THE COMPARISON OF PRICING PERFORMANCES BETWEEN COST OF CARRY MODEL AND IMPERFECT MARKET MODEL: AN EMPIRICAL STUDY ON SET 50 INDEX FUTURES

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Abstract

Choosing the right pricing approach is the key to deriving the true derivatives prices. This paper aims to compare the pricing performance of the cost of carry model and the imperfect market model in pricing the SET 50 index futures prices. This study replicates the study of Wang (2007) that compares the futures pricing performances of the cost of carry model and the imperfect market model in the Stock Exchanges of Japan, Hong Kong, Korea, and Taiwan. By using the mean percentage errors and the mean absolute percentage errors as criteria in measuring the pricing performances of two models, the empirical results indicate that the highly imperfect financial market like SET 50 index futures market is relatively mispriced based on the model of perfect market assumption, suggesting that the suitable approach in pricing the SET 50 index futures is the imperfect market model. Relying on the perfect market assumption evidences an enormous misprice especially when the calculation is based on the calendar days. Therefore practitioners should identify the appropriate pricing method before estimating the theoretical prices of stock index futures.

INTRODUCTION

Derivatives have a long history in the world of finance. The basic derivatives include forward, futures, swap, and option, whose values depend on the values of the other underlying variables. Futures and forward contracts are the agreement between two parties to buy or to sell a certain product at a certain future time for a fixed certain price but trading futures are on the exchange. Futures are now trading actively on many exchanges throughout the world, however, futures contracts on financial product has just been launched in Thailand Futures Exchange Ptc (TFEX) on April 28, 2006.

The TFEX, a subsidiary of The Stock Exchange of Thailand (SET), was established on May 17, 2004 as a derivatives exchange. The TFEX is governed by the Derivatives Act B.E. 2546 (2003) and is under the supervision of the Securities and Exchange Commission (SEC). SET 50 index futures is the first derivatives product in TFEX, which has the contract months in March, June, September, December, and the contract multiplier is THB 1,000 per index point1. As TFEX is a new emerging derivative exchange in Thailand, it is trying to stimulate both retail and institutional investors to manage their equity exposures by entering into these contracts. TFEX’s website provides many instruments to support trading for the investors including a program for calculating the futures price. The cost of carry model is the only pricing method in this program.

LITERATURE REVIEW

Pricing approach is a key issue for the practitioners in measuring the right price for derivatives products. Most financial theories are founded on the perfect market assumption. The cost of carry model is also one that relies on the perfect market assumption and no arbitrage argument in pricing futures. However, the real capital markets are not completely perfect, and the arbitrage mechanism does not work completely especially for index arbitrage. First, index arbitrage involves transactions costs including commission cost, bid-ask spread, and taxes. Second, the basic perfect assumption of borrowing and lending at risk-free rate and asymmetric information is in question. Third, the impact of short sale restrictions exists. Pope & Yadav (1994) explain the impact of short sales constraints on index stock. If the short sales are prohibited, short arbitrage is impossible except for the market participants already owning equity stock. To examine the effect of short sales restrictions, they examine the futures contracts on the London Stock Exchange. They conclude that short sales constraints are a significant factor leading to futures under-pricings. In addition, Fung & Draper (1999) analyze the model mispricing of the Hong Kong Hang Seng Index futures contracts for the period April 1, 1993 to September 30, 1996. They find that the short sale constraints affect the mispricing of futures contracts; however, relaxing the constraints reduces the extent of futures mispricing. Fourth, traders cannot quickly process all the information. Taylor (1989) finds that the markets do not appear to be perfectly efficient especially during the periods of turbulence.

There is much evidence showing the discrepancies between the actual and theoretical values estimated by the cost of carry model. Wang (2007) compares the cost of carry model and the imperfect market model by using Nikkei 225 Futures listed on the Osaka Securities Exchange (OSE) in Japan, Hang Seng Futures listed on the Stock Exchange of Hong Kong, KOSPI 200 Futures listed on the Korean Stock Exchanges, and SGX Futures listed on the Taiwan Stock Exchange during July 2, 1997 - December 31, 2005. The results show that the cost of carry model mispriced the stock futures contract for the immature markets and the turbulent periods with high market imperfection. Brailsford & Cusack (1997) examine the pricing of equity futures by comparing the performance of three models: the cost of carry method and two models which incorporate stochastic interest rate. The paper uses ten individual Share Futures (ISF) contracts during year 1994-1995 for analysis. The evidence shows that the pricing errors in ISF contract are consistent across all models especially in the cost of carry model. The finding implies that there are some risk premiums associated with the futures contract that cannot be captured by the pricing models caused by the dividends under the imputation tax system.

