction costs (to be described later), this trade turns out to be fruitless.

The put–call–futures relationship allows traders to arbitrage with the index futures and index options directly without taking any position in the cash index. This largely alleviates traders of the previously mentioned problems associated with transacting in the cash leg of the arbitrage trade. Furthermore, Fung and Chan (1994) also showed that stock distributions from the index portfolio will not affect the parity relationship. Moreover, the underlying asset (i.e., the average quotations taken at 5-minute intervals on the last trading day) is identical for the settlements of the HSIFs and the HSIOs; the risk associated with the mismatching between the settlement value and the cash index can be avoided.

To study the market efficiency of HSIFs and HSIOs in a practical sense, the equilibrium relationship in eq. (1) has to be extended to incorporate transaction and capital costs associated with any potential arbitrage trades. Lee and Nayer incorporated transaction costs to derive their pricing bounds. Similar to Lee and Nayer:

$$F_{\min} < F_t < F_{\max} \tag{2}$$

where

$$F_{\min}\, e^{r_L(t-T)} = C_j^h - P_j^a + X_j\, e^{r_B(t-T)} - \Gamma \tag{3}$$

and

$$F_{\max}\, e^{r_B(t-T)} = C_j^a = P_j^b + X_j\, e^{r_L(t-T)} + \Gamma \tag{4}$$

$F_{\min}$ and $F_{\max}$ are, respectively, the lower and upper bounds for the futures price. Superscripts a and b stand for the ask and bid prices of the securities. Continuously compounded risk-free lending and borrowing rates are represented by, respectively, r_L and r_B. Γ is the total transaction and capital costs. Because only spot month data are used and the time

to expiration is very short, the difference in discrete and continuous compounding is minimal.

According to eq. (3), if the ask futures price (i.e., F^a) is below $F_{\min}$, then an arbitrageur may long the futures at F^a, and at the same time, short a call at C^b, long a put at P^a lend (borrow) the present value of $F - X$ ($X - F$) at r_L (r_B) if F is greater (less) than X, and incur a total trading cost of Γ, to lock in a riskless profit.

On the other hand, according to eq. (4), if the bid futures price (F^b) exceeds $F_{\max}$, then the arbitrageur may lock in a riskless profit by shorting the futures at F^b and simultaneously long a call at C^a, short a put at P^b, borrow (lend) the present value of $F - X$ ($X - F$) at r_B (r_L) if F is greater (less) than X, and incur a total cost of Γ. If the futures and options markets are jointly efficient, then futures prices should satisfy the above boundary conditions.

DATA AND METHODOLOGY

Ex Post Tests

The Hong Kong Futures Exchange was established on December 17, 1976. The Hang Seng Index Futures (HSIFs) contracts began trading on May 6, 1986. The Hang Seng Index Options (HSIOs) contracts were first initiated on March 5, 1993. During August, 1995, the average daily volume (contracts) for HSIFs and HSIOs reached 16,544 and 2,530, respectively. Transaction data of the HSIFs and HSIOs are obtained from the Hong Kong Futures Exchange. These data do not contain bid or ask prices. In theory [as suggested in eqs. (3) and (4)] bid and ask prices will be needed to estimate the full impact of transaction and capital costs. However, this is not a problem for the present analysis, even though actual transaction prices are used. In this study, the focus is to investigate market efficiency, not the precise level of arbitrage profits. Thus, the calculation of $F_{\max}$ and $F_{\min}$ are not critical to the analysis. Γ is estimated to provide a range for total transaction and capital costs to evaluate if the arbitrage profit is above or below the total costs. The sample period is from April, 1993 to November, 1994. The following procedures are used to create and match the data set:

1. The first trading month, March, 1993, is excluded to avoid possible mispricing behavior due to unseasoned trading activities in the new index options market.
2. Only spot month contracts are used because they are the most active ones.

3. Spot month contracts in April, May, October, and November of 1993 and 1994 are used so that two months of data in both the first half and second half of the years are included.
4. Calls and puts of the same exercise price traded within 1 minute are matched.
5. The call and put are further matched with the futures transaction that occurs nearest (must be within a 1-minute interval) to the earlier trade from the matched call and put. Hence, the maximum time difference allowed for matching all three contracts is 1 minute.

