REEXAMINING THE EXPIRATION DAY EFFECTS OF STOCK INDEX DERIVATIVES: EVIDENCE FROM TAIWAN

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ABSTRACT

This study examines whether the expiration of derivative contracts affects the underlying spot assets in Taiwan. The expiration effect refers to abnormal return, price reversal, abnormal return volatility, and abnormal volume in underlying spot stock markets as derivatives contracts expire. Due to the unique settlement procedure in the Taiwan Futures Exchange, this study also examines if the expiration effects occur on the settlement day which is the next business day after the expiration day. Our empirical results indicate that expiration day effects do exist in Taiwan. However, the more pronounced expiration day effect occurs on the settlement day due to the unique settlement mechanism in Taiwan. This paper also investigates the expiration effect of MSCI Taiwan Stock Index Futures traded on the Singapore Exchange, which also uses Taiwan's stock market as the underlying asset. The results indicate that as SGXTW expires, there are also expiration effects such as abnormal return, abnormal return volatility, and abnormal volume in the Taiwan spot market.

JEL: G14, G18, G19

INTRODUCTION

In the new century, the globalization and liberalization of financial markets have been the trend. Hot money runs all over the world and beats the financial market. Stock index derivatives are one of the most successful and important innovations in the last century financial markets. The markets for these products first emerged in the U.S. in the 1980s and rapidly spread to other financial markets of Europe and Pacific Rim. Trading volume of index derivatives has grown dramatically and even exceeds that of the underlying assets. This metric is commonly used to measure the success of a financial contract market. The primary reason for the popularity of stock index futures and option markets are that they provide a fast and inexpensive way to change exposure to a stock market.

Despite their success, index derivatives are often criticized because of their effects on the market for the underlying securities. The positive effects of these new securities are due to new risk sharing opportunity and more complete financial markets. On the negative side, derivative securities, whose payoffs are a function of some other assets prices, also offer new opportunities for price manipulation. Expiration day effect is one of these negative effects.

Expiration day effects may result from a combination of several factors, including the existence of arbitrage opportunities, the cash settlement feature, the stock market procedures for accommodating the unwinding of arbitrage positions in the stocks, and attempts to purposely manipulate prices. Arbitrage positions are often unwound at the expiration of the index derivative contract. If index derivatives expire at the close, the derivatives self-liquidate through cash settlement at the closing price level. The stock position, on the other hand, must be liquidated through trades in the marketplace. An arbitrageur who longs the underlying stocks and shorts the derivative contract must sell the underlying stocks at their closing prices. If many arbitrageurs liquidate positions at the same time and in the same direction, price effects may happen.

The price effects on expiration day depends in part on the stock market procedures for accommodating order imbalances that may result when arbitrage positions are unwound. If the underlying market for the stocks is not deep and if suppliers of liquidity are not quick enough to respond to selling or buying pressure, the price effects of larger arbitrage unwinding will be large. If unjustified price effects were known to occur, informed investors would attempt to buy under priced stocks and sell overpriced stocks, thereby limiting price effects to fall within the bounds of transaction costs. If market mechanisms are not well designed to offset sudden imbalances, however, the price effects may be substantial.

Expiration day price effects may also result from attempts to manipulate stock prices. Such attempts may occur directly in the way an arbitrage position is unwound or indirectly through arbitrage unwinding that benefit other positions. An arbitrageur might engage in indirect manipulation, not to benefit the arbitrage account but to benefit another account.

The "triple witching hour" quarterly expiration of stock index futures, stock index options, and individual stock options in the U.S. has received vast attention from both academics and regulators. The settlement procedure has been blamed for generating volatile price swings in the final hour of trade. In June 1987, the settlement price was changed from the closing price to the opening price on the third quarterly Friday for some of the existing index futures and options contracts, aiming to reduce the volatility. However, a variety of other solutions for limiting expiration day effects were proposed. One of them was to use the expiration day average rather than the closing price as the settlement price.

Stock index expiration effects have been studied in the past. Widely known is a series of studies by Stoll and Whaley (1986, 1987, and 1991) that examined expiration day effects of U.S. index derivatives. Across all contract expirations since the inception of index futures, they found that the effects were remarkably consistent: index stock trading volume was abnormally high and observed price movements were small and within the bounds of transaction costs. Karolyi (1996) examined Nikkei 225 futures contract expirations, and, like Stoll and Whaley, concluded that the expiration of the Nikkei 225 futures induced abnormal trading volume but economically insignificant price effects. Stoll and Whaley (1997) found similar results for Australian All Ordinaries Share Price Index futures and option expiration.

As the Futures Trading Law was published in March 1997, it led to the establishment of Taiwan Futures Exchange (TAIFEX) in September in the same year. TAIFEX opened for business and launched its first product: the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) futures on July 21, 1998. Over the years, TAIFEX has earned significant attention and recognition. According to the statistics from the Futures Industry Association (FIA), TAIFEX's global ranking based on total trading volume rose to the 18th in 2005, from the 57th in 1998. In 2007, the trading volume of TAIEX Options (TXO) is ranked the 4th globally.

Taiwan's fast growing economy has also attracted international fund managers to invest in its vibrant stock market. SGX MSCI Taiwan Index Futures traded on the Singapore Exchange (SGX) is the first contract that traded Taiwan equity derivative in the world. Since its launch in 1997, trading volume and open interest in SGX MSCI Taiwan Index Futures have grown significantly.

It is uncommon to see that different contracts with the similar underlying can develop like these. Moreover, there are few studies that compare the relationship between different expiration days in the same month. Of interest is to know what kind of role the different features of the settlement system play in expiration day effects. This study examines the expiration day effect of derivative contracts (index futures, stock futures, index options, and stock options) on the abnormal return, price reversal, abnormal price volatility, and abnormal volume of the underlying in the Taiwan stock market. The Taiwan experience can shed new light on the existing literature and can also provide some evidence on emerging markets.

AN OVERVIEW OF THE TAIWAN DERIVATIVES MARKETS

From its establishment in July 1998 through December 2007, twelve financial derivatives products had been launched on the TAIFEX. The Taiwan Stock Exchange Capitalization Weighted Stock Index futures (TX) were the index product first introduced on July 21, 1998, followed by the Electronics Sector Index Futures (TE) and the Finance Sector Index Futures (TF) on July 21, 1999. In 2001, two other new products were launched: the Mini-TAIEX futures (MTX) and the TAIEX options (TXO) on April 9 and December 24. The former was designed to attract more small investors to participate, by asking a margin of one quarter of that for the TAIEX futures. The debut of the TAIFEX options added the first option products to the domestic futures market, which offered investors more vehicles to hedge. On June 30, 2003, the TAIFEX launched Taiwan 50 Futures (T5F) that consisted of the fifty biggest market value stocks in TSEC. Two more option products were launched on March 28, 2005: the Electronic Sector Index option (TEO) and the Finance Sector Index option (TFO), supporting more hedging tools to the investors. In order to attract more foreign investors, on March 27, 2006, TAIFEX introduced TAIFEX MSCI Taiwan Index Futures (MSF) and TAIFEX MSCI Taiwan Index Option (MSO). Their underlying index, the MSCI Taiwan Index^{SM}, is widely used by institutional investors worldwide to track the movement of Taiwan's stock market. The contacts are priced in U.S. dollar. On October 8, 2007, NonFinance NonElectronics Sub-index Futures (XIF) and NonFinance NonElectronics Sub-Index Options were launched to meet the requirement of investors who wished to hedge.

In the early years, the trading volumes of the index derivatives were small. Because of the diversified product line and growing investor familiarity, volume greatly increased, attracting the interest of arbitrageurs and speculators. As shown in Table 1, the trading volumes of each index derivative accelerate year by year. In 2004, the TAIFEX was awarded the honor "Derivates Exchange of the Year 2004" by Asia Risk. Moreover, in 2005, the TAIFEX expanded to become the 18th largest market in the world and the trading volume of TXO is the forth largest in single product in the world.

