
EXPIRATION-DAY EFFECTS ON INDIVIDUAL STOCKS AND THE OVERALL MARKET: EVIDENCE FROM TAIWAN

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On expiration days of the MSCI-TW index futures, the Taiwan spot market is associated with abnormally large volume and high index volatility, along with mild index reversal. The effects concentrate only in the last five minutes of expiration days and appear to be strengthened by the adoption a call auction closing procedure by the Taiwan Stock Exchange. Individual index stocks show high volatility and strong tendency of price reversal, with large- and small-cap stocks being affected more than the medium-sized stocks. The highest-weighted stocks exhibit excessive volume and volatility, which is disproportionate to the impact on all other index stocks, indicating that the expiration-day effects may have been amplified by the attempt of price manipulation using large-cap stocks. © 2009 Wiley Periodicals, Inc. *Jrl Fut Mark* 29:920–945, 2009

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INTRODUCTION

With the introduction of index futures, investors were provided with a means of hedging and speculating against the systematic risk of the stock market; however, one of the more controversial by-products of index futures is the “expiration-day effects.” Expiration-day effects are generally viewed as a combined result of the cash settlement feature of index futures contracts and the unwinding of index arbitrage positions in the stock market (Stoll and Whaley, 1987). Such unwinding activities are often found to be concentrated at a point immediately prior to the contract expiration day, creating excess volume, and noticeable price pressure on the constituent index stocks. Regulators around the world have expressed concern about the resulted price distortion and market destabilization.¹ In contrast to strong regulatory responses, the empirical evidence with regard to the significance, or even existence, of expiration-day effects is rather mixed. In brief, although the abnormal volume reported in most of the prior studies appears to be related to the unwinding of arbitrage positions, the price effects are less pronounced whether assessed by either volatility or price reversal.²

This study examines the extent to which trading on the expiration days of the Morgan Stanley Capital Index, Taiwan (MSCI-TW) index futures affects cash market prices and trading volume in Taiwan. In addition to the effects on the overall index market, this study places specific focus on the behavior of individual stocks, an issue rarely explored in the prior studies. It is of significant importance to undertake analysis of individual stocks because the primary purpose of imposing regulatory controls is to protect retail investors, the majority of whom tend to trade in individual stocks as opposed to large index portfolios. The understanding of whether, and to what extent, individual stocks are affected by futures expiration helps in the formulation of regulatory changes that will be effective in mitigating the expiration-day effects, while not being overly restrictive on other normal market activities.³ To date, the only study to have provided a comprehensive examination of expiration-day effects on individual stocks is Stoll and Whaley (1990).⁴

¹Examples of attempts by regulators to mitigate the expiration-day effects include (i) shifting the final settlement price from the market close to the market open (the S&P 500 in the United States, the TOPIX and Nikkei in Japan, and the SPI in Australia); (ii) using the average price as the final settlement price for the index futures (the HSI in Hong Kong, the FTSE-100 in the United Kingdom, and the CAC-40 in France); and (iii) the application of restrictive rules on index arbitrage (the TOPIX and Nikkei Stock Average in Japan).

²See Chow, Yung, and Zhang (2003), Alkeback and Hagelin (2004), and Vipul (2005) for summaries of relevant studies.

³This is of particular crucial in an emerging market pre-dominated by retail investors. According to the Taiwan Stock Exchange annual report, trading by retail investors accounted for about 83% of all stock market volume in Taiwan during our sample period.

⁴Two other studies involving individual stocks are Karolyi (1996), in which 25 large stocks were used for a robustness check of the index reversals, and Stoll and Whaley (1997), in which analysis of individual stock volatility and reversals was undertaken.

We compare the volume, volatility, and return reversals on expiration and non-expiration days for the MSCI stocks, and also undertake a similar comparison for non-index stocks. Our investigation reveals strong evidence of higher volume and volatility for the MSCI index on expiration days, along with weak evidence of price reversals, both with and without adjustment for the “normal” levels of the non-index stocks. The abnormal volume and volatility are found to be concentrated only in the last five minutes of trading, as opposed to being evenly spread over the expiration days. Furthermore, we find that the effects became much more pronounced after the call auction closing procedure was adopted by the Taiwan Stock Exchange (TSE), indicating that this call procedure has failed to mitigate the expiration-day effects.

It should, however, be noted that the abnormal behavior of the index is the combined result of individual stocks; thus, any study of the index in isolation would tend to mask much of the behavior of individual stocks. An investigation of the behavior of individual stocks around the expiration period helps us to tackle three previously unanswered questions. The first of these seeks to determine whether a particular subset of stocks is more likely to experience greater price distortion, thus, a regulatory remedy could be proposed to deal specifically with such stocks, rather than all stocks. Our results show that all individual index stocks are significantly affected by futures expiration, but with different magnitudes. Abnormal volume and volatility are higher for large and small stocks than for medium-sized stocks; a result that indicates that some index arbitrageurs use only a specific subset of stocks, usually large stocks, rather than the entire index portfolio.