The sample contains 8 full months of transaction data from 1993 to 1994. One-month Eurodollar daily rates are used as the lending and the borrowing rates. The Eurodollar rate was between 3% and 6% during this period. For the spot month transactions, there were 42,917 contracts for HSIFs, 3,794 for HSI call and 3,690 for HSI put in April, 1993. By December of 1994, there were 17,659 HSIFs, 19,989 HSI calls and 19,757 HSI puts. By using the 1-minute matching criterion, 317 three-way transactions are identified in 1993 and 536 trades are matched for 1994. Thus, a total of 853 matched trades during an 8-month period from 1993 and 1994 are used in the ex post analysis.

Table III describes the details of trading fees and minimum commissions suggested by the Exchange. The commissions for both futures and options are about HK$200 per contract.[1] Thus, the commissions for all three (put, call, and futures) contracts would cost HK$600. The total trading fees for all three contracts are estimated to be about HK$59.5 (HK$14.5 trading fees and HK$10 settlement fees for one futures contract, HK$25 trading fees for one call and one put and $10 for exercising one option contract[2]). The total trading cost is about HK$659.5 or 13.2 index points (HK$50 = 1 point). Margin requirement on futures and short positions of options is HK$50,000 per contract. Assuming a 6% annual interest rate on short-term loans (i.e., opportunity cost of capital) for institutional traders and 12% for individual investors, the cost of capital for 1 month is about 0.5%–1% of HK$100,000 (assuming a maximum of two long positions in the arbitrage transaction) or HK$500–HK$1,000 (10 to 20 points). Overall, it is possible to take up about 23.2 to 33.2

[1]Two major brokerage firms confirmed that their commissions for one futures or option contract is HK$200 and HK$204, respectively. The fee is for round-trip and the cost is the same even when the client trades one way only.

[2]Table II shows that the trading fees varied several times during the sample period. As the fees are relatively trivial, for simplicity, the mean value of the fees is used in this study. For HISFs, the fee range is HK$12 to HK$17 and the mean is HK$14.5. For HSIOs, the fee range is HK$10 to HK$15 and the mean is HK$12.5.

TABLE III

Trading Fees of HSIFs and HISOs

	Hang Seng Index Futures (HSIFs)		*Hang Seng Index Options (HSIOs) Calls and Puts*			
	Before Aug 15 1993	*After Aug 15 1993*	*Mar 3–Jun 4 1993*	*Jun 5–Aug 15 1993*	*Aug 16–Sep 5 1993*	*After Sep 5 1993*
Exchange fee	$9.5	$9.5	$4.75	$9.5	$9.5	$9.5
SFC levy	$2	$2	waived	waived	waived	$2
Compensation fund levy	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5
Special levy	$5	N.A.	$5	$5	N.A.	N.A.
Total per contract	$17	$12	$10.25	$15	$10	$12
Settlement/ exercise fees	HK$10.00 per contract		HK$10.00 per contract			
Commissions	HK$60 for day trade HK$100 for overnight		The lesser of 1% of contract value with minimum of HK$30; or HK$100. Options that are designated cabinet bids shall not attract a minimum commission, as they have no contract value.			

Cabinet Bids for Index Options:
These are options that are considered worthless and may be closed out at a nominal value of HK$10.00 per contract, which includes all trading fees. These contracts will be displayed on the price reporting screens as CAB bid, because options cannot otherwise be traded at less than the minimum fluctuation of one index point.

Sources: Hong Kong Futures Exchange Ltd. (1995a, 1995b) and personal interviews with brokers.

index points as total costs in a given arbitrage trade. Subsequently, any mispricing of less than 33.2 points in the transaction data may not represent a real arbitrage profit to an investor.

To test eq. (1), a regression model is run with $F_j e^{r(t-T)}$ as the dependent variable; the parity value, that is, $(C_j - P_j + X_j e^{r(t-T)})$, as an independent variable; and ε_j as the random error term. The model is as follows:

$$F_j e^{r(t-)} = \alpha + \beta(C_j - P_j + X_j e^{r(t-T)}) + \varepsilon_j.$$

If the market is practically efficient, the mispricing (or α) must be less than the average cost. In a highly efficient market, the value of α may not be statistically different from zero. Thus, the null hypothesis (i.e., efficient markets) is that $\alpha = 0$ and $\beta = 1$. This is because the actual mispricing per trade will fluctuate about a band, sometimes positive, sometimes negative on the right-hand side of the equation. Consequently, if the magnitude and number of positive and negative mispricings are similar, the regression coefficient, α, or the average mispricing, will be equal to zero.