Table 1: Trading Volume Growth of Index Derivatives on the Taiwan Futures Exchange

Contracts	Year					
	2002	2003	2004	2005	2006	2007
TAIFEX Futures (TX)	4,132,040 (45%)	6,514,691 (58%)	8,861,278 (36%)	6,917,375 (-21%)	9,914,999 (43%)	11,813,150 (19%)
Electronics Sector Index Futures (TE)	834,920 (22%)	990,752 (19%)	1,568,391 (58%)	1,179,643 (-25%)	1,459,821 (24%)	1,004,603 (-31%)
Finance Sector Index Futures (TF)	366,790 (-5%)	1,126,895 (207%)	2,255,478 (100%)	909,621 (-60%)	786,477 (-14%)	909,383 (16%)
Mini-TAIFEX Futures (MTX)	1,044,058 (183%)	1,316,712 (26%)	1,943,269 (48%)	1,088,523 (-44%)	1,760,583 (62%)	2,964,042 (68%)
TAIFEX Options (TXO)	1,566,446	21,720,083 (1287%)	43,824,511 (102%)	80,096,506 (83%)	96,929,940 (21%)	92,585,637 (-4%)
Taiwan 50 Futures (T5F)		4,068	6,157 (51%)	9,483 (54%)	332 (-96%)	506 (52%)
Electronics Sector Index Options (TEO)				680,026	773,353 (14%)	1,066,141 (38%)
Finance Sector Index Options (TFO)				756,570	937,044 (24%)	1,203,084 (28%)
TAIFEX MSCI Taiwan Index Futures (MSF)					8,333	1,132 (-86%)
TAIFEX MSCI Taiwan Index Options (MSO)					867,597	1,634,117 (88%)
Non-Finance Non-Electronics Sub-index Futures (XIF)						37,197
Non-Finance Non-Electronics Sub-index Options (XIO)						186,161

This table lists the trading volumes of index derivatives on the TAIFEX from 2002 to 2007. Numbers in parentheses indicate the average growth rate if trading volume per year for the current year versus the previous year.

The Singapore Exchange (SGX) is the first integrated securities and derivatives exchange in Asia Pacific. It was established on December 1, 1999 as a result of the merger of two well-established and respected financial institutions: the Stock Exchange of Singapore (SES) and the Singapore International Monetary Exchange Limited (SIMEX). The merger signifies the shift from a member-only club that existed largely to serve the interests of brokers - to a commercial, customer-focused organization. SGX MSCI Taiwan Index Futures is the first exchange traded Taiwan equity derivative in the world. Since its launch in 1997, trading volume and open interest in SGX MSCI Taiwan Index Futures have grown significantly. SGX MSCI Taiwan Index Options contracts offer another dimension of Taiwan equity investment and trading.

There are six main differences between TAIFEX and SGX Taiwan index futures contracts. First, the contracts traded in TAIFEX are quoted in New Taiwan Dollar, while the SGXTW traded in SGX is quoted in US dollar. Second, the TAIFEX index futures benefits from home market advantages in terms of local knowledge, proximity to news sources, and lack of language barriers, while the SGXTW obtains the first mover-advantage. Third, the trading mechanisms are different. Regular trading hours in both markets are the same, 8:45 to 13:45, in the morning, but SGX employs an Electronic Trading System from 14:45 to 19:00 in the afternoon. Fourth, the futures trading in Taiwan is levied a 0.025% transaction tax, while no transaction tax is applied to the Singapore Exchange. Fifth, the expiration day of TAIFEX is the third Wednesday of the month, but the expiration day of SGXTW is the day before the last trading day of the month. Finally, TAIFEX and SGXTS utilize different settlement procedures. The settlement price of TAIFEX is computed based on the first fifteen-minute volume-weighted average price on the next business day of expiration day. The settlement price of SGXTW is the closing price on the expiration day. The features of the derivative product of TAIFEX are showed in Appendix 1.

Because the unique settlement mechanism of TAIFEX distinguishes it from those in the U.S. markets or in the Hong Kong market we expected the expiration day effects in TAIFEX to behave somewhat in between those of the U.S. markets and the Hong Kong market. On the other hand, one of the characteristics of the Taiwanese futures market is that all the twelve index derivatives use the same settlement procedure. Thus, trading activities resulting from arbitrage and speculation should be more obvious when more derivatives products entered the market. If arbitrageurs attempt to liquidate their positions, or speculators are eager to change the final settlement price after the last trading day, then expiration effects in relation to the cash market should became more significant.

As discussed earlier, in the early and mid-1980s in the U.S., researchers expressed concern about the so-called “triple witching hour”, the last hour of trading on the third Friday of the quarterly month when stock index futures, stock index options, and equity options all expired simultaneously. The index derivatives traded on the TAIFEX expire once every third Wednesday of the delivery months, and settlement price for each contract is computed based on the first fifteen-minute volume-weighted average of each component stock’s prices in the index on the final settlement day. Therefore, the Taiwanese market could be used as a special case to examine the impact of expiration effects on the stock market. We will also analyze whether the effects will become more significant as more contracts expire at the same time.

LITERATURE REVIEW

There is extensive empirical evidence on the expiration effect of U.S. derivatives markets. Stoll and Whaley (1987) studied eight expiration days of the Standard and Poor’s Composite 500 (S&P 500) futures contracts in 1984 and 1985, and examined the S&P 500 and S&P 100 price changes in the last hour of expiration days as compared with those of non-expiration days. By measuring price reversal, they observed that the spot market volatility significantly increased on the futures expiration days and stated that the expiration-day price reversal appeared to be associated only with the expiration of index

futures contracts, but the index options expiration did not cause the abnormal price movement. They inferred that the additional cost of liquidity frequently increasing on expiration days lead to the price effect, and pointed out the efforts by the regulators to find effective ways for handling unexpected order imbalances in the stock market were desirable.

Nevertheless, Stoll and Whaley (1991) arrived at a different conclusion in another study by investigating the volatility and price effects on quarterly and monthly expiration days in the two and one-half year period before and the two and one-half year period after June 1987. The Chicago Mercantile Exchange, New York Stock Exchange, and New York Futures Exchange had changed the settlement time of their derivative contracts from the closing price to the opening price on expiration day beginning with the June 1987 quarterly expiration in order to lessen concern about abnormal stock price movements in the triple witching hour. Thus, from June 1987 forward, the last trading day of the S&P 500 futures contracts was moved from Friday to the Thursday on the third Friday of the contract month, and the final settlement price was based on the Friday opening for the underlying index. However, the expiration mechanism for the S&P 100 was not changed. Stoll and Whaley (1991) found that the return volatility is smaller at the expiration days during the period after June 1987 than at expiration days during the period before 1987. They also stated that switching the settlement from close to open would not decrease volatility meaningfully, but would only shift the location of volatility. They further concluded that regulators have overreacted to the expiration effect.

By using daily data from October 1, 1981 to June 30, 1987, Aggarwal (1988) examined the impact of index futures on the volatility of the S&P 500 and the Dow Jones Industrial Average (DJIA) indices with the over-the-counter (OTC) Composite index as a control. He also concluded that the high levels of the intra-day stock market volatility may be a result of futures-related activity. However, the inter-day price volatility of the underlying spot market should be nothing related to the index futures trading.

Herbst and Maberly (1990, 1991) adopted two different methodologies to investigate whether the change of the expiration settlement procedures for the S&P 500 in June 1987 reduces spot expiration volatility. They observed the change in triple witching hour volatility and expected price reversals before and after the new settlement mechanism. Their results were consistent with the findings of Stoll and Whaley (1991). They found that the volatility on the expiration-days had been significantly reduced, but the volatility shifted with a significant increase in the first hour volatility.

On the contrary, Bessembinder and Seguin (1992) used daily data on the S&P 500 index from January 1978 to September 1989 to investigate the volatility effect on expiration day and found different results. Adopting a regression of daily S&P 500 return standard deviation with the independent variables of spot-trading volume and a futures-trading, and days to expiration dummy variables, they concluded that although the equity volatility was slightly higher on the expiration days, it is not related to the futures.

Hancock (1993) investigated the triple witching hour effect by using minute-by-minute S&P 500 index values for the period from April 30, 1987 to July 24, 1989. He observed that the expiration day effect appeared in the underlying spot market. However, the noticeable increases or decreases in the spot market volatility around the triple witching hour in the U.S. can be attributed to the responses of investors to new information, especially important economic news often declared on Fridays.