In contrast, a number of studies found that arbitrageurs quickly eliminate the mispricing, and the cost of carry model is supported in highly competitive financial markets. Bailey (1989) examines the power of the cost of carry model to predict market price in Japanese Stock index contracts during June 9 to October 31, 1987. The analysis shows that the theoretical pricing models are reasonably accurate in predicting the futures price. This result is also supported by Wang (2007), who shows that the cost of carry model is suitable for pricing Nikkei 225 futures. However, some studies have observed that the cost of carry model is still usable in the emerging market with high degrees of imperfection. Gay & Jung (1999) examine the persistent under-pricing in Korean stock index futures market during the period of May 3, 1996 - May 12, 1998. The results show that the standard cost of carry model cannot be rejected as it provides a reasonable explanatory power to the futures price. The under-pricing characteristic of futures contract in Korean stock index futures occur because of unique restrictions on short sales and the accounting conventions in the Korean markets.

Consequently, the question of pricing model for the newly emerging futures market like TFEX arises. Motivated by the Wang (2007), this paper aims to predict deviations of actual SET 50 index futures prices from the theoretical prices based on the model of perfect market assumption and apply the imperfect market model initiated by Hsu & Wang (2004) to examine whether this model can effectively predict stock index futures prices in Thailand.
Theoretical Valuation Models

3.1 The Cost of Carry Model

To price the stock index futures, the cost of carry model is a standard model based on the assumptions of perfect markets and no arbitrage argument. If the interest rates are non-stochastic and dividends provide a known yield, the cost of carry model (Wang; 2007, Hull; 2006) can be defined as:

\[ F_t = S_t e^{(r-q)(T-t)} \]  

where \( F_t \) is the theoretical futures price at time \( t \); \( S_t \) is the current stock index; \( r \) is the annualized risk-free interest rate; \( q \) is the average annualized dividend yield in percentage term; and \( T-t \) is the annualized time to maturity.

If the underlying stock index provides the cash income rather than the known dividend yield, the cost of carry model can be defined as:

\[ F_t = (S_t - D_t) e^{(r-q)(T-t)} \]  

where \( D_t \) is the present value of income amount receives from the underlying stock index during the life of futures contract.

The arbitrage mechanism works completely in deriving valuation model under the perfect market assumption. A hedged position consisting of stock and futures can be rebalanced to remain riskless. However, much evidence shows that real capital markets are not perfect and index arbitrage cannot work completely. Figlewski (1989) analyzes the impact of market imperfections and other problems with the standard arbitrage trade, including uncertainty volatility, transaction costs, indivisibilities and rebalance the riskless portfolio only at the discrete intervals. All statistics come from the simulation results. He concludes that continuously rebalancing hedged positions is impossible in the real world, so the standard valuation models based on the perfect market assumption become inappropriate.

3.2 Imperfect Market Model

Hsu & Wang (2004) and Wang (2007) include the structural parameter of price expectation and develop the futures pricing model based on the imperfect market assumptions. The model assumes that the stock index (\( S \)) follows a Geometric Wiener Process. Consider a hedged port-

folio \( P \) that consists of the futures position. It is assumed that no initial cash outflow is required for the futures contracts. Then, the rate of return of the hedged portfolio, \( \frac{dP}{P} \):

\[ \frac{dP}{P} = (\mu_f u + u)dt + (\sigma_f^a + \sigma)dz \]  

where \( u \) is the constant expected growth rate in \( S \); \( \sigma \) is the constant volatility of \( S \); \( \mu_f \) is the weight of futures contracts; \( u_f \) is the instantaneous (unobserved) expected return on futures; \( \sigma_f \) is the instantaneous standard deviation of return on futures contracts and \( dz \) is a Wiener process. To derive a more intuitive understanding of this equation, the return on portfolio comes from the mean return of futures and the mean return of stock with the uncertainty component.