Ex Ante Tests

Given that violations of the no-arbitrage bounds do occur, it is more realistic to conduct an ex ante arbitrage test. It would be interesting to see if traders may have profited from such ex ante arbitrage trades. In addition, ex post tests assume spontaneous trading of index futures and options at the prevailing observed prices. In reality, traders are not sure if their buying or selling orders are executed according to the observed index futures and options prices. On the contrary, ex ante tests allow the execution of the orders with a time lag after a violation of no-arbitrage bounds occurs.

An ex ante trading simulation is conducted that is similar to the simulations of Lee and Nayar. There is a trade execution time lag after a violation of no-arbitrage bounds is identified. The time interval subsequent to the mispricing (duration) is set in minutes as duration < 5, $5 <$ duration ≤ 10, $10 <$ duration ≤ 15, $15 <$ duration ≤ 30, and $30 >$ duration. To allow a comparison to the ex post tests, two levels of transaction and capital costs of 33.2 and 23.2 index points are assumed to be the triggers for going long or short. In the 33.2 index point level, it is assumed that traders pay the transaction cost plus the 12% interest rate for the money borrowed to satisfy the margin requirement. For the 23.2 index points, traders are assumed to be institutional investors. These in-

stitutional investors pay only 6% interest rate plus the transaction cost, which amounts to 23.2 index points as the total trading costs. Specifically, the ex ante tests are conducted as follows:

1. Mispricings of each transaction are identified;
2. If the mispricing exceeds the minimum required transaction and capital costs (e.g., 23.2 index points and 33.2 points), a short or long hedge execution order follows;
3. After the short or long hedge signals appears, the next available trade within the specified time duration containing the same exercise price and same maturity date is executed;
4. The trading profit or loss is recorded.

RESULTS

Ex Post Tests

Table IV reports the descriptive statistics for the arbitrage profits in index points by month. Although the number of matched trades for 1994 is much larger than that of 1993, the average arbitrage profit before transaction and capital costs are similar (14.2 points for 1993 and 15.81 points for 1994).[3] The month-by-month profits are also similar for the 2 years, ranging from 10.31 points (April 1993) to 24.25 points (May 1994). In fact, the other descriptive statistics, including standard deviation and minimum and maximum values, of the two sample years exhibit very similar characteristics. The overall sample profit is 15.21 points. None of these average profit figures exceed our estimated maximum costs of 33.2 points. Our minimum cost is 23.2 points; only the average profit from April 1994 slightly exceeds it. These results suggest that, on average, no arbitrage profits can be earned after transaction and capital costs are considered.

Out of the 853 trades in the sample, 693 (81.24%) transactions show a profit less than 23.2 index points (the estimated minimum transaction cost). In addition, 87 (10.2%) of them earn a profit more than the lower bound (23.2 points) but less than the upper bound (33.2 points). Finally

[3]Although mean figures are used in discussing the results, the median values are computed as well. The median profit for the sample is 10.1152 points, 10.0171 points for 1993 and 10.1689 points for 1994. In fact, all median profits (including those in Table V) are smaller than their corresponding mean values. These results suggest that the profit distributions are skewed, leading to the conclusion that the ex post arbitrage profits are even smaller and the markets are more efficient if median figures are used.

TABLE IV

Descriptive Statistics for Arbitrage Profits (Points) by Month

	Overall	*1993*	*Apr 93*	*May 93*	*Oct 93*	*Nov. 93*	*1994*	*Apr 94*	*May 94*	*Oct 94*	*Nov 94*
No. of Observatios	853	317	25	33	118	141	536	75	107	164	190
Profit summary statistics											
Mean	15.21	14.20	10.31	22.23	12.23	14.66	15.81	20.42	24.25	12.04	12.48
t value	16.3**	12.9**	4.2**	2.7**	10.4**	12.8**	11.8**	8.2**	4.0**	13.9**	15.4**
S.D.	27.30	19.66	12.29	46.88	12.80	13.64	30.94	21.48	63.01	11.07	11.18
Max	652.99	226.52	54.962	226.52	79.93	84.74	652.99	114.87	652.99	79.86	54.59
Min	0	0	0	0.0078	0.0186	0.0156	0	0.0029	0.0303	0	0

Notes. t values are for the null hypothesis that the mean profit (in points) is equal to zero. The maximum and minimum points are for the corresponding years or periods (month and year). Data source: Hong Kong Futures Exchange.