Besides the U.S. stock markets, Chamberlain et al. (1989) studied the Toronto Stock Exchange (TSE) 300 during the last half-hour of trading on expiration and non-expiration days in the Canadian market from November 1985 to May 1987. They inferred that the rate of return during the last half hour of trading is significantly more volatile on expiration days than that on non-expiration Fridays. Moreover, the expiration returns also tended to be reversed during the first half-hour of trading on the following Monday. With these results, Chamberlain et al. (1989) concluded that index arbitrage activities really exist in the

Canadian market. Illueca and Lafuente (2005) investigated the IBEX 35 in the Spanish market from January 17, 2000 to December 20, 2002. They detect a slight downward trend in the spot index, but the behavior of index reversals suggests that this pattern is not attributable to the maturity of the futures index derivative contract.

Gannon (1994) studied the Share Price Index (SPI) futures and All Ordinaries Share Price Index in the Australian market with 15-minute intra-day data. The observations are sampled for the three months to expiration for the March 1992 SPI futures contracts, and came to a different conclusion. They conclude that the expiration-day volatility effect is not at all significant on the spot market. Bacha and Vila (1994) studied the Nikkei 225 Stock Average with its futures contracts traded on Singapore International Monetary Exchange (SIMEX), Osaka Securities Exchange (OSE) and Chicago Mercantile Exchange (CME) for the period from September 3, 1986 to August 31, 1991. They also find that the futures expiration days on all three types of futures contracts cause no higher cash market volatility than ordinary. Chow, Tung, and Zhang (2003) observed the 5-minute interval of the Hang Seng Index from 1990 to 1999 to examine the impact of the expiration of HSI derivatives on the underlying spot market in Hong Kong. They indicated that expiration days in Hong Kong may be associated with a negative price effect and some return volatility on the underlying stock market but there is no evidence of abnormal trading volume on the expiration day or price reversal after expiration, so the existence of expiration day effects cannot be confirmed in the Hong Kong market. They inferred that the HSI derivative market is different from most other markets because the settlement price is computed by taking the average of 5-minute quotations of the HSI on the last trading day.

DATA AND METHODOLOGY

Data

Following the previous studies, we assess the expiration day effects of index derivatives by focusing on abnormal price movements and trading volumes. To examine whether the stock market produces abnormal changes when the index derivatives expire, we employ the comparison-period approach (CPA) to compare the average returns, stock price volatilities, and trading volumes on expiration days with those for non-expiration days, as did Masulis (1980). The CPA is used to compare the estimated parameters, such as the mean and the standard deviation of returns, on expiration days with those on non-expiration days.

The data for this study is from TSEC (Taiwan Stock Exchange) and Taiwan Economic Journal, a local data vendor. The sample period is drawn from January 1, 2002 to December 31, 2007, including 72 expiration days. The data includes both the Taiwan Stock Exchange Capitalization Weighted Stock Index and MSCI Taiwan Index^{SM} collected at 5-minute intervals respectively during the entire sample period. Besides the whole period, we also analyze the sub-period to gain additional insights related to this event. Specifically, we investigate the expiration day effects using the full sample and the following four sub-periods: (1) January 2002 to June 2003, (2) July 2003 to March 2005, (3) April 2005 to March 2006, and (4) April 2006 to December 2007.

It is customary to choose the trading day before and after the expiration day as comparison days. To avoid any potential weekly effect, we also examine 5 trading days before and 5 trading days after the expiration day for comparison. Furthermore, based on the empirical finding of Stoll and Whaley (1991) and Hancock (1993) that the changing of settlement system may affect the reaction time of expiration effects, we also set the first 15-minute period and the whole day of the settlement day as the comparison base for examining the impacts of index derivatives.

Abnormal Return Effect

If various arbitrageurs and speculators create price pressure on the expiration day for the index derivatives, the returns of the stock market will abnormally move. In order to detect whether the abnormal price movement of the stock market on the expiration day exists or not, we compare the average return for the expiration day with that of the non-expiration day. We use the logarithm of the return to calculate the stock index return. For the *t*th 5-minute interval on the expiration day or non-expiration day in the *i*th month, the return ($r_{i,t}$) is:

$$r_{i,t}=\ln\left(\frac{P_{i,t+1}}{P_{i,t}}\right) \quad (1)$$

where $P_{i,t}$ is the opening stock index for the *t*th 5-minute interval on the expiration day or non-expiration day of the *i*th month. The average returns on the expiration days and the non-expiration days during the overall sample period are defined as:

$$AR_e=\frac{1}{N_e}\sum_{i=1}^{N_e} r_{e,i}, \quad (2)$$

and

$$AR_c=\frac{1}{N_c}\sum_{i=1}^{N_c} r_{c,i} \quad (3)$$

respectively, where N_e and N_c signify the sample numbers for the expiration days and non-expiration days throughout the overall sample period. From the literature we know that financial returns are neither independent, nor distributed normally, so we use the Modified Levene's paired t-test to examine whether the average returns of the stock market for the expiration days are different from those for the non-expiration days. The null hypothesis is $H_0: AR_{e,i}\text{-}AR_{c,i}=0$, and the alternative hypothesis is $H_1: AR_{e,i}\text{-}AR_{c,i}\neq 0$. The testing statistic t_L^* is:

$$t_L^*=\frac{\bar{d}_e-\bar{d}_c}{S_p\sqrt{\frac{1}{T_e}+\frac{1}{T_c}}} \quad (4)$$

where $\bar{d}_e$ and $\bar{d}_c$ are the mean of d_{ei} and d_{ci}, respectively, and $T_e=\sum_{i=1}^{N_e} N_{e,i}$ and $T_c=\sum_{i=1}^{N_c} N_{c,i}$, respectively, are the numbers of expiration days and non-expiration days with standard deviation S_p as follows:

$$S_p=\sqrt{\frac{\sum(d_{ei}-\bar{d}_e)^2+\sum(d_{ci}-\bar{d}_c)^2}{T_e+T_c-2}}. \quad (5)$$

We use the last hour period of the expiration day and the whole expiration day of TAIFEX and SGXTW to investigate the abnormal returns. Furthermore, we also set the first 15-minute period of the settlement day and the whole settlement day of TAFEX as the second comparison base for comparing the average stock market returns. This approach allows us to examine the change of the reaction time of expiration effects.

Index Reversal Effect

The prices in the spot markets may deviate from equilibrium if the arbitrageurs liquidate their position when the index derivatives expire due to price pressure or the speculators attempt to change the prices in the spot markets in order to increase their profits.

If there is indeed such a price pressure on the expiration day, then stock prices should on average reverse in the opposite direction after the derivative contracts have expired. That is, if the stock index goes up on the expiration day, then it will go down after the expiration day and the price pressure will disappear. If the stock index goes down on the expiration day, then it will go up after the expiration day. The temporary price overreaction should be observed in the underlying spot market. In other words, examining the existence of the price reversal effect on the underlying spot market can be another measure of the existence of the expiration effect of index futures trading. The approach is used by Stoll and Whaley (1991).

Here we use three measures to test whether the reversal effect exists when the index derivatives in the TAIFEX and SGXTW expire. Similar to the approach adopted by Stoll and Whaley (1991) and Hancock (1993), we first define the last 60-minutes index return, R_t, and the return after expiration, R_{t+1}, as:

$$R_t = \frac{P_{close,t} - P_{close-60,t}}{P_{close-60,t}} \tag{6}$$

and

$$R_{t+1} = \frac{P_{open,t+1} - P_{close,t}}{P_{close,t}} \tag{7}$$

respectively, where $P_{close-60,t}$ is the index price 60 minutes before the market close on the expiration day, $P_{close,t}$ is the closing price on the expiration day, and $P_{opne,t+1}$ is the opening price of the next trading day after expiration. The first measure of the price reversal effect is defined as:

$$Rev = \begin{cases} R_{t+1} & \text{if} \quad R_t < 0 \\ -R_{t+1} & \text{if} \quad R_t \geq 0 \end{cases}. \tag{8}$$

A positive Rev indicates a price reversal effect because the price trend for the day after the expiration day moves in the opposite direction to that for the expiration day. If Rev is negative, it indicates that the stock market does not exhibit a price reversal effect because the price trend for the day after the expiration day moves in the same direction as that for the expiration day. The price reversal may be caused by aggregated price pressure of index derivatives or it may happen in the stock market randomly. If it occurs randomly there is a 50% probability that the price trend will either move continuously forward or in reverse. We use the binomial test to determine whether the price reversal in the stock market after the expiration day occurs randomly or is statistically significant.