If the portfolio is rebalanced continuously until the expiration of the futures contract with the weight of futures contract equals to \( \mu_f = -\frac{\sigma}{\sigma_f} \), then the portfolio becomes riskless \( \mu_f \sigma_f + \sigma = 0 \). This risk-free portfolio can be created under the perfect market; however, in the world of market imperfection, the portfolio cannot be riskless because the arbitrage mechanism cannot work completely. This implies that the portfolio must earn some expected rate of return, price expectation factor which can be greater than, smaller than, or equal to the risk-free rate, rather than the risk-free rate.

From equation (3) the portfolio returns come from two components:

\[ \mu_f u + \mu = u_p \]  

\[ \sigma_f^a + \sigma = \sigma_p \]

Let \( u \) be the instantaneous expected rate of return of hedged portfolio and \( \sigma_p \) be the coefficient of \( dZ \) in Equation (3).

From Equation (4) and (5), Hsu & Wang (1994) obtained the following partial differential equation (PDE):

\[ \frac{1}{2} \sigma^2 S^2 \frac{\partial F}{\partial S} + u_p SF + F = 0 \]  

where \( u = \frac{(u_p - q) - (u - q)(\frac{\sigma_p^2}{\sigma^2})}{1 - (\frac{\sigma}{\sigma_p})^2} \) is the degree of market imperfection which reflects the total effect of all market imperfection between the stock index futures market (\( F \)) and its underlying spot index market
when implementing the arbitrage activities. Consequently, the imperfect market model for the known dividend yield derived from the PDE (6) can be defined as:

$$F_t = S_t e^{(r-q)T}$$  \hspace{1cm} (7)

If the underlying stock index provides the cash income rather than the known dividend yield, the imperfect market model can be defined as:

$$F_t = (S_t - D_t)e^{(r-q)T}$$  \hspace{1cm} (8)

where $u = \frac{u_p - u_q}{1 - \frac{D_t}{S_t}}$ is the degree of market imperfection with the underlying stock index providing the cash income.

DATA AND METHODOLOGY

4.1 Data

The SET 50 index futures trades on the underlying SET 50 index listed on the Stock Exchange of Thailand. The SET 50 index is calculated from the stock prices of the top 50 listed companies on SET in terms of large market capitalization, high liquidity and compliance with requirements regarding the distribution of shares to minor shareholders.

To estimate the theoretical futures price, the proxies for each variable must be identified. The proxy for the spot underlying index is the closing price of the SET 50 index; the proxy for the dividend yield is the SET 50 dividend yield, thus this dividend yield is assumed to be known and continuously paid until the expiration date of the futures contracts; the proxy for risk-free interest rate is the 3-month interbank rate quoted by Bangkok Bank Public Company Limited. In addition, to compare the performance of each model, the proxy for actual futures price is found by using the closing price of the SET 50 index futures, and to reduce the thin trading problems, only the near-month contracts are in considerations. All daily data are retrieved from Bloomberg during period of April 28, 2006 to April 30, 2008, thus the total sample size is 492. To get a clearer picture of the theoretical pricing performance, this study divides the total sample period to two subsample periods starting from April 28, 2006 to April 30, 2007 (sample size is 245) and May 2, 2007 to April 30, 2008 (sample size is 247). Hull (2006) explains that volatility is much higher when the exchange is opened for trading than when it is closed. In practice, most treasurers calculate the futures prices based on the actual trading days. Consequently, to increase the model precision, this study is based on the actual trading days both for computing the contract period and annualized time to maturity. The actual trading contains 243 days in year 2006, 245 days in year 2007, and 246 days in year 2008. However, the program in calculating the futures prices offered by TFEX’s website is based on calendar days.

4.2 Methodology

This study compares the relative pricing performance of the cost of carry and the imperfect market models in two approaches. The first approach examines the pricing performance of the cost of carry model by applying the multiple regression model to test the fitness of model. Taking a natural logarithm on both sides of equation (1) yield:

$$\ln F_t = \ln S_t + (r - q)(T - t)$$  \hspace{1cm} (9)

For the regression purpose, equation (9) can be rewritten as:

$$\ln AF_t = \beta_0 + \beta_1 \ln S_t + \beta_2 (T - t) + \epsilon_t$$  \hspace{1cm} (10)

