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Price Efficiency of Stock Index Futures Contracts: Are There Any Arbitrage Opportunities?

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ABSTRAK

Kontrak niagaan ke depan adalah perjanjian antara pembeli dan penjual sesuatu komoditi yang menetapkan harga, kuantiti dan kualiti komoditi tersebut dan masa bila urus niaga ini akan berlaku. Aset atau komoditi yang terlibat dalam kontrak niagaan ke depan indeks saham ialah seratus saham-saham indeks komposit Bursa Saham Kuala Lumpur (BSKL). Salah harga kontrak boleh berlaku apabila terdapat perbezaan ketara antara harga kontrak niagaan ke depan di pasaran dengan harga kontrak niagaan ke depan yang sepatutnya atau harga sebenar yang dinilai dengan menggunakan kaedah "Cost and Carry". Salah harga ini boleh berbentuk harga berlebihan atau harga berkurangan. Harga kontrak niagaan ke depan berlebihan berlaku apabila harga pasaran kontrak melebihi harga sebenar dan kos urus niaga. Harga berkurangan berlaku apabila harga pasaran kontrak niagaan ke depan adalah kurang dari harga sebenar dan kos urus niaga. Salah harga kontrak niagaan ke depan memberi peluang kepada pelabur untuk meraih keuntungan dengan memperbetulkan perbezaan antara harga pasaran dan harga sebenar, iaitu dengan menjual kontrak niagaan ke depan dan membeli saham indeks komposit BSKL apabila berlaku harga berlebihan dan membeli kontrak niagaan ke depan dan menjual (atau menjual pendek) saham-saham indeks komposit BSKL apabila berlaku harga berkurangan. Aktiviti pembetulan ini dikenali juga sebgai aktiviti arbitraj, yang membantu mempertingkatkan kecekapan harga kontrak niagaan ke depan. Kajian ini menilai peluang arbitraj atas harga harian kontrak bulanan niagaan ke depan indeks komposit BSKL, atau dikenali sebagai kontrak FKLI bagi jangka masa 1996 hingga 1999. Kecekapan harga kontrak niagaan ke depan dinilai dengan kaedah ralat piawai antara harga pasaran dengan harga sebenar kontrak niagaan ke depan. Penemuan kajian menunjukkan adanya berlebihan dan berkurangan harga kontrak niagaan ke depan, tetapi tidak ada aktiviti arbitraj untuk menyatukan harga sebenar dengan harga pasaran kontrak. Ini kemungkinan, di antara faktor lain, kerana pelabur tidak boleh menjual pendek saham-saham indeks komposit BSKL apabila berlakunya berkurangan dalam harga kontrak niagaan ke depan. Penemuan juga menunjukkan perubahan harga kontrak niagaan ke depan tidaklah berekanada tetapi berubah mengikut masa yang menyebabkan ada jangka masa yang menunjukkan harga kontrak berlebihan dan ada jangka masa di mana harga kontrak niagaan ke depan berkurangan, menepati tahap kecekapan harga kontrak yang berbeza mengikut masa.

ABSTRACT

A futures contract is an agreement between a seller and a buyer that calls for the seller to deliver to the buyer a specified quantity and grade of an identified commodity, at a fixed time in the future, and at a price agreed in the contract. Stock index futures contract specify an equity index as the underlying asset. Arbitrage opportunity exists when the actual futures price deviates from the fair price by more than transactions costs. This study measures the arbitrage opportunities on the daily FKLI contracts price from calendar years 1996 through 1999. The pricing efficiency of the futures contracts was determined by the standard error between the closing actual and theoretical fair values for each month FKLI futures contract, where the theoretical value was estimated using the cost-of-carry model. The findings show that the actual futures prices do not converge towards theoretical prices with the passage of time. Arbitrage opportunities are

consistently available for traders who have full use of proceeds. One crucial assumption driving this result is the ability to sell short the cash index (or a subset of stocks in the KLSE CI). The results also reveal that the stock index futures contract pricing is not monotonic but rather varies over time with periods of both greater and lesser efficiency.