We may be unable to capture the potential price reversal effect in the Taiwan stock market by using the above measure provided by Stoll and Whaley (1991, 1997). Because the TAIFEX uses the average trading price of the first 15 minutes of the settlement day (the day after the expiration day) as the final settlement price, speculators may attempt to influence this price to their benefit. Major price pressure may occur during this 15-minute period, so we use two more measures to capture the price reversal effect. We use the average return for the stock market during the first 15 minutes of the day after the expiration

day (settlement day of TAIFEX) as a comparison base to compare the return during the last 60-minute of the expiration day to the opening price of the day after the expiration day. That is, we define two new measures for the price of returns as:

$$R_t = \frac{P_{open,t+1} - P_{close-60,t}}{P_{close-60,t}} \tag{9}$$

and

$$R_{t+1}' = \frac{P_{open+15,t+1} - P_{open,t+1}}{P_{open,t+1}} \tag{10}$$

where $P_{open,t+1}$ is the opening index on the day after expiration day (settlement day of TAIFEX), $P_{close-60,t}$ is the index price 60 minutes before the market close on the expiration day, and $P_{open+15,t+1}$ is the index for the first 15-minute period after the opening of the day after the expiration day (the settlement day of TAIFEX). We define the second measure of the price reversal measure Rev' as:

$$Rev' = \begin{cases} R_{t+1}' & \text{if} \quad R_t < 0 \\ -R_{t+1}' & \text{if} \quad R_t \geq 0 \end{cases}. \tag{11}$$

Similarly, if Rev' is positive, then it indicates that the stock market exhibits a price reversal effect, because the price trends before and after the opening index price of the day after expiration day (settlement day of TAIFEX) moves in opposite directions. If Rev' is negative, then it indicates that the stock market does not exhibit a price reversal effect because the price trends before and after the opening index price of the day after expiration day move in the same direction. Because price reversal in the stock market after the opening index price of the day after expiration day is decided may take place randomly or may be caused by price pressure as the index derivatives expire, we still use the binomial test to determine whether the price reversal taking place in the stock market after the opening index price of the day after expiration day occurs randomly or whether it is statistically significant.

Moreover, we use the spot index right after the 15-minute period as a comparison base to compare the average return for the stock market during the first 15 minutes of the settlement day of TAIFEX. That is, we define two more measures for the price of returns as:

$$R_{t+1}'' = \frac{P_{open+15,t+1} - P_{open,t+1}}{P_{open,t+1}}, \tag{12}$$

and

$$R_{t+1}''' = \frac{P_{close,t+1} - P_{open+15,t+1}}{P_{open+15,t+1}}, \tag{13}$$

where $P_{open+15,t+1}$ is the index for the first 15-minute period after the opening of the settlement day of TAIFEX (the day after the expiration day), $P_{open+15,t+1}$ is the opening index on the settlement day of TAIFEX (the day after the expiration day), and $P_{close,t+1}$ is the closing index of the settlement day. We then define the third measure of the price reversal measure Rev" as:

$$Rev''=\begin{cases} R_{t+1}''' & \text{if} \quad R_{t+1}''<0 \\ -R_{t+1}''' & \text{if} \quad R_{t+1}'' \geq 0 \end{cases}. \tag{14}$$

Similarly, if Rev" is positive, then it indicates that the stock market shows a price reversal effect, because the price trends before and after the final settlement price of TAIFEX is decided move in opposite directions. If Rev" is negative, then it indicates that the stock market does not exhibit a price reversal effect because the price trends before and after the settlement price of TAIFEX is decided move in the same direction. Because price reversal in the stock market after the settlement price is decided may take place randomly or may be caused by price pressure as the index derivatives expire, we still use the binomial test to determine whether the price reversal taking place in the stock market after the settlement price is decided occurs randomly or whether it is statistically significant.

Abnormal Price Volatility

If either arbitrageurs liquidate their positions or speculators attempt to influence the spot market price when index derivatives expire, which may cause the spot markets out of equilibrium. If such temporal price disequilibrium exists, then the index returns around the expiration should on average be more volatile. In general, trading volume and volatility within the stock market are higher during the opening and closing of the market.

Therefore, we test the volatility effect during the whole expiration day and the last hour before closing on the expiration day. We used the standard deviation of the return for the stock index to estimate the volatility of the stock market. A pooled F-test is used to test whether expiration day returns are associated with a higher volatility from that of the comparison period.

The null hypothesis is $H_0: S_e \leq S_c$, where S_e and S_c are the standard deviations of the returns of the stock index on the expiration day and the non-expiration day, respectively, and the F-statistic is:

$$F=\frac{S_e^2}{S_c^2}. \tag{15}$$

However, because the reaction time of expiration effects might move to the settlement day of TAIFEX, we also set the first 15-minute period of the settlement day of TAIFEX and the whole settlement day of TAIFEX as the second comparison base for examining the abnormal volatility effects.

Abnormal Volume Effect

If large stock positions from index arbitrage carry into the derivatives contract expiration day and are unwound with a large imbalance orders, then the volume of trading in index portfolio stocks should be abnormally high on expiration days. We used two measures to test the abnormal volume effect. The first measure compares the average trading volume of the last one hour on expiration days (denoted as V_e) with that of the daily average in the current month (denoted as V_c).

As in the case of testing for index reversals, a simple binomial test is used to test whether expiration days are associated with abnormally heavy trading volume. We denote the probability of $V_e > V_c$ as p, and the probability of $V_e \leq V_c$ as q = 1 -p. Under the null hypothesis that there are no abnormal trading

volumes on expiration days, we expect an equal probability of observing either $V_e > V_c$ or $V_e \leq V_c$, i.e., p = q = 0.5.

The second measure to capture the abnormal volume effect, involves using the first 15 minutes of the day after the expiration day (the settlement day of TAIFEX) as the basis for comparison. Since the TAIFEX uses the average trading price of the first 15 minutes of the settlement day (the day after the expiration day) as the final settlement price, the price pressure may cause the trading volume to inverse suddenly. After this 15-minute period when the price pressure disappears, the trading volume will back to the normal level. Therefore, the major abnormal trading volume effect may occur only during this 15-minute period. This measure compares the stock market volume during the first 15-minutes period of the day after the expiration day (the settlement day of TAIFEX) with that on the non-settlement day, so as to capture the possible abnormal volume effect.

EMPIRICAL RESULTS AND ANALYSIS

In this section we present the results of our empirical investigation. The results of abnormal return effects are discussed first, followed by the results for the price reversal, abnormal return volatility, and trading volume tests on the expiration days and settlement days.

Abnormal Return Effect

First, we compare the average return of TAIFEX index of the expiration day with that of the four non-expiration days to observe the abnormal return effect of the stock market that is caused by each kind of index derivative in the TAIFEX on the expiration day from 2002 to 2007. On the days immediately before(T-1) and after (T+1) the expiration day is a natural choice for the purpose of examining the abnormal price or volume effect. We also capture 5 trading days before (T-5) and after (T+5) the expiration day as comparison days to alleviate the possible day-of-the-week effect, which has been extensively documented. The results are reported in Table 2, where Panel A reports the differences in terms of average return of the stock market between the expiration day and the four non-expiration days. We find that in the whole period, compared with the day after the expiration day, the phenomenon of abnormal return effect is signicant at the 5% level. However, there is no abnormal return effect during the sub-periods. Panel B shows the difference in terms of the average return of the stock market during the last hour before closing between the expiration day and the four non-expiration days. Our findings indicate that the stock market does not exhibit any abnormal return during the last hour before closing on the expiration day throughout the sample period or sub-periods. However, the returns are generally smaller during the closing of the market.

Furthermore, we compare the average return of the settlement day with that of the four non-settlement days. The results are presented in Table 3, where Panel A reports the differences in terms of the average return of the stock market between the settlement day and the four non-settlement days. Our findings show 5% significance levels on the fifth day before the settlement day and the day before the settlement day. Nevertheless, the abnormal return effect apears in the sub-period during the period (2003/07~2005/03) after T5F entered the maeket, the difference on terms of the average return of the stock market between the settlement day and the fifth day before the settlement day is 0.009946, which is significant at 1% level. Another two non-settlement days also exhibit 5% significant level. We also compared the first 15-minute average return between the settlement day and four non-settlement days. However, the results in Panel B indicate that the stock market still does not show abnormal return effects during the first 15-minute after opening on the settlement day, but in general returns are larger during the opening of the market.