The null hypothesis of each coefficient can be set as $\beta_0 = 0$; $\beta_1 = 1$; $\beta_2 = r - q$. If the null hypothesis fails to be rejected, it implies that the cost of carry model holds. Additionally, to reduce the spurious correlation, the stationarity of data will be tested. The popular test of stationarity is the unit root test as explained by Gujarati (2003). $Y_t$ is a time series data with stochastic process. Stationary stochastic process’ mean and variance are constant over time and the value of the covariance between two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed. The simplest form of the Dickey-Fuller test is:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \epsilon_t$$  \hspace{1cm} (11)

To check whether the data consists of a unit root or whether the series is non-stationary, the formal test assumes that the error terms □ are uncorrelated. The augmentation by adding lagged values of \( Y \) in the model is proposed by Dickey and Fuller (1979) to compensate with the correlated error term □. The lag variable to be included should be large enough so that the error terms are serially uncorrelated. The null hypothesis is stated as \( \beta = 0 \) or \( Y \) contains unit root, non-stationary of time-series data, thus rejecting the null hypothesis implies that the times series data is stationary.

The other econometric problems in regression model include the serial correlation, and heteroskedasticity will be checked in order to apply the Ordinary Least Square estimators.

To evaluate the model pricing performance, the theoretical futures prices of two models must be estimated. However, the imperfect market model requires estimating one unobservable parameter \( u \) and \( u' \). As the SET 50 index futures contracts provide the known dividend yield, so the implied method to estimated \( u \) parameter from equation (7) can be derived as:

\[
\hat{u}_{zt-1} = \frac{1}{t-(t-1)} \ln \left( \frac{F_{zt-1}}{S_{zt-2}} \right)
\]

(12)

The second approach to evaluate the model performance is applying the most standard measures, means percentage errors (MPE) and means absolute percentage errors (MAPE). The formulae for both models can be defined as:

\[
MPE = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{AF_t - F_t}{F_t} \right|
\]

(13)

\[
MAPE = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{AF_t - F_t}{F_t} \right|
\]

(14)

where \( n \) is the number of observation; \( AF_t \) is the actual futures price; and \( F_t \) is the theoretical futures price.

This approach analyzes the model performances from four perspectives. The first perspective is analyzed by comparing the model performances in terms of mean and standard deviation, so the mean and the standard deviation of the percentage errors and the absolute percentage errors for each model are computed according to the three periods of analysis: whole sample period, period 1 and period 2. The second perspective is analyzed by classifying the percentage errors as either premium or discount.

If the actual futures price is higher than the theoretical futures price defined as premium and if the actual futures price is lower than the theoretical futures price defined as discount, then the number of premium (discount) and the means of premium (discount) will be calculated according to the three periods of analysis. The third perspective is analyzing the mispricing by graph. This graph plots the percentage error of each model in terms of premium (discount) for the whole sample period.

The last perspective is analyzed by comparing the difference in mean absolute percentage errors between the two pricing models by t-test. Walpole et al. (2006) consider the experimental situation of the estimation procedures for the difference of two means when the samples are not independent and the variances of two populations are not necessarily equal as the paired observations. The conditions of two populations are not assigned randomly to experimental units, rather each homogeneous experimental unit receives both population conditions. As a result, each experimental unit has a paired observation, one for each population. When the \( x_1 \) and \( x_2 \) are means of random samples of treatment 1 and 2 for size \( n_1 \) and \( n_2 \) from the population, the test statistic to compare the mean difference is the paired t-test. The paired t statistic can be computed as:

\[
t = \frac{(\bar{x}_1 - \bar{x}_2) - d_0}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}
\]

(15)

where \( s_p^2 = \frac{s_1^2(n_1-1) + s_2^2(n_2-1)}{n_1 + n_2 - 2} \)

Each experimental unit in this study has a paired observation, one for absolute percentage error of the cost of carry model and another for absolute percentage error of the imperfect market model. Consequently, comparison of the mean difference between the mean absolute percentage errors of two models should be tested by using the paired sample t-test. The paired t-test will be computed for three periods of analysis. The null and the alternative hypothesis can be set as: \( H_0: \mu_1 - \mu_2 = d_0 \) and \( H_1: \mu_1 - \mu_2 \neq d_0 \). If the computed t is greater than the critical \( t \) for \( (n_1 + n_2, \alpha) \), the null hypothesis would be rejected meaning there is a significant difference between the mean absolute percentage errors of two models. However, if the null hypothesis fails to be rejected, it implies that there is no difference between the mean absolute percentage errors of two models.
EMPIRICAL RESULTS

5.1 Fitness of the Cost of Carry Model

After using the unit root test to test the stationary of data, Table 1 presents the statistic on the Augmented Dickey Fuller test. The result shows that all variables except T-t is non-stationary. Consequently, the first difference (1 lag) is applied to all variables to solve the problem, then all variables become stationary.