The second question deals with the abnormally large index volatility around the expiration period, seeking to determine whether this is due to the co-movement of index stocks, or increased volatility in individual stocks. If co-movement is the primary source of high index volatility, the expiration-day effects should be of no great concern because there is no temporary price distortion on individual stocks and no investors will be hurt. Conversely, the higher individual stock volatility around the expiration period would pose a potential threat to small investors. Our evidence shows that both effects exist on expiration days, with individual stocks revealing higher volatility and a greater tendency to move in the same direction.

The third question is related to whether manipulation also plays a role in the price distortion exhibited on expiration days. In their theoretical model, Kumar and Seppi (1992) demonstrated that for a cash-settled futures contract, uninformed manipulators could artificially bid up (down) the spot price so as to benefit their earlier established long (short) futures positions. Although the possibility of price manipulation on futures expiration days was recognized by Stoll (1988), Stoll and Whaley (1997), and Alkeback and Hagelin (2004), no empirical evidence has thus far been provided.

This study therefore addresses this issue by examining the behavior of the highest-weighted stock, because such a stock would clearly be the most feasible vehicle for such manipulation, given its considerable influence on the index. Our results indicate that attempts at price manipulation in Taiwan may have been responsible for intensifying the expiration-day effects; as we find that transactions in the highest-weighted stock can alone contribute a considerable proportion of the total market volume and volatility prior to contract expiration, with this proportion being substantially higher than both its own normal level and that of other individual stocks.

The remainder of this article is organized as follows. The section “Institutional Setting and Data” provides a description of the data and methodology used in this study, along with an introduction to the institutional setting of the SGX-traded MSCI-TW index futures and the underlying Taiwan stock market. The abnormal volume, volatility, and return reversals of the overall index market on expiration days, vis-(-vis those on non-expiration days, are presented in the section “The Overall Market Effects.” The section “Individual Stock Effects” examines the expiration-day effects on individual stocks, with special focus on whether the effects differ across stocks of varying index weights, and whether an excessive price effect is discernible for the highest-weighted stocks. Finally, the conclusions drawn from this study are presented in the last section.

INSTITUTIONAL SETTING AND DATA

The SGX-traded Taiwan index futures contracts are based on the MSCI-TW. The index comprises 65–103 large-cap stocks, which together account for about 65% of the market capital of all listings (maximum 787 stocks in our study period) on the TSE. The MSCI-TW index futures, the daily volume of which amounted to around 30,000 contracts in 2004, are one of the most actively traded index contracts on the SGX. The contracts have a monthly expiration cycle, with the last trading day being the penultimate business day of the contract month. The final settlement price is based on the closing price of the MSCI-TW index on the last trading day, the “expiration day.” According to Stoll and Whaley (1997), the settlement procedure involving a single price at the market close, as opposed to other procedures where the average price is used, or where settlement takes place at the market open, is most likely to induce significant expiration-day effects.

The expiration-day effects of MSCI-TW contracts have attracted much regulatory attention in Taiwan.⁵ On July 1, 2002, the TSE changed the stock

⁵Given that MSCI-TW contracts are traded on the SGX-DT, the Taiwan authorities have little control over the rules for determining the futures settlement price. The Ministry of Finance and the Financial Supervisory Commission of Taiwan have consulted several times with the SGX for possible change in the settlement rules, but without success. See *Economic Daily News* (June 8, 2005 and August 16, 2005).

market closing procedure, from frequent calls (every 20–40 seconds), to a call procedure in which all orders for a particular stock are batched during the last five minutes and cleared at a single price. The change in the closing procedure was undertaken in the hope that the longer batch period would prove to be more capable of absorbing large order imbalances, thereby mitigating the expiration-day effects. However, as noted by Stoll and Whaley (1997), the outcome is dependent both on the transparency of the call procedure and the ability to prevent arbitrageurs from “gaming” the market (e.g. submitting false orders to affect the final clearing price).

This study uses intraday stock index data covering the period from January 1997 (the time of the launch of MSCI-TW contracts) to December 2005. The sample period comprises 107 expiration days and 2,160 non-expiration days.⁶ In order to evaluate the impact of the change in the stock market closing procedure, we divide the full sample into two sub-periods, one prior to July 1, 2002, and the other after that date. The *Taiwan Economic Journal* (TEJ) database provides minute-by-minute intraday data on the MSCI-TW spot index, as well as the trade-by-trade price and volume for every individual stock listed on the TSE.

This study assesses the expiration-day effects by comparing the volume, volatility, and price reversals of the MSCI-TW index stocks on expiration days to the same measures for five non-expiration-day samples comprising (i) all non-expiration days; (ii) one trading day before expiration ($E-1$); (iii) one trading day after expiration ($E+1$); (iv) five trading days before ($E-5$); and (v) five trading days after ($E+5$).