Table 2: Abnormal Return Effect of TAIFEX Index on Expiration Day

	T-5	T-1	T+1	T+5
Panel A: Whole Expiration Day (T)				
2002/01~2007/12	-0.00236	-0.0004	-0.00449	-0.00152
(whole period)	(-1.29906)	(-0.20147)	(-2.28097)*	(-0.78446)
2002/01~2003/06	-0.00626	-0.00328	-0.00713	-0.00483
	(-1.53043)	(-0.64518)	(-1.52691)	(-0.92464)
2003/07~2005/03	0.002399	0.00289	-0.00568	4.67E-05
	(0.643863)	(0.76974)	(-1.43194)	(0.013502)
2005/04~2006/03	-0.00366	-0.00264	-0.00438	-0.00283
	(-0.98258)	(-0.77874)	(-1.09328)	(-0.83655)
2006/04~2007/12	-0.00299	6.41E-05	-0.0011	0.000602
	(-1.02851)	(0.019007)	(-0.37741)	(0.202287)
Panel B: Last Hour on Expiration Day				
2002/01~2007/12	-0.00082	-0.00051	0.002316	-0.00116
(whole period)	(-1.0435)	(-0.62879)	(-0.41363)	(-1.39457)
2002/01~2003/06	-0.00199	-0.00214	-0.00158	-0.00216
	(-0.89861)	(-0.99113)	(-0.65317)	(-0.89815)
2003/07~2005/03	0.002235	0.001569	4.67E-05	-0.00011
	(1.797434)	(1.309778)	(0.40157)	(-0.10086)
2005/04~2006/03	-0.00099	-0.00012	-0.00034	-0.00072
	(-0.75639)	(-0.105)	(-0.20106)	(-0.63755)
2006/04~2007/12	-0.00277	-0.00141	-0.0003	-0.00171
	(-2.37684)*	(-0.89549)	(-0.24426)	(-1.13219)

*This table shows the difference in the average return of the stock market between the expiration day and the non-expiration day of TAIFEX during the whole sample period and four sub-periods. To reduce the influence on the empirical results due to the weekly effect, we have chosen four non-expiration days as the comparison base. In parentheses are the statistical values for the modified Levene t-test. The sign ** and * indicate a significance levels of 1% and 5%, respectively.*

Table 3: Abnormal Return Effect of TAIFEX Index on Settlement Day

	(T+1)-5	(T+1)-1	(T+1)+1	(T+1)+5
Panel A: Whole Settlement Day (T+1)				
2002/01~2007/12	0.004757	0.004491	0.002316	0.003273
(whole period)	(2.56111)*	(2.28097)*	(1.35902)	(1.76061)
2002/01~2003/06	0.002733	0.00713	-0.0006	0.0057
	(0.58683)	(1.52691)	(-0.14661)	(1.16605)
2003/07~2005/03	0.009946	0.00568	0.007191	0.008541
	(2.83548)**	(1.43194)	(2.24844)*	(2.65413)*
2005/04~2006/03	0.002165	0.00438	0.002069	-0.00147
	(0.65035)	(1.09328)	(0.56458)	(-0.39645)
2006/04~2007/12	0.002874	0.0011	0.000108	-0.00125
	(0.93066)	(0.37741)	(0.04104)	(-0.44662)
Panel B: First 15-minutes on Settlement Day				
2002/01~2007/12	0.000323	0.000813	0.000745	0.000385
(whole period)	(0.52810)	(1.36979)	(1.19899)	(0.61986)
2002/01~2003/06	-0.00094	0.000704	-0.00111	-0.00033
	(-0.55031)	(0.43923)	(-0.64709)	(-0.19068)
2003/07~2005/03	0.000939	0.000572	0.00119	0.001158
	(0.90607)	(0.56218)	(1.19972)	(1.19926)
2005/04~2006/03	0.001331	0.001234	0.002396	0.001029
	(0.87167)	(0.77282)	(1.41011)	(0.67269)
2006/04~2007/12	0.000221	0.000906	0.00095	-9.1E-05
	(0.29095)	(1.34237)	(1.33277)	(-0.10583)

*This table shows the difference in the average return of the stock market between the settlement day and the non-settlement day of TAIFEX during the whole sample period and four sub-periods. To reduce the influence on the empirical results due to the weekly effect, we have chosen four non-settlement days as the comparison base. The statistical values for the modified Levene t-test are reported in parentheses. The sign ** and * indicate a significance levels of 1% and 5%, respectively.*

Finally, we compare the average return of the expiration day of SGXTW with that of the four non-expiration days to observe the abnormal return effect of the stock market. With the same period and sub-period we compare in the TAIFEX from 2002 to 2007. The results are exhibited in Table 4, where Panel A indicates the differences in terms of the average return of the stock market between the expiration day and the four non-expiration days. For the whole period, compared with the day before the

expiration day, the phenomenon of abnormal return effect is significant with a 5% level. We also compare the difference in terms of the average return of the stock market during the last hour before closing between the expiration day and non-expiration day. The results in Panel B show that the returns are generally larger during the last hour before the closing of the market although no one is significant.

Table 4: Abnormal Return Effect of SGXTW on Expiration Day

	T-5	T-1	T+1	T+5
Panel A: Whole Expiration Day (T)				
2002/01~2007/12 (whole period)	-0.00069 (-0.32916)	0.00396 (1.93703)*	-0.00166 (-0.80666)	-0.00151 (-0.68887)
2002/01~2003/06	-0.00338 (-0.59663)	0.008913 (1.94664)	0.000874 (0.17145)	-0.00333 (-0.56399)
2003/07~2005/03	-0.0004 (-0.11422)	0.000409 (0.10922)	-0.00422 (-1.04076)	-0.00621 (-1.89485)
2005/04~2006/03	0.00514 (1.28785)	0.004745 (1.26831)	-0.00272 (-0.63264)	-0.00115 (-0.26424)
2006/04~2007/12	-0.00195 (-0.62789)	0.001238 (0.77007)	-0.00067 (-0.23408)	0.003105 (0.78213)
Panel B: Last Hour on Expiration Day				
2002/01~2007/12 (whole period)	0.001403 (1.41279)	0.001466 (1.52509)	7.35E-05 (0.07661)	0.000334 (0.34797)
2002/01~2003/06	0.001301 (0.46983)	0.003997 (1.62558)	0.0015 (0.57602)	0.00142 (0.60459)
2003/07~2005/03	0.001382 (0.73155)	-0.00027 (-0.15171)	-0.00166 (-1.0696)	-0.00048 (-0.26679)
2005/04~2006/03	0.002092 (1.20107)	0.001229 (0.67220)	0.000428 (0.21570)	-2.5E-05 (-0.01278)
2006/04~2007/12	0.002818 (1.06654)	0.001171 (0.78401)	0.000382 (0.24723)	0.000456 (0.29141)

*This table shows the difference in the average return of the stock market between the expiration day and the non-expiration day of SGXTW during the whole sample period and four sub-periods. To reduce the influence on the empirical results due to the weekly effect, we have chosen four non-expiration days as the comparison base. The statistical values for the modified Levene t-test are enclosed on parentheses. The sign ** and * indicate a significance levels of 1% and 5%, respectively.*

By further examining the test outcomes in Table 2, Table3, and Table 4 for abnormal returns effects, we discover that abnormal effects exist on the expiration day regardless of TAIFEX or SGXTW. In addition, when we compare the abnormal returns effects on settlement day of TAIFEX, we find that abnormal return effect also appears on the settlement day. This means that under the special settlement system in TAIFEX, the abnormal return effect also appear on the settlement day.