Table 2 summarizes the results of testing the fitness of the cost of carry model. If the null hypothesis fails to be rejected, it implies that the cost of carry model is the suitable method. To resolve both the heteroskedasticity and serial correlation problems that occur in these models, the Newey West is applied to adjust the standard errors, t score, and significance level, while leaving the coefficient unaffected. The results show that in the whole sample period, only one null hypothesis is rejected indicating that the cost of carry model is partly rejected. However, when dividing the whole sample period into the sub-period analysis, most of the null hypotheses are strongly rejected at 1% significance level which indicates that when the cost of carry model is applied to this emerging market with high level of market imperfection, there would be a much larger difference between the actual futures prices and the theoretical values estimated by the cost of carry model.

Table 1: Augmented Dickey Fuller Test

The table shows the statistics of the unit root test on the sample obtained from Bloomberg. The sample includes all near month futures contracts during period of April 28, 2008 to April 30, 2008. The variables in the regression line, \( \ln AF_t = \beta_0 + \beta_1 \ln S_t + \beta_2 t + \beta_3 \) are checked for the stationary problem. The natural log of actual futures price at time \( t \) is denoted as \( \ln AF_t \), the natural log of current stock index is denoted as \( \ln S_t \) and annualized time to maturity is denoted as \( T-t \). After solving the stationary problem, the new variables are rechecked again. The natural log of actual futures price at time \( t \) after solving the stationary problem is denoted as \( d\ln AF_t \) and the natural log of current stock index after solving the stationary problem is denoted as \( d\ln S_t \).

<table>
<thead>
<tr>
<th>Variables</th>
<th>T-Test</th>
<th>Critical</th>
<th>Stationary</th>
<th>1stDiffVar</th>
<th>T-Test</th>
<th>Critical</th>
<th>Stationary</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln AF )</td>
<td>-1.437810</td>
<td>-3.443442</td>
<td>No</td>
<td>( d\ln AF )</td>
<td>-23.49779</td>
<td>-3.443469</td>
<td>Yes</td>
</tr>
<tr>
<td>( \ln S )</td>
<td>-1.477826</td>
<td>-3.443442</td>
<td>No</td>
<td>( d\ln S )</td>
<td>-24.58937</td>
<td>-3.443469</td>
<td>Yes</td>
</tr>
<tr>
<td>T-t</td>
<td>-4.974396</td>
<td>-3.443442</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Fitness of the Cost of Carry Model

The table presents the coefficient from the time series regression of natural log of actual futures prices on the natural log of current stock index and time to maturity after solving the stationary problem as described in Table 1. The full period is the daily data during period of April 28, 2006 to April 30, 2008. The period 1 is the daily data during period April 28, 2006 to April 30, 2007 and the period 2 is the daily data during period May 2, 2007 to April 30, 2008. The p values based on the Newey West covariance matrix are reported in parenthesis.

<table>
<thead>
<tr>
<th>Ho: ( \beta_3 = 0 )</th>
<th>Ho: ( \beta_3 = 1 )</th>
<th>Ho: ( \beta_3 = r-q )</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Period</td>
<td></td>
<td></td>
<td>491</td>
</tr>
<tr>
<td>( -0.0000233 )</td>
<td>( -0.109144 )</td>
<td>( -0.097464 )</td>
<td></td>
</tr>
<tr>
<td>(0.9614)</td>
<td>(0.3327)</td>
<td>(0.0000)***</td>
<td></td>
</tr>
<tr>
<td>Period 1</td>
<td></td>
<td></td>
<td>244</td>
</tr>
<tr>
<td>( -0.000690 )</td>
<td>( -0.310767 )</td>
<td>( -0.349089 )</td>
<td></td>
</tr>
<tr>
<td>(0.4579)</td>
<td>(0.0005)***</td>
<td>(0.0000)**</td>
<td></td>
</tr>
<tr>
<td>Period 2</td>
<td></td>
<td></td>
<td>247</td>
</tr>
<tr>
<td>( -0.000323 )</td>
<td>( 0.134920 )</td>
<td>( 0.157601 )</td>
<td></td>
</tr>
<tr>
<td>(0.5038)</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td></td>
</tr>
</tbody>
</table>