THE OVERALL MARKET EFFECTS

Abnormal Volume

Trading activity on expiration days is measured by the cross-sectional average trading volume of the MSCI stocks for every five-minute interval, t , as in the following equation:

$$MV_t = \frac{1}{N} \sum_{i=1}^N V_{it}^{IS} \quad (1)$$

where MV_t is the cross-sectional mean volume at interval t ; V_{it}^{IS} is the volume (in 1,000s of shares) for index stock i at interval t ; and N is the number of MSCI index stocks. It should be noted that greater weights are assigned to the

⁶There are a total of 2,332 trading days in our sample period. Data are missing from the TEJ database on a total of five days trading, and all 51 Saturday trading days are discarded because these occurred only prior to 2001. A further nine days, including one expiration day, are discarded as a result of missing data. The final sample comprises 2,267 trading days.

large-cap stocks in the calculation of cross-sectional average volume. To overcome this “size effect,” we also express the five-minute volume as a fraction of the volume for the entire trading day, using the following equation:

$$M\% V_t = \frac{1}{N} \sum_{i=1}^N \left(\frac{V_{it}^{IS}}{V_i^{IS}} \right) \quad (2)$$

where $M\% V_t$ is the cross-sectional percentage mean volume at interval t ; and V_i^{IS} is the volume for index stock i on that particular day.

Figure 1 plots the intraday pattern of the cross-day average of the mean percentage volume ($M\% V_t$) for both expiration days and the five non-expiration-day samples, with the overnight interval being situated in the center of the graph.

A large spike occurs in the last five minutes prior to the market close on expiration days, during which the volume is twice that exhibited on non-expiration days. Apart from this abnormal volume at the market close, the intraday pattern of expiration days closely resembles that of non-expiration days, showing a frequently observed intraday pattern, with higher volume at market open and close than during the rest of the day. Thus, the figure clearly suggests the

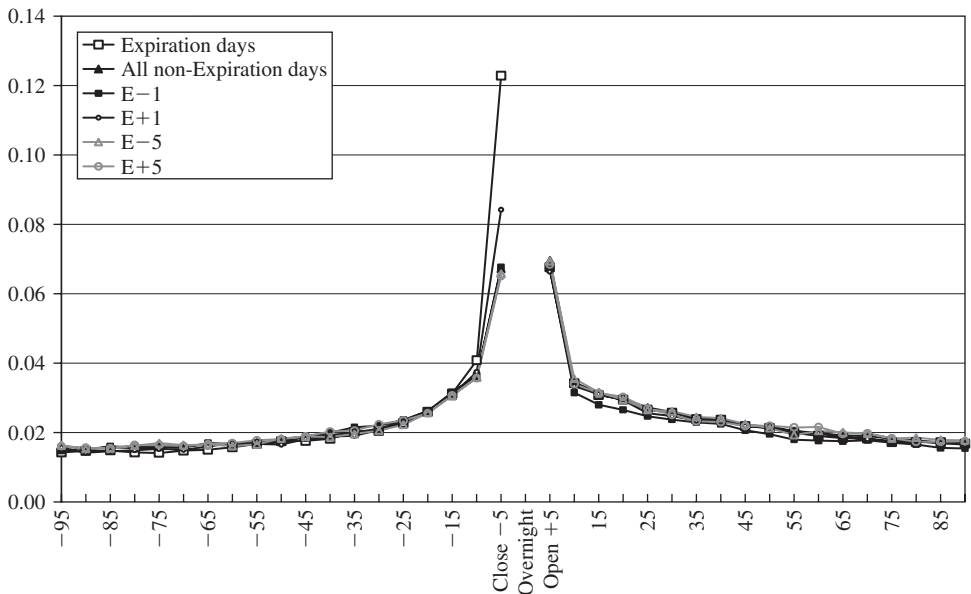


FIGURE 1

Mean percentage volume of the MSCI-TW index for each five-minute interval on expiration and non-expiration days.

Percentage volume is the ratio of the volume in interval t to the whole day volume. A five-minute time series of percentage volume is first created for each stock; the percentage volume is then averaged across stocks by interval to create a market time series of percentage volume for each of these daily intervals. The intraday pattern in the figure is calculated by averaging the five-minute percentage volume across both expiration days and non-expiration days.

presence of abnormal volume for MSCI stocks on expiration days, which is only discernible in the five-minute period immediately prior to futures expiration.

Table I presents the significance tests for the abnormal volume of the MSCI portfolio in the last five-minute interval. The last five-minute volume on expiration days (1,307) is almost twice that for non-expiration days (763), with the difference being statistically significant. The percentage volume shows that transactions taking place in the last five minutes account for an average of 12.3% of the total daily volume on expiration days, which is nearly double the 6.7% on regular days.