INTRODUCTION

A futures contract is an agreement between a seller and a buyer that calls for the seller to deliver to the buyer a specified quantity and grade of an identified commodity, at a fixed time in the future, and at a price agreed in the contract. All futures contracts are traded on designated futures exchanges. Futures markets had their start in agriculture, with the introduction of commodity futures contracts that provided farmers, distributors, and processors of agricultural products to shift the price risk of their output to speculators. Financial futures contracts based on financial instruments as the underlying asset were first introduced in 1972 with the introduction of currency futures traded on the International Monetary Market. In 1975 the Chicago Board of Trade pioneered trading in interest rate futures and the stock index futures were introduced in 1982 on the Kansas City Board of Trade (KCBT).

Stock index futures contract specify an equity index as the underlying asset. It is an agreement between a seller and a buyer to respectively deliver and take delivery of a basket of shares that makes up the index, at an agreed price at a specific future date. However, these contracts are usually cash-settled avoiding the need to deliver all the shares that make up the underlying stock index.

Stock index futures contracts provide financial executives and money managers' a risk management tool to reduce potential losses on a cash position.

Futures provide a more effective and flexible alternative to adjusting the returns and risk characteristics of a cash position. For example, using either betas or portfolio analysis only allows the investor limited flexibility in changing the amount of risk in the portfolio. Moreover, betas and portfolio risk measures change over time. It also provides speculators a degree of leverage that typically is not available with other instruments and allow speculators to change their risk profiles.

Besides helping to hedge risk and alter the risk profile of a cash portfolio, stock index futures contracts also perform the price discovery function. That is the stock index futures contract prices reflect the combined views of a large number of buyers and sellers as to the current supply/demand situation and the relationship of prices 12 to 18 months hence. It is an expression of opinions concerning today's expectations about the level of market or stock index performance at some point in the future. As conditions change, opinions change and prices of futures contracts also change. The expected changes in futures prices become important inputs for market participants in making effective hedging and speculative decisions.

Besides the hedging and speculation, stock index futures can be used for arbitrage activities. Arbitrage is risk-free and costless activity that aligns the fair price of a futures contract with the current price of the contract in the market. The logic underlying index arbitrage is that the theoretical futures price should equal that of a portfolio of stocks composing the index plus the net cost of carrying the stocks until delivery. If the futures price exceeds the price of the portfolio by the net cost of carry, it would be profitable for the arbitrager to buy the index portfolio and sell futures against it. If the futures price were less than the price of portfolio and the costs, it would be profitable for the arbitrager to buy the futures contract and sell the index portfolio. Such actions force the futures price back toward the fair price. The buying of the futures contracts is usually done in anticipation of share price increase and selling in anticipation of share price decrease. However, expectations can be wrong, and if expectations are wrong then the selling of the underlying shares (in case of buying the futures contracts when they are undervalued) and buying the underlying shares (when the futures contracts are sold when they are overvalued) will generate some gains to buffer losses. Without arbitrage, the futures price could deviate significantly from the fair price, causing hedgers to avoid using futures markets because of poor hedging results and the uncertainty of the pricing process.

The pricing of futures contracts and arbitrage between futures and cash are closely

related concepts. The fair price of a futures contract is determined by a pricing model that incorporates the value of the underlying cash asset, the time to expiration of the futures contract, the cost of financing the cash position, the cash inflows of the asset, and any special characteristics of the futures contract at expiration. In perfect markets – that is, when transactions costs and tax effects are not relevant – the actual futures price equals the fair price. Real futures markets are not perfect and there will always be opportunities to arbitrage the differences in the fair and actual prices of futures contracts and in the process aligning these prices, while earning arbitrage profits. The research issue addressed in this paper is whether arbitrage opportunities exists on the FKLI contracts and whether the futures market is price efficient over time.