*** Significant at 1% level.
5.2 Evaluating Two Models Performances

This section shows the models' performances by comparing the percentage errors and absolute percentage errors from four different perspectives. For the first perspective, Table 3 summarizes the mean and the standard deviation of the pricing errors for two models. Firstly, the percentage errors column shows that the cost of carry models tends to misprice the futures contracts in the whole period especially for the period 1. As the negative mean percentage errors means the theoretical futures price is more than the actual futures prices, so the mean percentage errors of the cost of carry model being negative implies the theoretical futures price overprice all futures contract. Magnitudes of mean percentage errors of the cost of carry model are greater than magnitudes of mean percentage errors of the imperfect market model because of greater amount of negative number during whole sample period especially in the period 1. However, the period 2 showing positive mean percentage errors means the theoretical futures price is less than the actual futures prices, so the mean percentage errors of the cost of carry model being positive implies the theoretical futures price underprices all futures contract. To avoid the cancelling effects, the absolute percentage errors would be applied. The absolute percentage errors will be considered conversely from the percentage errors, which mean that the more positive numbers the more model errors tends to occur. The results from this analysis shows the consistent pattern that the SET50 futures index market has a high level of market imperfection as the higher magnitude in mean absolute percentage errors of the cost of carry model compares to the mean absolute percentage errors of the imperfect market model, so the cost of carry model cannot estimate the true price of this futures market.

### Table 3: Statistics for the Pricing Errors of Two Models

The table compares the performance of two pricing methods from the first perspective. The summary statistic of percentage error and absolute percentage error of two pricing methods are reported. The full period is the daily data during period of April 28, 2006 to April 30, 2008. The period 1 is the daily data during period April 28, 2006 to April 30, 2007 and the period 2 is the daily data during period May 2, 2007 to April 30, 2008. All numbers are reported in percentage.

<table>
<thead>
<tr>
<th></th>
<th>Cost of Carry Model</th>
<th></th>
<th>Imperfect Market Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage Error</td>
<td>Abs Percentage Error</td>
<td>Percentage Error</td>
</tr>
<tr>
<td></td>
<td>Mean (%)  Std (%)</td>
<td>Mean (%)  Std (%)</td>
<td>Mean (%)  Std (%)</td>
</tr>
<tr>
<td>Full Period</td>
<td>-1.3657762  6.6659674</td>
<td>4.7600330  4.8579952</td>
<td>-0.0742217  0.8357474</td>
</tr>
<tr>
<td>Period 1</td>
<td>-4.5447567  6.9281976</td>
<td>6.0254153  5.6819627</td>
<td>-0.0353960  0.8567050</td>
</tr>
<tr>
<td>Period 2</td>
<td>1.7745931  4.6009411</td>
<td>3.5100197  3.4583697</td>
<td>-0.1125758  0.8144346</td>
</tr>
</tbody>
</table>
Second perspective is analyzed by classifying the percentage errors as either premium or discount. Table 4 summarizes the statistics for the premiums and discount. If the actual futures price is higher than the theoretical futures price defined as premium, it implies that the theoretical futures prices under-price the futures contract. If the actual futures price is less than the theoretical futures price defined as discount, it implies that the theoretical futures price overprice the futures contract. For the cost of carry model, numbers of premiums are less than the numbers of discounts in the full period and period 1 which indicates that during the full period and the period 1, the theoretical futures prices by the cost of carry model tends to overprice the futures contracts. However, during the period 2, the number of premiums is greater than the number of discounts for the cost of carry model which indicates that during that period the cost of carry model tends to under-price the futures contract. These results are consistent with the previous analysis that the cost of carry model tends to overprice the actual futures prices in full period and period 1 while underpricing the actual future price in the period 2. The magnitudes of premium and discount of the cost of carry model are greater than the magnitudes of premium and discount of the imperfect market model in every study period. For the imperfect market model, the means premium and the means discount are quite low and the number of premium and the number of discount are not much different, implying that the imperfect market model outperforms the cost of carry model in every study period.