As a result of splitting the sample into two sub-periods, we find that the abnormal volume is particularly significant during the second sub-period, the period immediately after the adoption of the closing call procedure in the TSE. Following this regulatory change, the average volume in the last five-minute interval on expiration days (2,029) is almost three times that recorded for

TABLE I
Mean Volume of MSCI Stocks During the Last Five Minutes of Trading Days

<i>Volume Measures</i>	<i>Expiration Days</i>	<i>All Non-Expiration Days</i>	<i>E - 1</i>	<i>E + 1</i>	<i>E - 5</i>	<i>E + 5</i>
<i>Whole period (107 expiration days, 2,159 non-expiration days)</i>						
<i>Last five-min volume</i>	1,307.50	763.10	732.54	894.05	766.68	797.15
<i>Pooled t-test</i>	—	16.35**	6.16**	4.21**	5.76**	5.41**
<i>Paired t-test</i>	—	—	6.41**	4.72**	6.02**	5.82**
<i>Percentage volume</i>	0.123	0.067	0.068	0.084	0.066	0.065
<i>Pooled t-test</i>	—	23.58**	8.99**	5.84**	9.34**	9.55**
<i>Paired t-test</i>	—	—	8.79**	6.24**	8.63**	9.16**
<i>January 1, 1997–June 30, 2002 (65 expiration days, 1,330 non-expiration days)</i>						
<i>Last five-min volume</i>	841.06	756.24	746.62	810.70	768.43	794.18
<i>Pooled t-test</i>	—	2.49*	1.72	0.55	1.36	0.83
<i>Paired t-test</i>	—	—	2.38*	0.88	1.60	1.01
<i>Percentage volume</i>	0.091	0.074	0.075	0.087	0.073	0.071
<i>Pooled t-test</i>	—	7.10*	4.07**	0.93	4.85**	5.39**
<i>Paired t-test</i>	—	—	5.39**	1.13	4.93**	5.50**
<i>July 1, 2002–December 31, 2005 (42 expiration days, 829 non-expiration days)</i>						
<i>Last five-min volume</i>	2029.30	774.10	710.75	1,019.70	763.97	806.77
<i>Pooled t-test</i>	—	21.38**	7.71**	5.41**	7.29**	7.08**
<i>Paired t-test</i>	—	—	8.02**	5.51**	7.69**	7.74**
<i>Percentage volume</i>	0.172	0.056	0.056	0.079	0.055	0.056
<i>Pooled t-test</i>	—	31.52**	11.16**	7.76**	11.24**	11.29**
<i>Paired t-test</i>	—	—	12.25**	9.15**	11.29**	12.19**

Note. Two volume measures, share volume and percentage volume (of whole-day volume), are used to assess the trading activity of the MSCI component stocks in the last five-minute interval of expiration days. Each measure is computed for every stock day and averaged, first within a day to produce a daily cross-sectional mean, then across days. This table reports the cross-day mean over expiration days for each volume measure, as well as over five groups of comparison days: all non-expiration days, the day before ($E - 1$), the day after ($E + 1$), five days before ($E - 5$), and five days after ($E + 5$) the expiration days. The pooled t -statistics and paired- t statistics are reported for the difference between the expiration-day sample and each of the comparison-day samples. *and **indicate significance at the 5 and 1% confidence levels, respectively.

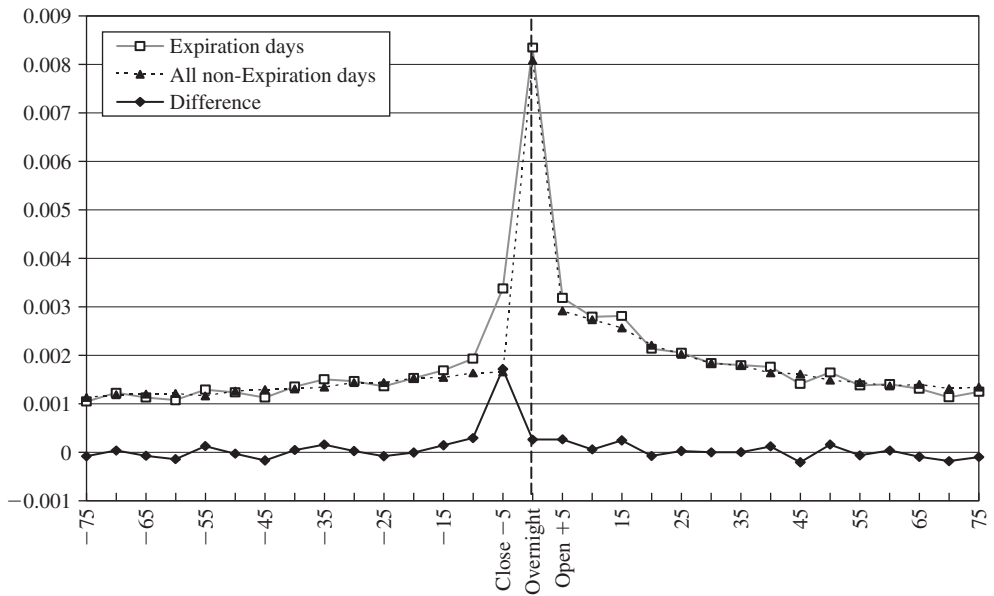


FIGURE 2

Mean volatility of the MSCI-TW index return for each five-minute interval on expiration and non-expiration days.