THE MALAYSIAN STOCK INDEX FUTURES CONTRACTS

In Malaysia, the stock index futures contracts were introduced on the Kuala Lumpur Options & Financial Futures Exchange ("KLOFFE") on 15 December 1995. Since June 2001, KLOFFE is observed under the MDEX a Malaysian Derivatives Market. The contracts also recognized that FKLI futures contract are based on the 100 Kuala Lumpur Stock Exchange Composite Index (KLSE CI) stocks. Contract specifications of the FKLI futures call for delivery of a basket of shares, which makes up the KLSE CI. However, the contracts are always cash-settled. Cash settlement means that at the time of delivery, the seller of the futures contract does not have to deliver to the buyer the 100 KLSE CI shares, but rather will exchange cash equal to the difference between the price of the index in the futures contract and the price of the underlying index at the time of delivery. The underlying cash "value" of the contract is determined by multiplying the Index by value 100. The minimum change (tick) in the Index is 0.1, which is worth RM10. A change of one index point is worth RM100 (that is 100 x1.0).

OBJECTIVE

Futures contracts traded on the KLOFFE should reflect the actual worth of the asset in a future period. Theoretically, the futures price should equal the cash price of the asset (KLSE CI) plus the transaction costs. Arbitrage exists when the actual futures price deviates from the fair price by more than transactions costs. When sufficiently large profits above the risk-free return exist, arbitragers step in and buy the lower-priced security (the cash asset) and sell the higher priced security (the futures contract). Such actions force the futures price back toward the fair price. Profits are realised by unwinding the positions when the prices of the securities get properly aligned. Without arbitrage, the futures price could deviate significantly from the fair price, causing hedgers to avoid using futures markets because of poor hedging results and the uncertainty of the pricing process. This study measures the arbitrage opportunities on the daily FKLI contracts price from calendar years 1996 through 1999. To test the pricing efficiency of the futures contracts, the standard error between the closing actual and theoretical fair values for each month FKLI futures contract for the same period. The measurement period for each contract was the 18-22 tracking days when the contract was the spot month. The spot month contract has, so far, been the most liquid, making this period the most appropriate for measuring market efficiency. If the FKLI futures market becomes more price efficient, the standard errors should decline over time, implying lesser opportunities for arbitrage.

MODEL SPECIFICATION

The cost of carry model explains the relationship between the cash asset price and futures price. It shows the relationship created between these markets when an arbitrager buys the cash asset now, holds and finances the asset with borrowed funds for the life of the futures contract, and then delivers the cash asset into the futures contract when the futures expire. The fair futures price calculated by the cost of carry model for stock index futures must consider the dividends received from holding the stocks in the index that is,

$$P_{FAIR} = P_C (1 + i)^t - D \qquad (1)$$

where

P_{FAIR} = the fair futures price for a stock index
P_C = the current value of the underlying cash stock index
i = the financing rate of interest or equivalent investment return desired

D = the Ringgit dividend amount in index points received on the stocks in the index from now until the expiration of the futures contract

t = number of days until expiration of the futures divided by 365

Equation (1) illustrates both the relationship between the futures and current cash values and the net difference between the financing (or opportunity) costs and the income received.

The Ringgit dividend, D, must be recalculated whenever a stock in the index pays its dividend or a firm alters its dividend. The model shows that the effect of receiving dividends over the life of the futures contract is to lower the futures price. This relationship occurs because (a) the dividends received reduce the net funds needed to finance the cash position and (b) a purchase of the futures contract is an alternative to holding the cash stocks, but a long position in futures does not provide any income from dividend payments.

The continuous time equivalent to the above cost of carry equation is used frequently, since only the dividend yield rather than the frequency changing total Ringgit dividends are needed for its calculation:

$$P_{FAIR} = P_C \, e^{(i - d)t} \qquad (2)$$

where d = the dividend yield on the stock index
If one has only the dividend yield, then an alternative to using Equation (2) is to convert the yield to Ringgit dividends, as shown in Equation (3)

$$D = d \, P_C \, t \qquad (3)$$

Note that Equation (1) provides the most accurate calculation of the effects of dividends and therefore is employed in many of the arbitrage computer models.

Equations (1) and (2) and Example 1 illustrate both the relationship between the futures and current cash index values and the net difference between the financing costs and the dividend income received. In particular, the larger the difference between i and d, the larger the price difference between P_{FAIR} and P_C. In addition, the larger the value of t, the larger the price difference between the futures and cash index values.

Example 1 also illustrates that Equations (1) and (2) used for determining the fair futures price, $P_{FAIR,}$ can provide slightly different values. Which equation the trader employs depends on the trader's beliefs concerning which equation best describes the cash flow process.