**Significantly different from zero at the 1% level.

there are only 73 (8.56%) trades that experience an ex post profit higher than 33.2 points (mean profit = 60.63 points). These findings indicate that, for higher-cost traders, 91.44% of all the transactions in the sample do not earn enough profit to justify trading after transaction and capital costs are considered. For more cost-efficient traders (e.g., brokers), 160 (18.76%) transactions provide an arbitrage opportunity. But judging from the size and frequency of the profits, few trades would provide an incentive for the traders to focus on such arbitrage trading.

Table V divides the arbitrage profits by a short hedge strategy (short futures, long call, and short put) and a long hedge strategy (long futures, short call, and long put). The short hedge strategy is used when mispricing (α) is positive, and the long hedge strategy is used when mispricing (α) is negative. The average profits seem to be a little (4.6 points) higher with the long hedge than with the short hedge strategy. Again, the overall average arbitrage profits in Table V do not exceed the estimated total trading cost, indicating that the markets are practically efficient.

The level of arbitrage profits classified by the lower bound and the upper bound of the estimated cost are examined further. For the long hedge strategy, 42 (10.74%) trades earn a profit exceeding 33.2 points (mean profit = 70.72 points), whereas only 31 (6.71%) trades show a profit higher than 33.2 points (mean profit = 46.97 points) under the short hedge strategy. This result suggests that a long hedge strategy provides a slightly better arbitrage opportunity.

Table VI describes the regression results by year and by strategy. All five regressions (overall, 1993, 1994, short hedge, and long hedge) show a β coefficient very close to 1 and a α close to 0. Additional t tests indicate that all the αs are not statistically different from 0 and βs are not statistically different from 1. The F tests for the null hypothesis of $\alpha = 0$ and $\beta = 1$ are not statistically significant either. All models have high adjusted R^2 (0.9885 – 0.9997). These findings strongly support that the two sides of the eq. (1) are statistically the same during the sample period. In short, it can be concluded that the put–call–futures parity condition holds fairly well and the HSIF and HSIO markets are practically efficient in an ex post sense.

Ex Ante Tests

The results of ex ante tests for traders who use 23.2 index points as the trading signal are in Table VII, Panels A and B. For the short hedge strategy in Panel A, there are 44 cases of mispricing. In the overall sample, the mean profit is 18.36 index points and the median profit is 14.21 index

TABLE V

Descriptive Statistics for Arbitrage Profits (Points) by Strategy

Panel A: Short Hedge Strategy (Short Futures, Long Call and Short Put)	*Overall* *N (%) [Mean]*	*1993* *N (%) [Mean]*	*1994* *N (%) [Mean]*
No. of observations	462	174	288
Profits in points			
profit < 23.2 points	385 (83.33%) [8.7234]	145 (83.33%) [7.7417]	240 (83.33%) [9.3861]
23.2 point ≤ profit ≤ 33.2 points	46 (9.96%) [26.9276]	19 (10.92%) [26.7350]	27 (9.38%) [27.0631]
profit > 33.2 points	31 (6.71%) [46.9677]	10 (5.75%) [52.9156]	21 (7.29%) [44.1353]
Profit summary statistics:			
Median	9.9854	9.5259	10.2066
Mean	13.1022	12.4119	13.5192
t value	21.8295**	12.1334**	18.3034**
S.D.	12.9010	13.4937	12.5347
Max	114.8780	84.7373	114.8779
Min	0	0	0

Panel B: Long Hedge Strategy (Long Futures, Short Call and Long Put)	*Overall* *N (%) [Mean]*	*1993* *N (%) [Mean]*	*1994* *N (%) [Mean]*
No. of observations	391	143	248
Profits in point:			
profit < 23.2 points	308 (78.77%) [9.1490]	112 (78.32%) [8.5714]	196 (79.03%) [9.4790]
23.2 point ≤ profit ≤ 33.2 points	41 (10.49%) [27.6179]	18 (12.59%) [26.6037]	23 (9.28%) [28.4117]
profit > 33.2 points	42 (10.74%) [70.7198]	13 (9.09%) [69.3830]	29 (11.69%) [71.3191]
Profit summary statistics			
Median	10.3120	10.2002	10.4219
Mean	17.6994	16.3695	18.4662
t value	9.2888**	7.8005**	6.7108**
S.D.	37.6778	25.0947	43.3341
Max	652.993	226.524	652.993
Min	0.0029	0.0156	0.0029