Intraday volatility is measured by the absolute return of the MSCI index for each five-minute interval. The index volatility within each five-minute interval is averaged across both expiration and non-expiration days. The bold solid line shows the difference between volatility on expiration and non-expiration days.

non-expiration days (774), whereas prior to the change, the difference was only marginal (841 versus 756). The percentage volume on expiration days also exhibits significant growth, from 9.1% in the first sub-period, to 17.2% in the second sub-period.

Although this dramatic increase in volume in the second sub-period may or may not be directly related to the implementation of the closing call procedure, it nevertheless suggests that the adoption of the five-minute call auction was ineffective in reducing the concentrated trading during the last five minutes of expiration days.

Abnormal Volatility

The intraday volatility of the index is assessed by the five-minute absolute return ($|ret|$), and the ratio of the five-minute absolute return to the whole day range return ($\%|ret|$). Both measures are first calculated for each five-minute interval in every trading day, and then averaged across days by intervals.⁷

Figure 2 shows the intraday patterns of $|ret|$ surrounding the overnight interval for the expiration days and for the “all non-expiration days” sample.

⁷We also use return standard deviation and the volatility measure of Parkinson (1980) to measure five-minute volatility; the results are qualitatively similar to those shown here.

Volatility rises sharply during the last five-minute interval of expiration days as compared to non-expiration days, resulting in a spike in the difference between expiration and non-expiration days (the bold solid line). Apart from this obvious peak, intraday volatility remains at almost the same level on both expiration and non-expiration days for every other interval, including the overnight interval.

Details of the cross-day average volatility during the last five-minute interval on both expiration and non-expiration days are provided in Table II. For the whole sample period, the mean absolute return on expiration days (0.00338) is over twice that for all non-expiration days (0.00166). The difference is found to be significant using both the variance ratio test and the Wilcoxon rank sum test. The results of $|\text{ret}|$ show that the last five-minute volatility, from 0.9528 to 0.1296, accounts for approximately 10% of daily volatility on non-expiration days, whereas the $|\text{ret}|$ increases to 20% on expiration days.

TABLE II
Mean Volatility in the MSCI Index During the Last Five Minutes of Trading Days

Volatility Measures	Expiration Days	All Non-Expiration Days	$E - 1$	$E + 1$	$E - 5$	$E + 5$
<i>Whole period (107 expiration days, 2,159 non-expiration days)</i>						
$ \text{ret} $	0.00338	0.00166	0.00179	0.00220	0.00173	0.00196
Variance ratio (F -test)	—	3.65**	19.47**	11.02**	23.17**	19.27**
Wilcoxon rank sum	—	6.67**	4.74**	3.23**	4.59**	3.66**
$ \text{ret} $	0.20157	0.10127	0.09528	0.12963	0.09615	0.12347
Variance ratio (F -test)	—	3.43**	4.13**	2.24**	3.42**	2.19**
Wilcoxon rank sum	—	6.22**	4.82**	2.89**	4.88**	3.36**
<i>January 1, 1997–June 30, 2002 (65 expiration days, 1,330 non-expiration days)</i>						
$ \text{ret} $	0.00281	0.00191	0.00223	0.00202	0.00199	0.00216
Variance ratio (F -test)	—	2.23**	1.66*	3.91**	3.94**	2.84**
Wilcoxon rank sum	—	2.95**	1.77	1.59	2.03*	0.79
$ \text{ret} $	0.14684	0.10065	0.10371	0.11022	0.09539	0.12080
Variance ratio (F -test)	—	2.43**	2.34**	2.22**	3.05**	1.98**
Wilcoxon rank sum	—	2.74**	1.84	1.37	2.15*	0.87
<i>July 1, 2002–December 31, 2005 (42 expiration days, 829 non-expiration days)</i>						
$ \text{ret} $	0.00426	0.00126	0.00111	0.00248	0.00133	0.00165
Variance ratio (F -test)	—	7.65**	31.26**	7.08**	26.65**	20.22**
Wilcoxon rank sum	—	6.68**	5.05**	3.02**	4.60**	4.34**
$ \text{ret} $	0.28627	0.10226	0.08224	0.16075	0.09732	0.12880
Variance ratio (F -test)	—	3.42**	5.54**	1.88*	2.83**	1.81*
Wilcoxon rank sum	—	6.32**	5.12**	3.06**	4.79**	3.91**

Note. Two volatility measures, absolute returns ($|\text{ret}|$) and proportional absolute returns ($|\text{ret}|$), are used to assess the MSCI index return volatility in the last five-minute interval on expiration days as well as on five groups of comparison days. The $|\text{ret}|$ is the close-to-close return of the index in the last five-minute interval, and $|\text{ret}|$ is the ratio of $|\text{ret}|$ to the daily range return defined as the highest minus lowest index divided by the daily average index. $E - 1$, $E + 1$, $E - 5$, and $E + 5$, respectively, stand for one day before, one day after, five days before, and five days after futures expiration. This table reports the mean volatility across sample days. The F -statistics for the variance ratio test and z -statistics of the Wilcoxon rank sum test are used for the difference in volatility between expiration and non-expiration days. *and **indicate significance at the 5 and 1% confidence levels, respectively.