The third perspective is analyzing the mispricing by graph. Figure 1 displays the premiums and discounts for two models for the whole sample period. Again, if the actual futures price is higher than the theoretical futures price defined as premium, it implies that the theoretical futures prices under-price the futures contract. If the actual futures price is less than the theoretical futures price defined as discount, it implies that the theoretical futures price overprice the futures contract. Figure 1 clearly shows that the cost of carry model tends to misprice the futures contracts relative to the imperfect market model all over the sample period. However, the recent trend shows that the cost of carry model tends to underprice the actual futures price because the positive MPE means that the actual futures prices are higher than the estimated futures prices. Even though the possible arbitrage is short hedge by taking long stock and short futures position because of high actual futures price, the profit may not be achievable because the SET 50 index futures market is an imperfect market.

Table 4: Statistics for the Premiums and Discounts

<table>
<thead>
<tr>
<th></th>
<th>Cost of Carry Model</th>
<th></th>
<th></th>
<th></th>
<th>Imperfect Market Model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Premiums</td>
<td>Number of Discounts</td>
<td>Mean Premium</td>
<td>Mean Discount</td>
<td>Number of Premiums</td>
<td>Number of Discounts</td>
</tr>
<tr>
<td>Full Period</td>
<td>222</td>
<td>269</td>
<td>3.7535587</td>
<td>-5.5906549</td>
<td>220</td>
<td>271</td>
</tr>
<tr>
<td>Period 1</td>
<td>61</td>
<td>183</td>
<td>2.9613171</td>
<td>-7.0487813</td>
<td>107</td>
<td>137</td>
</tr>
<tr>
<td>Period 2</td>
<td>161</td>
<td>86</td>
<td>4.0537247</td>
<td>-2.4921532</td>
<td>113</td>
<td>134</td>
</tr>
</tbody>
</table>
Figure 1: Percentage Errors of Two Pricing Models during the Whole Sample Period

The figure compares the performance of two pricing methods from the third perspective by plotting the percentage errors as either premium or discount. The Y axis is the percentage error and the X axis is the time line during the period of April 28, 2006 to April 30, 2008. If the actual futures price is higher than the theoretical futures price defined as premium which fall in the positive areas. If the actual futures price is lower than the theoretical futures price defined as discount which falls in the negative area.

![Graph showing percentage errors]

The last perspective is analyzed by comparing the mean difference by using paired t-test. Table 5 shows the statistical test for the difference in mean absolute percentage errors between the two pricing models.

Table 5: Paired T-Test

The table compares the performance of two pricing methods from the fourth perspective by comparing the difference in mean absolute percentage errors between the two pricing models by t-test. The null hypothesis is the mean absolute percentage errors of cost of carry model equals to the mean absolute percentage errors of imperfect market model. The t statistics are reported in the table and p values are reported in the parenthesis. The full period is the daily data during period of April 28, 2006 to April 30, 2008. The period 1 is the daily data during period April 28, 2006 to April 30, 2007 and the period 2 is the daily data during period May 2, 2007 to April 30, 2008.

<table>
<thead>
<tr>
<th>Cost of Carry VS Imperfect Market Model</th>
<th>Full Sample</th>
<th>Period 1</th>
<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPEcc = MAPEmp</td>
<td>18.779</td>
<td>14.861</td>
<td>12.845</td>
</tr>
<tr>
<td></td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
</tr>
</tbody>
</table>

*** Significant at 1% level.
The null hypothesis is set as there is no difference between the mean absolute percentage errors of the cost of carry and the mean absolute percentage errors of the imperfect market model. The positive t value indicates that mean absolute percentage errors of the cost of carry model is higher than mean absolute percentage errors of the imperfect market model implying market imperfection because the cost of carry model produces more pricing errors. The result shows the mean absolute percentage errors of the cost of carry model is significantly higher than mean absolute percentage errors of the imperfect market model. Consequently, for markets with high market imperfections, the imperfect market model outperforms the cost of carry model.

CONCLUSION

In a highly imperfect financial market like SET 50 index futures market, the force of index arbitrage cannot drive an actual price to a theoretical value estimated by the cost of carry model due to some imperfect market factors, so the cost of carry model does not perform better than the imperfect market model in this market. The results from this study suggest the practitioner to apply the imperfect market model when pricing the index futures in Thailand. Therefore the practitioners should identify the appropriate pricing method before estimating the theoretical prices of stock index futures. Caution is emphasized for practitioners who apply TFEX’s program in estimating the futures price as the TFEX’s website provides the pricing instrument based on the cost of carry model and calculation based on calendar days.

REFERENCES


About the author

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