Notes: t values are for the null hypothesis that the mean profit (in points) is equal to zero. The numbers in parentheses are the percentage of observations that fall into the various profit ranges. The numbers in square brackets are the mean values of the profits in points.
**Significantly different from zero at the 1% level.

points which, again, is less than the trading cost of 23.2 index points. Hence, on average and on median, the trades executed do not yield profits that are able to recover trading cost. With respect to different durations, trades that are executed after the first 5 minutes of trading signals yield only below trading cost profits. Nevertheless, there are 19 cases in the first 5 minutes of mispricing able to yield an average of 31.43 index points of profit. The long hedge strategy in Table VII is more unattractive than the corresponding short hedge strategy.

TABLE VI

Regression Results by Year and by Strategy

	Overall	*1993*	*1994*	*Short Hedge*	*Long Hedge*
Dependent variable	$F_i e^{r(t-1)}$	$F_i e^{r(t-1)}$	$F_i e^{r(t-1)}$	$F_i e^{r(t-1)}$	$F_i e^{r(t-1)}$
Independent variable	$C_i - P_i + X_i e^{r(t-1)}$	$C_i - P_i + X_i e^{r(t-1)}$	$C_i - P_i + X_i e^{r(t-1)}$	$C_i - P_i + X_i e^{r(t-1)}$	$C_i - P_i + X_i e^{r(t-1)}$
Intercept (α)	−2.7212	−5.6526	−1.5025	4.3716	−27.6596
t value	(−0.211)	(−0.485)	(−0.035)	(0.649)	(−1.091)
β	1.0002	1.0006	1.0000	1.0010	1.0011
t value ($\beta = 1$)	(0.1324)	(0.4390)	(0.0051)	(1.3010)	(0.3942)
N	853	317	536	462	391
F statistics for $\alpha = 0$ and $\beta = 1$	0.0176	0.1924	0.0000	1.5149	0.1554
Adj R^2	0.9983	0.9994	0.9885	0.9997	0.9970

Notes: The *t* values for α are testing the null hypotheses of $\alpha = 0$ and the *t* values for β are testing the null hypotheses of $\beta = 1$. The *F* statistics are for the null hypotheses of $\alpha = 0$ and $\beta = 1$.

TABLE VII

Descriptive Statistics for Arbitrage Profits (Points) Using Ex Ante Tests with 23.2 Points as the Mispricing Criteria (Trading Signal)

Panel (A): Short Hedge Strategy (Short Futures, Long Call and Short Put)

	Overall	*1993*	*1994*
	N (%) [Mean]	*N (%) [Mean]*	*N (%) [Mean]*
No. of observations	*44*	*9*	*35*
Time interval subsequent to the mispricing:			
duration ≤ 5 min	19 (43.18) [31.4270]	3 (33.33) [6.7954]	16 (45.71) [36.0454]
5 min < duration ≤ 10 min	6 (13.64) [7.0898]	3 (33.33) [25.1943]	3 (8.57) [−11.0146]
10 min < duration ≤ 15 min	1 (2.27) [25.3904]	—	1 (2.86) [25.3904]
15 min < duration ≤ 30 min	4 (9.09) [6.0587]	1 (11.11) [5.3205]	3 (8.57) [6.3048]
duration > 30 min	14 (31.82) [8.4607]	2 (22.22) [18.648]	12 (34.29) [6.7628]
Profits in points:			
profit < 23.2 points	25 (56.82) [0.4792]	6 (66.67) [6.3151]	19 (54.29) [−1.3637]
23.2 points ≤ profit < 33.2 points	6 (13.64) [27.5617]	1 (11.11) [30.1637]	5 (14.29) [27.0413]
profit > 33.2 points	13 (29.55) [48.4906]	2 (22.22) [35.2657]	11 (31.43) [50.8951]
Profit summary statistics:			
Median	14.2081	17.1581	13.3206
Mean	18.3574	15.3984	19.1183
t-value	4.82**	2.88**	4.14**
S.D.	25.29	16.0655	27.2991
Max	86.918	35.3677	86.918
Min	−30.648	−4.9576	−30.648

Panel (B): Long Hedge Strategy (Long Futures, Short Call and Long Put)