We also find that abnormal volatility became stronger after the frequent call procedure was superseded by the five-minute closing call procedure in the TSE. Both $|\text{ret}|$ and $\%|\text{ret}|$ are smaller in the first sub-period than in the second sub-period on expiration days. The difference between the volatility measures for expiration and non-expiration days is more significant in the second sub-period than in the first.

By consolidating liquidity at specific times, a closing call auction is expected to improve price discovery and thereby reduce volatility (Madhavan, 1992; Pagano & Schwartz, 2003); thus, the finding of increased expiration-day effects after the implementation of the closing call procedure comes as something of a surprise.

A number of factors may contribute to this result. Firstly, the performance of a call mechanism is sensitive to its design of pre-trade transparency (Madhavan, 1992; Stoll, 1988; Stoll & Whaley, 1997). The five-minute closing call procedure in Taiwan is designed such that information on the state of the limit order book is undisclosed until the final clearing price is determined. The mechanism therefore fails to encourage the provision of liquidity during periods of significant order imbalance. Secondly, as suggested by Comerton-Forde and Rydge (2006), the closing call prices are vulnerable to manipulation. The significant volatility effects found in the second sub-period may be, in part, ascribed to the attempt of price manipulation.⁸ Thirdly, the stronger expiration-day effects in the second sub-period may simply be a consequence of more active index arbitrage in a mature market. Nevertheless, the results suggest that if the closing call auction, which was implemented in Taiwan, has not in fact exacerbated the expiration-day effects, it has clearly failed to mitigate the situation.

Abnormal Price Reversals

Stoll and Whaley (1987, 1990, 1997) suggest that if the unwinding of index arbitrage leads to a temporary order imbalance, which drives the price away from the equilibrium level, the index will tend to reverse at the next open when all of the pressure has dissipated. We apply the three measures of return reversals ($REV0$, $REV1$, and $REV2$), as proposed by Stoll and Whaley (1987). Reversals are calculated between the last five-minute interval (R_t) and the overnight close-to-open returns (R_{t+1}), because significant abnormal volume and volatility are observed only during these intervals. The three reversal measures are specified as

⁸The same view is shared by Chung and Hseu (2007), who document greater TAIEX index volatility after the TSE adopted the closing call procedure.

$$\begin{aligned} REV0_t &= R_{t+1} \text{ if } R_t < 0 \\ REV0_t &= R_{t+1} \text{ if } R_t \geq 0 \end{aligned} \quad (3)$$

$$\begin{aligned} REV1_t &= |R_{t+1}| \text{ if } \text{sign}(R_t) \neq \text{sign}(R_{t+1}) \\ REV1_t &= 0 \quad \text{otherwise} \end{aligned} \quad (4)$$

and

$$\begin{aligned} REV2_t &= |R_t| \text{ if } \text{sign}(R_t) \neq \text{sign}(R_{t+1}) \\ REV2_t &= 0 \quad \text{otherwise} \end{aligned} \quad (5)$$

We report the mean reversal for expiration days and the five non-expiration day samples in Table III. For the sample period as a whole, *REV0*, *REV1*, and *REV2* are all positive on expiration days, indicating that the price movements during the last five minutes of the expiration day tend to be reversed during the overnight interval. Significant results are, however, only discernible for *REV2*, and not for *REV0* or *REV1*. The significant *REV2* on expiration days over the whole sample period is mainly attributable to the substantial reversals during the second sub-period, whereas the first sub-period shows only a marginal tendency for reversals. This result echoes our previous findings of more pronounced abnormal volume and volatility in the second sub-period.

We carry out an alternative test to examine the frequency of reversals on expiration days vis-à-vis non-expiration days; the results are presented in Table IV, from which it shows that there were 66 reversals on 107 expiration days. The percentage of reversals on expiration days, at 62%, is significantly higher than that for the “all non-expiration days” sample. Expiration-day price reversals tend to be more clustered in the second sub-period, with a reversal rate of 69%, as compared to the first sub-period, where the reversal rate is 57%.

Although the findings of the present study confirm the statistical significance of the abnormal volatility and moderate price reversals on expiration days, the economic significance of the price effect should be evaluated against the normal bid–ask spreads, as suggested by Stoll and Whaley (1987). Studies have shown that the average percentage quote spreads in the Taiwan stock markets is about 0.5%.⁹ If the selling (buying) pressure results in all stocks being pushed to trade at the bid (ask) price upon futures expiration, the index will fall (rise) by half the spread, an approximate amount of 0.25%.