When the actual stock index futures price differs from the cost of carry forward price by more than transactions costs, arbitrage opportunity is created. Equation (1) can be expressed to include transactions costs to define the arbitrage opportunities for stock index futures:

$$P_C \, (1 + i)^t - D + T < P_F < P_C \, (1 + i)^t - D - T \qquad (4)$$

or more compactly as

$$P_{FAIR} + T < P_F < P_{FAIR} - T \qquad (5)$$

with T being the total transactions costs.

DATA

The data on the closing FKLI futures contracts prices was obtained from KLOFFE. The closing KLSE CI values and 90-days Malaysian T-bills rate were obtained from Bank Negara Malaysia. The dividend yield values for the KLSE CI was obtained from the *Investor's Digest*. The risk-free rate was the yield of the 3-months Treasury Bills security maturing nearest to the expiration date of each contract. The data was collected for a 4-year period from February 1996 to December 1999.

FINDINGS

The fair value of futures prices is calculated using a cost-of-carry model (Equation 1). The extent of deviation of the market price of futures contract (FKLI) from their fair values is defined as a percentage of futures market premium over futures fair values, π, as,

$$\pi = \ln (P_F / P_{FAIR})$$

where,

π is the percentage premium of the FKLI price over fair value

P_F is the FKLI price and

P_{FAIR} is the FKLI fair value as implied from the KLSE CI price

EXAMPLE-1 : Determining the Fair Value of a Stock Index Futures Contract

The following values represent actual stock market values:

KLSE CI	319.72
3-months T-bill yield	6.59%
Dividend yield on the Index stocks	3.02%
Days until expiration of the futures	84

Using these data, the fair price is calculated as follows:

$$P_{FAIR} = P_C\, e^{(i-d)t}$$
$$P_{FAIR} = 319.72\, e^{(0.0659-0.0302)(84/365)}$$
$$= 319.72\, e^{0.0082159}$$
$$= 322.36$$

Equation (1) can also be used to calculate the fair price if the dividend yield first is converted to total Ringgit dividends (or if the total Ringgit dividends expected over the life of the futures contract are added up separately for the individual stocks). Equation (3) is employed to convert dividend yields to dollar dividends:

$$D = d\, P_C\, t$$
$$D = (0.0302)(319.72)(84/365) = 2.222$$

Then one is able to calculate the fair price as follows:

$$P_{FAIR} = P_C\,(1+i)^t - D$$
$$P_{FAIR} = 319.72\,(1+0.0659)^{84/365} - 2.222$$
$$= 322.23$$

Notice that the two calculated values for the fair futures price differ slightly. There are two reasons for this. Most important, Equation (1) calculates the dividend value in index points, whereas Equation (2) uses the dividend yield. Moreover, the first formulation uses discrete compounding, whereas the second employs continuous compounding.

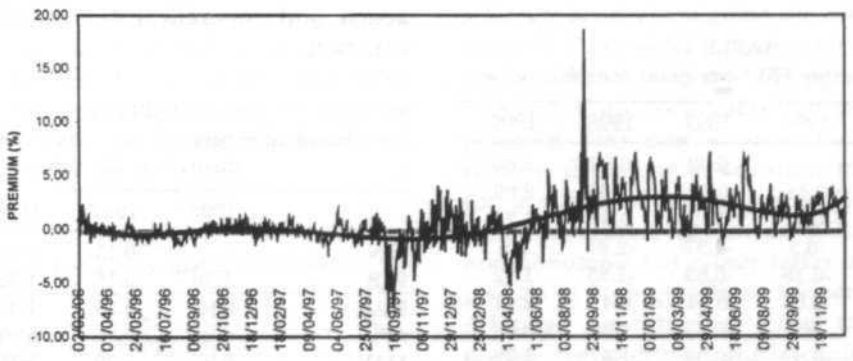

Fig. 1: Plots of future premium over the period

Fig. 1 plots the percent of mispricing of each contract on a daily basis. This percent is the difference between the actual and theoretical price expressed as a percent of the theoretical price. The plot shows considerable deviation of FKLI prices from fair value during the crisis period, from September 1997 onwards. The September 1997 contract was undervalued by as much as 7.86% at the beginning of the financial crisis. By contrast, the September 1998 contract was overpriced by 18.67% and this was the month when Malaysia implemented the capital and exchange controls. Overall, the 1996 contracts traded approximately at fair value compared to contracts in the later years (September 1997 onwards).