Price Reversal Effect

If there is a negative price pressure on the underlying stock market during expiration days, as found by Klemlosky (1978), Pope and Yadav (1992), and Stoll and Whaley (1991), then the index price will reverse at the opening of the next trading day. We adopt three measures to capture the possible price reversal. The results of TAIFEX are shown in Table 5 and those of SGXTW are shown in Table 6. First, we compared the stock index returns of TAIFEX between the last hour before the closing of the market and the day after the expiration day. There are 72 expiration day samples during the whole sample period, and 39 of them indicate price reversal or approximately 54.17% of the total number of samples. For the whole period, the price reversal effect is not significant (the p-value of the binomial test is 0.2048). However by observing the sub-period, we find that during the period (2002/01~2003/06) after the TXO entered the markets, the phenomenon of price reversal effect is significant with a 5% level. We also compare the stock index returns of SGXTW. The result shows that there are 72 expiration day samples during the whole sample period, with 38 of them showing price reversal. This finding is not significant (the p-value of the binomial test is 0.2780). However during the sub-period, we discover the period (2005/04~2006/03) after T5F entered the markets, 75% of the total number of samples show price reversal effect, which is significant at the 5 percent level. For the whole period neither the TAIFEX nor

the SGXTW shows significant price reversal effect, and the significant results could be found during the sub-periods. Thus, we suggest that the phenomenon of price reversal effect in the stock market appear in some periods.

Table 5: Price Reversal Effect of TAIFEX Index

	Measure 1 Number of Reversals	Measure 2 Number of Reversals	Measure 3 Number of Reversals	Number of Expiration Days
2002/01~2007/12	39 (0.2048)	40 (0.1444)	31 (0.8556)	72
2002/01~2003/06	12 (0.0481)*	11 (0.1189)	9 (0.4072)	18
2003/07~2005/03	11 (0.3318)	13 (0.0946)	15 (0.0133)*	21
2005/04~2006/03	5 (0.6128)	6 (0.3872)	6 (0.3872)	12
2006/04~2007/12	11 (0.3318)	10 (0.5)	10 (0.5)	21

*This table explains the price reversal phenomenon of the stock market when the index derivatives expired during the whole sample period and the four sub-periods. We used three measures to test for the reversal effect. Measure 1 compared the return of the stock market during the last hour before closing on the expiration day with that on the day after the expiration day. Measure 2 compared the return of the stock market during the last hour before closing on the expiration day with that before the 15 minute on the day after the expiration day. Measure 3 compared the return during the first 15 minutes of the settlement day with that during the others times after the first 15 minutes of the settlement day. The null hypothesis is that price reversal occurs "randomly." That is, the probability of reversal was 50%. The p-value were calculated using a binomial distribution and are shown in parentheses. The sign ** and * indicate significance level of 1% and 5%, respectively.*

Second, we compare the last one hour return before the closing of the market of the expiration day and the return of the first 15-minute after the opening of the market of the day after expiration day (settlement day of TAIFEX). The results are presented in Table 6. For the whole sample period comprising 72 expiration days of TAIFEX, the price reversal phenomenon occurs on 40 days, or approximately 55.56%. The price reversal phenomenon of TAIFEX (the p-value of the binomial test is 0.1444) form the expiration day to settlement day is not significant. We also compare the price reversal effect of SGXTW from the expiration day to the next day. However, in the whole sample period, including 72 expiration days, 38 days of them show price reversal, or approximately 52.78%. The price reversal effect of SGXTW (the p-value of the binomial test is 0.2780) is not significant. By observing the results of the price reversal effect of the sub-periods of TAIFEX and SGXTW, there is no significant situation. However, by noting two sub-periods of SGXTW, when T5F entered the market, the phenomenon of price reversal effect becomes more significant after 15 minutes from the opening of the market of the day after expiration day (the p-value of the binomial test is 0.0946). The same situation is observed at the sub-period when MSF and MSO entered the market (the p-value of the binomial test is 0.7020). Thus, we suggest that the settlement system of SGXTW affect the price reversal effect more than that of TAIFEX when comparing the last one hour return before the closing of the market of the expiration day and the return of the first 15-minute after the opening of the market of the day after expiration day.

Finally, for the third price reversal measure, we compare the first 15-minute return after the opening of the market and the return after the first 15-minute of the settlement day of TAIFEX (the day after the expiration day of SGXTW) by using the time after the final settlement price is set as the basis for comparison basis. For the whole sample period of TAIFEX including 72 expiration days, 40 of them show price reversal, or approximately 55.56%. The phenomenon of price reversal effect (p-value of the binomial test is 0.1444) is still not significant for the whole period. However, by observing when T5F entered the market, the phenomenon of price reversal is significant at the 5% level. We also adopt the same measure to capture the possible price reversal of SGXTW in the stock market. There are 72 expiration day samples during the whole sample period, and 31 (43.06%) of them exhibit price reversal. With respect to the whole period, the price reversal effect is not significant on the day after expiration day (the p-value of binomial test is 0.8556). The statistic results from the sub-period are not significant either.

Table 6: Price Reversal Effect of SGXTW

	Measure 1 Number of Reversals	Measure 2 Number of Reversals	Measure 3 Number of Reversals	Number of Expiration Days
2002/01~2007/12	38 (0.2780)	38 (0.2780)	31 (0.8556)	72
2002/01~2003/06	7 (0.7597)	9 (0.4072)	6 (0.8811)	18
2003/07~2005/03	12 (0.1917)	13 (0.0946)	10 (0.5)	21
2005/04~2006/03	9 (0.0193)*	8 (0.0720)	6 (0.3872)	12
2006/04~2007/12	10 (0.5)	8 (0.8083)	9 (0.6682)	21

*This table shows the price reversal phenomenon of the stock market when the index derivatives expired during the whole sample period and the four sub-periods. We used three measures to test for the reversal effect. Measure 1 compared the return of the stock market during the last hour before closing on the expiration day with that on the day after the expiration day. Measure 2 compared the return of the stock market during the last hour before closing on the expiration day with that before the 15 minute on the day after the expiration day. Measure 3 compared the return during the first 15 minutes of the day after expiration day with that during the others times after the first 15 minutes of the day after the expiration day. The null hypothesis is that price reversal occurs "randomly." That is, the probability of reversal was 50%. The p-value were calculated using a binomial distribution and are shown in parentheses. The sign ** and * indicate significance level of 1% and 5%, respectively.*

By further comparing the results of these three price reversal measures, we discover that the first measure can capture the phenomenon of price reversal of SGXTW and the earlier period of TAIFEX. However, the second measure can capture the phenomenon of price reversal more on the expiration day of SGXTW. This means that the settlement system of SGXTW reflects the price reversal effect more than TAIFEX. Finally, we find that the third measure, which uses the time after the settlement price of TAIFEX, is able to capture the price reversal effect of TAIFEX only. This means that the mechanism in the TAIFEX, which separates the settlement day from the expiration day, can reduce the probability of price reversal in the stock market on the expiration day and the day after the expiration day. The purpose of using the average trading price during 15 minutes after the opening of the market was to reduce the influence of speculators and to alleviate the disequilibrium caused by market volatility. However, the average trading price during 15 minutes seems not enough as the price reversal effect still exist. Thus, if the TAIFEX were to extend the sampling time in relation to determining the settlement price like in the case of the HSI, the price reversal effect on the stock market would be weakened.

Abnormal Price Volatility

Next, we compare the price volatility on the expiration day with that on the four non-expiration days to observe the abnormal price volatility effect of the stock market that is caused by each kind of index derivative in the TAIFEX on the expiration day. We also focus on the first 15 minute of the settlement day and whole settlement day by comparing the data on the settlement day and the four non-settlement days. The results are shown in Table 7 and Table 8. First, from Table 7, for the whole period we do not observe significant results during the whole trading day and last hour on the expiration day. During the sub-periods, we can only observe a significant result from the whole expiration day. However, from Panel A of Table 8, by observing the whole settlement day, the F-test results exhibit that the abnormal volatility obviously exist at the 5% and 1% significance levels as compared with the fifth day before the settlement day and the day after the settlement day. In the sub-period when the MSF and MSO entered the market the stock market showed signs of abnormal volatility at the 1% significance level on the settlement day. Panel B of Table 8 exhibits that the abnormal volatility effect, with a significance level of 5%, also existed during 15 minute of the market on the settlement day regardless if compared to the fifth day before the settlement or the day before the settlement day. We infer that this phenomenon occurs because of the special settlement mechanism used by the TAIFEX. Speculators attempt to raise or lower the price on the settlement day in order to influence the final settlement price, so that the abnormal volatility was found to be more significant during the settlement day as compared with that on the non-settlement days.