⁹Brockman, Chung, and Perignon (2008) report an average relative effective spread of 0.53% for the top 289 firms in Taiwan. Ke, Jiang, and Huang (2004) show respective spreads of 0.34 and 0.97% for stocks traded under two different tick-size categories.

TABLE III
Price Reversals in the MSCI Index During the Last Five-Minute and Overnight Intervals

<i>Reversal Measures</i>	<i>Expiration Days</i>	<i>All Non-Expiration Days</i>	<i>E - 1</i>	<i>E + 1</i>	<i>E - 5</i>	<i>E + 5</i>
<i>Whole period (107 expiration days, 2,159 non-expiration days)</i>						
<i>REV0</i>	0.00055	-0.00032	0.00063	-0.00166	0.00121	0.00074
Pooled <i>t</i> -test	—	0.72	-0.05	1.31	-0.43	-0.12
Wilcoxon rank sum	—	1.17	0.13	1.10	0.26	0.19
<i>REV1</i>	0.00445	0.00386	0.00409	0.00277	0.00412	0.00413
Pooled <i>t</i> -test	—	0.81	0.35	1.88	0.31	0.32
Wilcoxon rank sum	—	2.28*	0.86	1.99*	1.37	1.02
<i>REV2</i>	0.00217	0.00080	0.00093	0.00124	0.00080	0.00101
Pooled <i>t</i> -test	—	9.17*	3.69*	2.56*	4.43*	3.66*
Wilcoxon rank sum	—	4.94**	3.04**	2.53*	3.33**	2.74**
<i>January 1, 1997–June 30, 2002 (65 expiration days, 1,330 non-expiration days)</i>						
<i>REV0</i>	0.00011	-0.00042	0.00079	-0.00234	0.00218	0.00050
Pooled <i>t</i> -test	—	0.31	-0.29	1.06	-0.91	-0.17
Wilcoxon rank sum	—	0.23	-0.42	0.72	-0.70	-0.07
<i>REV1</i>	0.00495	0.00441	0.00487	0.00275	0.00517	0.00460
Pooled <i>t</i> -test	—	0.51	0.06	1.62	-0.13	0.22
Wilcoxon rank sum	—	1.07	-0.04	1.38	0.11	0.64
<i>REV2</i>	0.00154	0.00091	0.00122	0.00104	0.00092	0.00114
Pooled <i>t</i> -test	—	3.23*	0.88	1.48	2.06*	1.23
Wilcoxon rank sum	—	2.39*	0.91	1.55	1.32	1.12
<i>July 1, 2002–December 31, 2005 (42 expiration days, 829 non-expiration days)</i>						
<i>REV0</i>	0.00123	-0.00014	0.00039	-0.00061	-0.00028	0.00103
Pooled <i>t</i> -test	—	0.90	0.52	0.77	0.91	0.12
Wilcoxon rank sum	—	1.78	1.03	0.92	1.63	0.52
<i>REV1</i>	0.00367	0.00298	0.00289	0.00279	0.00250	0.00339
Pooled <i>t</i> -test	—	0.82	0.87	0.98	1.24	0.30
Wilcoxon rank sum	—	2.46*	1.60	1.54	2.28*	0.93
<i>REV2</i>	0.00315	0.00064	0.00050	0.00155	0.00062	0.00080
Pooled <i>t</i> -test	—	11.27**	4.40**	2.16*	4.16**	3.83**
Wilcoxon rank sum	—	4.86**	1.60	2.20*	3.51**	2.98**

Note. The average magnitude of cross-day price reversals are reported for the expiration-day sample and five comparison-day samples, with the price reversals being measured by *REV0*, *REV1*, and *REV2* as defined in Stoll and Whaley (1987). Reversals are calculated between the last five-minute interval and the overnight close-to-open returns. *E - 1*, *E + 1*, *E - 5*, and *E + 5*, respectively, stand for one day before, one day after, five days before, and five days after futures expiration. The pooled *t*-test and Wilcoxon rank sum test are presented for the difference between the expiration-day sample and each comparison-day sample. *and **indicate significance at the 5 and 1% confidence levels, respectively.

The empirical results shown in Table II indicate that the absolute price change in the last five minutes of expiration days is 0.338%; in other words, the abnormal price effects over and above the bid–ask bounce caused by the unwinding of index arbitrage positions will be no greater than 0.1% (0.338–0.25). This result concurs with that of Stoll and Whaley (1987), showing that despite

TABLE IV
Binomial Tests for the Frequency of Reversals on Expiration and Non-Expiration Days