Fig. 2 shows the distribution of the futures premium, p over the fair value. The frequency of distribution is positively skewed indicating more numerous positive and persistent premiums compared to negative premium. This means, on average, the futures contracts are overpriced,

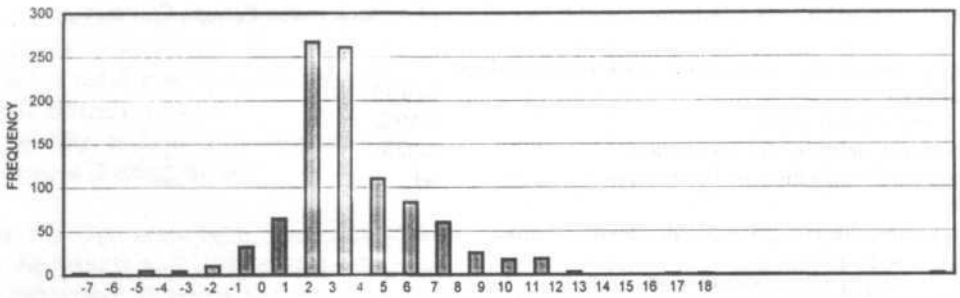

Fig. 2: Distribution of the FKLI premium over fair value

that is market price of futures contracts is higher than their fair price.

Table 1 shows that the FKLI futures for year 1996 and 1997 were undervalued by 0.14% and 0.42% respectively. Ignoring transaction costs, there were a long futures arbitrage opportunities in both years. Profits from long futures arbitrage is generated when the actual futures price is less than the fair price plus transactions cost which is usually a constant for stock index futures contracts. The way to implement the arbitrage is to buy the undervalued futures and sell the KLSE CI shares (assuming that short selling of shares is allowed).

TABLE 1
Average monthly FKLI premium over fair value

	1996	1997	1998	1999
JAN		0.02	0.09	3.36
FEB	0.54	0.04	-0.31	2.09
MAR	-0.02	0.19	0.37	1.24
APR	-0.3	-0.37	-2.21	2.6
MAY	-0.18	-0.85	-1.55	1.72
JUN	-0.65	0.14	0.48	2.01
JUL	-0.3	-0.37	1.55	3.02
AUG	-0.82	-0.39	1.67	1.76
SEP	-0.33	-3.21	4.06	1.26
OCT	0.21	-1.54	3.98	1.21
NOV	0.27	0.16	3.09	2.22
DEC	0.09	1.09	3.37	2.04
AVERAGE	-0.14	-0.42	1.22	2.04

For the year 1998 and 1999, the FKLI futures were overvalued by 1.22% and 2.04% respectively. Since the actual futures price is greater than the fair price, selling the higher-priced futures contract and purchasing shares of the KLSE CI index generates an arbitrage profit. This represents a short futures arbitrage opportunity.

To test the pricing efficiency of the futures contracts or in other words the gradual convergence of the market price to the fair price of futures contracts, the standard error between the closing actual and theoretical fair values for each month FKLI futures contract was estimated and the results are summarized in Table 2. If the FKLI futures market is getting more efficient, then there should be a narrowing of the difference in the market and fair price of futures contract (also indication of active arbitrage activity) indicated by declining values of standard errors over time. Fig. 3 plots the monthly standard errors between the closing actual and theoretical fair value of futures contracts.