Table 7: Abnormal Volatility Effect of TAIFEX Index on Expiration Day

	Expiration Day (T)	T-5	T-1	T+1	T+5
Panel A: Whole Expiration Day (T)					
2002/01~2007/12	0.01165	0.0095	0.01226	0.01198	0.01144
		(1.48958)	(0.90323)	(0.94659)	(1.03699)
2002/01~2003/06	0.01288	0.01118	0.01734	0.01507	0.01806
		(1.32638)	(0.55163)	(0.73007)	(0.50828)
2003/07~2005/03	0.01343	0.00959	0.01032	0.01226	0.00786
		(1.96249)	(1.69485)	(1.19986)	(2.9184)*
2005/04~2006/03	0.00905	0.00918	0.00747	0.01053	0.00748
		(0.97095)	(1.46649)	(0.73854)	(1.46297)
2006/04~2007/12	0.00986	0.00853	0.01169	0.00895	0.00940
		(1.33719)	(0.71193)	(1.21483)	(1.09949)
Panel B: Last Hour on Expiration Day					
2002/01~2007/12	0.00477	0.00445	0.00489	0.00564	0.00513
		(1.14887)	(0.95173)	(0.71501)	(0.86426)
2002/01~2003/06	0.00734	0.00559	0.00550	0.00715	0.00707
		(1.72876)	(1.78536)	(1.05448)	(1.07960)
2003/07~2005/03	0.00326	0.00456	0.00436	0.00622	0.00375
		(0.51129)	(0.55881)	(0.2742)	(0.75374)
2005/04~2006/03	0.00283	0.00356	0.00286	0.00508	0.00271
		(0.63062)	(0.97822)	(0.31005)	(1.08795)
2006/04~2007/12	0.00404	0.00322	0.00591	0.00405	0.00560
		(1.57203)	(0.4672)	(0.99677)	(0.52092)

*This table presents the estimates of price volatility for the stock market (measured by standard deviation of the returns) on the expiration day and the non-expiration day of TAIFEX during the whole sample period and the four sub-periods. To reduce the influence on the empirical results due to the weekly effect, we chose four non-expiration days as the comparison base. We compared the standard deviation of the stock market on the expiration day and the non-expiration day by means of an F-test. The pooled F-statistics are reported in parentheses. The signs ** and * indicate that the price volatility on the expiration day is higher than that on the non-expiration day with significance level of 1% and 5 %, respectively.*

We also investigate the abnormal price volatility on the expiration day of SGXTW as a comparison. The statistic results are shown in Table 9. As Panel A of Table 9 indicates, during the whole trading day and the different sub-periods, as various index derivatives entered the market consecutively, the abnormal volatility effect of the stock market does not appear to be significant. Meanwhile, from Panel B of Table 9, by observing the last hour before the closing of the market, the statistical results from the whole period are not significant. However, by observing the sub-periods, abnormal volatility appears. In particular, during the sub-period (2005/05-2006/03) after MSF and MSO enter the markets, the F-test result exhibited a 1% significance level for the existence of abnormal volatility on the expiration day as compared with that on the fifth day before the expiration day. We infer that the launch of MSF and MSO affect the spot market both on TAIFEX and SGXTW.

Abnormal Volume Effect

Finally, we investigate the abnormal volume effect of the stock market when index derivatives in the TAIFEX and SGXTW expire. The results of the tests are shown in Table 10 and Table 11, respectively. We adopt two measures to capture the possible abnormal volume effect in the stock market. By observing table 10, the first measure which uses the last hour of the expiration day as a basis, shows that the trading volume of the stock market on the expiration days of TAIFEX is not significantly larger than that on non-expiration days. For the whole sample period of 72 expiration days, we find that there were 28 expiration days whose trading volumes are larger than that on non-expiration days, or about 38.89%. Both the whole sample period and sub-period results show that no significant abnormal volume exists during the last hour on the expiration day (the p-value of the binomial test is 0.9618). With the same measure, we set the last hour of the expiration as a basis for the observed abnormal volume effect on the stock market on the expiration days of SGXTW. From Table 11, for the whole sample period comparing 72 days, there are 49 expiration days with larger trading volume than non-expiration days, or about 68.06% of total number of samples. The phenomenon of abnormal volume effect is significant.

Table 8: Abnormal Volatility Effect of TAIFEX Index on Settlement Day

	Settlement Day (T+1)	(T+1)-5	(T+1)-1	(T+1)+1	(T+1)+5
Panel A: Whole Settlement Day (T+1)					
2002/01~2007/12	0.01198	0.00959	0.01165	0.00798	0.01006
		(1.559)*	(1.056421)	(2.2534)**	(1.41637)
2002/01~2003/06	0.01507	0.01160	0.01288	0.00885	0.01377
		(1.68927)	(1.369741)	(2.90211)*	(1.19837)
2003/07~2005/03	0.01226	0.00909	0.01343	0.00802	0.00819
		(1.82027)	(0.83343)	(2.33532)*	(2.24302)*
2005/04~2006/03	0.01053	0.0047	0.00905	0.00710	0.00662
		(4.989)**	(1.354015)	(2.19849)	(2.52661)
2006/04~2007/12	0.00895	0.01078	0.00986	0.00777	0.00916
		(0.68828)	(0.823164)	(1.32429)	(0.95392)
Panel B: First 15-Minutes on Settlement Day					
2002/01~2007/12	0.00399	0.00308	0.00307	0.00341	0.00338
		(1.6776)*	(1.688)*	(1.36677)	(1.39702)
2002/01~2003/06	0.00551	0.00429	0.00399	0.00474	0.00473
		(1.64783)	(1.91141)	(1.34915)	(1.35957)
2003/07~2005/03	0.00318	0.00328	0.00341	0.00325	0.00308
		(0.94057)	(0.86824)	(0.95775)	(1.06679)
2005/04~2006/03	0.00500	0.00173	0.00238	0.00311	0.00169
		(8.313)**	(4.4255)*	(2.5815)	(8.7346)**
2006/04~2007/12	0.00234	0.00252	0.00202	0.00221	0.00316
		(0.86427)	(1.34305)	(1.12085)	(0.55016)

*This table presents the estimates of price volatility for the stock market (measured by standard deviation of the returns) on the settlement day and the non-settlement day of TAIFEX during the whole sample period and the four sub-periods. To reduce the influence on the empirical results due to the weekly effect, we chose four non-expiration days as the comparison base. We compared the standard deviation of the stock market on the expiration day and the non-expiration day by means of an F-test. The pooled F-statistics are reported in parentheses. The signs ** and * indicate that the price volatility on the expiration day is higher than that on the non-expiration day with significance level of 1% and 95 %, respectively.*

Table 9: Abnormal Volatility Effect of SGXTW on Expiration Day

	Expiration Day (T)	T-5	T-1	T+1	T+5
Panel A: Whole Expiration Day (T)					
2002/01~2007/12	0.01125	0.01348	0.01320	0.01338	0.01453
		(0.69661)	(0.72611)	(0.70731)	(0.6)
2002/01~2003/06	0.01465	0.01905	0.01275	0.01590	0.01997
		(0.59159)	(1.32038)	(0.84927)	(0.53827)
2003/07~2005/03	0.00998	0.01215	0.01397	0.01568	0.01099
		(0.67477)	(2.8211)	(0.4051)	(0.82514)
2005/04~2006/03	0.01046	0.00905	0.00766	0.01057	0.01033
		(1.33609)	(1.86465)	(0.97867)	(1.02525)
2006/04~2007/12	0.00943	0.01041	0.01387	0.00926	0.01542
		(0.81956)	(0.4621)	(1.03727)	(0.373)
Panel B: Last Hour on Expiration Day					
2002/01~2007/12	0.00608	0.00569	0.00544	0.00541	0.00521
		(1.14157)	(1.24902)	(1.26116)	(1.36243)
2002/01~2003/06	0.00836	0.00825	0.00624	0.00722	0.00502
		(1.02662)	(1.79417)	(1.34079)	(2.772)*
2003/07~2005/03	0.00568	0.00627	0.00594	0.00428	0.00591
		(0.82154)	(0.91386)	(1.75897)	(0.92382)
2005/04~2006/03	0.00561	0.00220	0.00293	0.00397	0.00323
		(6.495)**	(3.6829)*	(1.99703)	(3.029)*
2006/04~2007/12	0.00420	0.00313	0.00541	0.00570	0.00575
		(1.79256)	(0.60106)	(0.54114)	(0.5324)

*This table presents the estimates of price volatility for the stock market (measured by standard deviation of the returns) on the expiration day and the non-expiration day of SGXTW during the whole sample period and the four sub-periods. To ease the influence on the empirical results due to the weekly effect, we chose four non-expiration days as the comparison base. We compared the standard deviation of the stock market on the expiration day and the non-expiration day by means of an F-test. The pooled F-statistics are reported in parentheses. The signs ** and * indicate that the price volatility on the expiration day is higher than that on the non-expiration day with significance level of 1% and 95 %, respectively.*

at the 1% level. Moreover by observing the sub-periods with various index derivatives entering the market continually, the abnormal volume effect also emerge with 1% and 5% significance levels after the

MSF and MSO entered the market and after the XIF and XIO entered the market respectively.