	Overall	*1993*	*1994*
	N (%) [Mean]	*N (%) [Mean]*	*N (%) [Mean]*
No. of observations	*44*	*16*	*28*
Time interval subsequent to the mispricing:			
duration ≤ 5 min	15 (34.09) [11.4256]	5 (31.25) [4.6886]	10 (35.71) [14.7941]
5 min < duration ≤ 10 min	1 (2.27) [−5.0475]	—	1 (3.57) [−5.0475]
10 min < duration ≤ 15 min	1 (2.27) [1.8825]	1 (6.25) [1.8825]	—
15 min < duration ≤ 30 min	5 (11.36) [15.7454]	3 (18.75) [27.9095]	2 (7.14) [−2.5008]
duration > 30 min	22 (50.00) [8.7890]	7 (43.75) [1.3034]	15 (53.57) [12.2822]
Profits in points:			
profit < 23.2 points	33 (75.00) [2.4993]	13 (81.25) [2.1503]	20 (71.43) [2.7262]
23.2 points ≤ profit ≤ 33.2 points	7 (15.91) [25.8378]	2 (12.5) [25.0692]	5 (17.86) [26.1453]
profit > 33.2 points	4 (9.09) [44.2403]	1 (6.25) [40.0857]	3 (10.71) [45.6252]

TABLE VII (Continued)

Descriptive Statistics for Arbitrage Profits (Points) Using Ex Ante Tests with 23.2 Points as the Mispricing Criteria (Trading Signal)

Panel (A): Short Hedge Strategy (Short Futures, Long Call and Short Put)

	Overall	*1993*	*1994*
	N (%) [Mean]	*N (%) [Mean]*	*N (%) [Mean]*
No. of observations	*44*	*9*	*35*
Profit summary statistics:			
Median	5.4419	5.1281	7.94305
Mean	10.0069	7.3861	11.5045
t-value	3.8558**	1.88*	3.36**
S.D.	17.2151	15.7239	18.1170
Max	50.1383	40.0857	50.1383
Min	−14.8921	−14.8921	−14.8625

Notes: *t*-values are for the null hypothesis that the mean profit (in points) is equal to zero. The numbers in parentheses are the percentages of observations that fall into the various profit ranges. The numbers in square brackets are the mean values of the profits in points.

**Significantly different from zero at the 1% level.

Generally, the results in Table VII suggest that although the mean and median profits are positive and statistically significantly different from zero, they are not attractive once the trading cost is considered. Nevertheless, there are some cost-adjusted profitable trades with the short hedge strategies within the first 5 minutes of mispricing. If trades are executed within the first 5 minutes after the mispricing signal, there are 7 out of 17 trades in excess of 23.2 points in (Table VII, Panel A). However, these profitable trades are not economical. This is because the frequency of such profitable mispricing opportunities is so low that it is difficult to justify hiring investment professionals to specialize in such activities. The results of ex ante tests for traders who use 33.2 index points as the trading signal are similar to those of Table VII. To conserve space, the findings of using 33.2 index points as the trading signal are not reported here.[4]

CONCLUSION

This study investigates the joint pricing efficiency of the Hong Kong Hang Seng index futures and index options markets. By using 853 transaction

[4]There are 20 cases of mispricing that exceed the 33.2 index points out of a total 853 observations. The mean and median ex ante profits are approximately 25.23 and 22.45 index points, respectively, for the overall short hedge sample. The trades do not yield a profit that recovers the trading cost of 33.2 index points. With respect to the time interval subsequent to the mispricing, it seems that trades executed within the first 5 minutes of mispricing yield better results with an average of 36.55 index points profit. These results are available from the authors upon request.

triplets involving futures, call, and put contracts matched within a 1-minute interval in 1993 and 1994, it is found that 91.44% of all transactions do not earn enough ex post profits to justify arbitrage trading when a total cost of 33.2 points is assumed. The sample is divided further by trading strategy, and it is found that a long hedge strategy results in better arbitrage opportunities than short hedge strategy. The regression results also show that, on average, no arbitrage profit is found in the total sample or in the subsamples by year and by strategy. Finally, ex ante tests are conducted with 23.2 and 33.2 points as trading signals. The average profit is found to be less than the trading costs. Hence, trading based on such mispricing strategies are not practically attractive. This study suggests that the index futures and index options markets in Hong Kong are practically efficient during the 1993–1994 sample period. This result supports the work of Lee and Nayer (1993), who found that arbitrage using index options and futures cannot generate abnormal profits. Because Lee and Nayer examined U.S. data, whereas this article analyzes Hong Kong data, this study concludes that the result of no arbitrage is robust across different markets.

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