TABLE 2
Standard errors of the actual closing and theoretical fair value

	1996	1997	1998	1999
JAN		0.15	2.54	19.06
FEB	1.30	0.15	1.33	8.21
MAR	0.09	0.19	1.40	4.77
APR	0.21	0.32	8.92	9.29
MAY	0.27	1.20	5.19	8.42
JUN	0.58	0.65	1.53	5.80
JUL	0.21	0.57	6.42	17.60
AUG	0.98	2.35	5.12	4.88
SEP	0.39	16.86	41.34	3.20
OCT	0.16	5.57	24.08	2.52
NOV	0.22	2.35	13.19	6.09
DEC	0.37	4.52	17.54	5.87
AVERAGE	0.44	2.91	10.72	7.97

Table 2 and Fig. 3 show that the standard errors are not declining but rather increasing over the period of analysis suggesting that the pricing efficiency of FKLI futures contract has declined over time. This also implies lack of

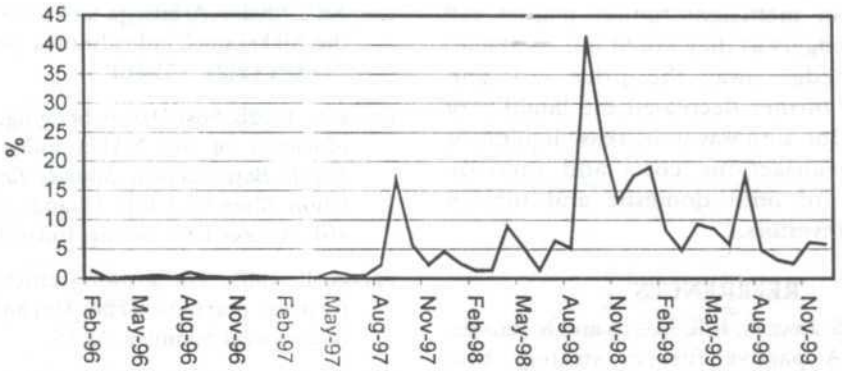

Fig. 3: Standard error between the closing actual and theoretical fair value

active arbitrage activity to correct the differences between actual and fair price of futures contracts. This also implies that the futures market creates more opportunities for speculating rather than hedging; as it is difficult for hedgers to use the inefficiently priced futures contract to cover their price risk.

A regression analysis between the theoretical and actual value of futures contracts confirms a positive and significant relationship with 99.78% of the variation in the theoretical value explained by the changes in the actual value of the futures contract.

Details of the regression analysis are summarized in Table 3. The positive relationship is vital for hedgers to construct an effective hedge to cover the price risk on their cash portfolio.

TABLE 3
Relationship between actual and fair prices

Mean, P_F	825.6531
Mean, P_{FAIR}	822.0683
a	-14.4293
b	1.0131
r	0.9989
R^2	0.9978
t	661.9527
n	965

CONCLUSION

Arbitrage activity on the stock index futures contracts links the cash stock market to the stock index futures market. Arbitrages ensure that futures market values do not diverge too much from fair values, and arbitrage profits are created if the divergence exceeds the costs of transactions. This implies a predictable positive relationship between cash and futures prices, which is vital to hedgers to hedge the price risk of their cash portfolios using stock index futures.

This study provides some preliminary evidence of the efficiency of the FKLI stock index futures based on the simple "cost-of-carry" model. The findings suggest that the actual futures prices do not converge towards theoretical prices with the passage of time. This pricing inefficiency might be due to the infancy of FKLI futures market and immaturity of the arbitrage activity in aligning the cash and futures markets. This implies that arbitrage opportunities are consistently available (though do not seem to be taken up) for traders who have full use of proceeds. One crucial assumption driving this result is the ability to sell short the cash index (or a subset of stocks in the KLSE CI). The results also reveal that the stock index pricing is not monotonic but rather varies over time with periods of both greater and lesser efficiency. Arbitrage opportunities exists when risk-free profits are possible, which occurs when the futures and market prices deviate by more than transactions costs. Usually in developed markets, arbitrage opportunities are available to insiders and are quickly exploited thereby increasing the pricing efficiency of futures markets. Therefore, stock index arbitrage is a self-regulating mechanism that increases the price efficiency of the futures markets. However, the findings of this study show a continuous inefficiency of the futures market and thereby existence of arbitrage opportunities for traders. This implies that our futures market requires greater liquidity to enable arbitragers to correct any mispricing and consequently increase price efficiency of futures

contracts. An inefficient futures market will deter away hedgers as they would not be able to effectively hedge away the price risk and consequently further decreased the liquidity of the market. One sure way to increase liquidity is to reduce transactions costs and increase participation of both domestic and foreign institutional investors.

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