Table 10: Abnormal Volume Effect of TAIFEX

	Measure 1 Number of Abnormal Volumes	Measure 2 Number of Abnormal Volumes	Number of Expiration Days
2002/01~2007/12	28 (0.9618)	45 (0.0122)*	72
2002/01~2003/06	5 (0.9519)	9 (0.4073)	18
2003/07~2005/03	7 (0.9053)	14 (0.0392)*	21
2005/04~2006/03	8 (0.073)	9 (0.0193)*	12
2006/04~2007/12	8 (0.8083)	13 (0.0946)	21

*This table presents the test results for abnormal volume in the stock market as the index derivatives of TAIFEX expire during the whole sample period and the four sub-periods. Two comparison bases were used to test the abnormal volume effect. Measure 1 compared the stock market volume during the last one hour on the expiration day with that on the non-expiration day. The null hypothesis of the test is that the probability that the stock market on the expiration day is larger than that on the non-expiration day occurs randomly. That is, the probability is 50%. Measure 2 then compared the stock market volume during the first 15 minutes of the settlement day with that of the non-settlement day. The null hypothesis of the test is that the probability that the stock market volume on the 15-minute period of the settlement day is larger than that on the non-settlement day occurs randomly. That is, the probability is also 50%.. The p-value are calculated using a binomial distribution and shown in parentheses. The sign ** and * indicate a significance level of 1% and 5%, respectively.*

In the second measure for abnormal effect, we set the first 15 minutes of the settlement day (the day after expiration day) of TAIFEX and the day after the expiration day of SGXTW as a basis for comparison. In the Table 10, for the whole sample period of 72 days, 45 of them exhibit abnormal volume effects, or approximately 62.50% of total number of samples. The phenomenon of abnormal volume effect is significant at the 5% level during the 15-minute period for the whole period. We also observe the sub-periods with various index derivatives entering the market. We find that the abnormal volume effect of the stock market is also significantly at the 5% level. Moreover, we observe the first 15 minutes of the day after the expiration day of SGXTW to investigate the abnormal volume effect. The results are shown in Table 11. There are 72 expiration day samples during the whole sample period, of which 26 appear abnormal volume, or about 36.11% of total number of samples. This result shows that the trading volume of the stock market during the first 15 minutes after the opening of the market on the day after the expiration day is not significant. By observing the sub-periods, the abnormal volume effect of the stock market is significant at the 1% level during the period after T5F entered the market.

Table 11: Abnormal Volume Effect of SGXTW

	Measure 1 Number of Abnormal Volumes	Measure 2 Number of Abnormal Volumes	Number of Expiration Days
2002/01~2007/12	49 (0.0006)**	26 (0.9878)	72
2002/01~2003/06	11 (0.1189)	15 (0.0007)**	18
2003/07~2005/03	13 (0.0946)	9 (0.6682)	21
2005/04~2006/03	10 (0.0032)**	6 (0.3872)	12
2006/04~2007/12	15 (0.0133)*	8 (0.8083)	21

*This table presents the test results for abnormal volume in the stock market as the index derivatives of TAIFEX expire during the whole sample period and the four sub-periods Two comparison bases were used to test the abnormal volume effect. Measure 1 compared the stock market volume during the last one hour on the expiration day with that on the non-expiration day. The null hypothesis of the test is that the probability that the stock market on the expiration day is larger than that on the non-expiration day occurs randomly. That is, the probability is 50%. Measure 2 then compared the stock market volume during the first 15 minutes of the day after the expiration day with the four comparison days. The null hypothesis of the test is that the probability that the stock market volume on the 15-minute period of the day after the expiration day is larger than that on the four comparison days occurs randomly. That is, the probability is also 50%. The p-value are calculated using a binomial distribution and shown in parentheses. The sign ** and * indicate a significance level of 1% and 5%, respectively.*

By further comparing the results for these two abnormal volume measures, we find that the first measure, setting the last hour period of the expiration day as the basis for comparison, can catch the abnormal volume effect on SGXTW more clearly. However, the second measure, setting the first 15-minute period of the settlement day as the basis for comparison, is able to capture the abnormal volume effect on TAIFEX more clearly. This implies that the two different settlement mechanisms in the SGXTW and TAIFEX determine the abnormal volume effect.

The change of the settlement mechanism can reduce the abnormal volume effect on the expiration day. However, the abnormal volume effect seems to be moved to the 15-minute period of the settlement day. Therefore, if the TAIFEX could extend the sampling time for determining the settlement prices as in the case of the HIS, the abnormal volume on the stock market would be further weakened.

SUMMARY AND CONCLUSIONS

This study uses data on the Taiwan Weighted Stock Price Index and MSCI Taiwan Index to examine the stock market effect of index derivatives on the TAIFEX and SGXTW. The data covers derivatives expiring over the period from January 2002 through December 2007. Seven index derivatives entered the market consecutively from 2002 to 2007. We also divide the whole period to four sub-periods. The differences in terms of returns, volatility, and trading volumes between the expiration day and the non-expiration day are compared and tested in order to identify possible expiration effects.

The empirical results show that the expiration effects of the index derivatives in the TAIFEX appear on the expiration day. It also shows that dividing the settlement day from expiration day cannot reduce the expiration effect effectively. Moreover, under the special settlement procedure on the TAIFEX, using the 15 minutes average price on the settlement day as the settlement price, the expiration effects of index derivatives appear on the settlement day. This result shows that using the opening 15-minute period on the settlement day to determine the final settlement price does not prevent speculators from manipulating the market during this period, but rather extends the period of expiration day effect. The empirical results also show that the expiration effects of the index derivatives in the SGXTW occur on the expiration day. This means that the expiration effect occur in the same stock market no matter what the mechanism or where is market is.

Based on our empirical results that the expiration effect appear both on the expiration day and settlement day of TAIFEX, we argue that the TAIFEX's unique settlement procedure does not successfully reduce expiration effects. Moreover the expiration day of SGXTW also generates the expiration effect. Therefore we close by suggesting that regulators consider changing the settlement procedure on Hang Seng Index derivatives if they are eager to reduce the expiration effects. We also suggest the SGX consider changing their settlement mechanism to prevent affecting the stock market of another country.

APPENDIX

Appendix 1: The Features of the Index Derivative in TAIFEX

Item	Description
Delivery Months	Spot month, the next calendar month, and the next three quarterly months.
Last Trading Day	The third Wednesday of the delivery month of each contract.
Trading Hours	08:45AM-1:45PM Taiwan time. Monday through Friday of the regular business days of the Taiwan Stock Exchange.
Margin	The initial and maintenance margin levels as well as the collecting measures prescribed by the FCM to its customers shall not be less than those required by the TAIFEX. The margin levels will be adjusted and announced by the TAIFEX in accordance with "the Criteria and Collecting Methods regarding the Clearing Margins".
Final Settlement Day	The first business day following the last trading day. All of the open interests after the final settlement day shall be settled on the final settlement price.
Final Settlement Price	The final settlement price for each contract is computed from the first fifteen-minute volume-weighted average of each component stock's prices in the index on the final settlement day. For those component stocks that are not traded during the beginning fifteen- minute interval on the final settlement day, their last closing prices would be applied instead.
Settlement	Cash settlement.

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