Reversal Measures	Expiration Days	All Non-Expiration Days	$E - 1$	$E + 1$	$E - 5$	$E + 5$
<i>Whole period (107 expiration days, 2,159 non-expiration days)</i>						
No. of days	107	2,159	107	107	107	107
No. of reversals	66	1,056	58	56	53	56
% Of reversal days	0.62	0.49	0.54	0.52	0.50	0.52
Binomial test	—	2.584**	1.108	1.381	1.789*	1.381
<i>January 1, 1997–June 30, 2002 (65 expiration days, 1,330 non-expiration days)</i>						
No. of days	65	1,330	65	65	65	65
No. of reversals	37	639	37	32	34	31
% of reversal days	0.57	0.48	0.57	0.49	0.52	0.48
Binomial test	—	1.398	0.000	0.879	0.528	1.054
<i>July 1, 2002–December 31, 2005 (42 expiration days, 829 non-expiration days)</i>						
No. of days	42	829	42	42	42	42
No. of reversals	29	417	21	24	19	25
% of reversal days	0.69	0.50	0.50	0.57	0.45	0.60
Binomial test	—	2.379*	1.778*	1.131	2.205*	0.911

Note. The table reports the number of days in which a price reversal is experienced by the expiration-day sample and the five comparison-day samples. $E - 1$, $E + 1$, $E - 5$, and $E + 5$, respectively, stand for one day before, one day after, five days before, and five days after futures expiration. The table also presents binomial tests for whether the percentage of the reversals is higher on expiration days than on non-expiration days. *and **indicate significance at the 10 and 1% confidence levels, respectively.

the statistically significant price movements, the expiration-related price impact on the overall market appears to have little economic significance.¹⁰

INDIVIDUAL STOCK EFFECTS

In the previous section, we demonstrated that the stock market as a whole is characterized by abnormally large volume and volatility on expiration days, along with some price reversal. We devote this section to the study of the abnormal behavior of individual stocks on expiration days.

Throughout our examination, we focus on how stock capitalization influences the abnormal behavior of individual stocks, with the focus on this single

¹⁰To check for the robustness of the results in the section “The Overall Market Effects,” we also compare the expiration-day effects of the MSCI-TW index to the effects of a non-MSCI index. Essentially, stocks not subject to program trading are supposed to act “normal,” even on expiration days. The non-MSCI index is constructed by value-weighting TSE-listed stocks excluded from the MSCI-TW index. The non-MSCI index comprises 283–598 stocks, which together account for about 35% of the TSE market capital. We adjust the MSCI-index measures (volume, volatility, and reversal) for the “normal” measures of the non-MSCI index, with the adjustment made by either dividing to (for volume measures) or subtracting from (for volatility and reversal measures) the corresponding non-MSCI measures. Results based on the adjusted measures are highly consistent with those reported in Tables I–IV, showing greater volume, volatility, and moderate reversals in the second sub-period. The results are available from the author on request.

dimension being essentially based upon the following two reasons. Firstly, index arbitrage activity is sometimes carried out using a subset of large-cap index stocks. It is therefore possible that stocks will be subjected to different magnitudes of impact according to their relative weights in the index. Secondly, the highest-weighted stock is, by design, most influential to the index; hence, it is most susceptible to price manipulation. Price manipulators attempting to artificially move the final settlement index can achieve the greatest impact, at the minimum cost, by concentrating their trading on the highest-weighted stock. Therefore, any excessively large volume and volatility for the highest-weighted stock may well reflect the transactions motivated by price manipulation.

In order to compare the magnitude of the expiration-day effects between high- and low-weighted stocks, we provide a ranking for all of our MSCI sample stocks on each day, from highest to lowest, according to their daily market capitalization. Individual stocks are aggregated across days by stock-size ranking, with size rank 1 containing the highest-weighted stocks from each day, rank 2 containing the second highest, and so on, up to the 63rd size rank.¹¹ The abnormal volume, volatility, and reversals are then summarized within each size rank. A comparison sample is formed by performing the same ranking process for stocks *not* in the MSCI index.¹² For the sake of brevity, we report only the results for the period from July 1, 2002, to December 31, 2005, a time during which the closing call procedure was adopted by the TSE; and indeed, the expiration-day effects are found to be particularly significant.¹³

Abnormal Volume of Individual Stocks

The abnormal volume for each individual stock is measured by the proportional volume in that stock during the last five-minute interval ($V_{i,-5}$) relative to the total share volume for the entire day (V_i); i.e.

$$\%V_i = \frac{V_{i,-5}}{V_i}. \quad (6)$$

This measure determines the concentration of trading in individual stocks immediately prior to futures expiration, and is comparable across different sizes of firms.¹⁴

¹¹The number of MSCI constituent stocks varies over time during our sample period, from 63 to 103. To avoid the problem of unequal sample size when aggregating variables across days by stock weighting, we use only the highest 63 weighted stocks.

¹²The number of non-MSCI index stocks varies from 283 to 598 in our sample period. In order to match with the MSCI sample, we only retain the largest 63 size ranks.

¹³Although moderate volume effects are discernible prior to the implementation of the closing call procedure, there is no abnormal volatility or price reversal for majority of individual stocks; the results are not included here but are available from the author on request.

¹⁴Other measures on trading activity, number of shares, and dollar volume, which are not shown here, provide very similar results.

Figure 3 illustrates the mean proportional volume for the MSCI stocks on both expiration days (MSCI_Exp) and all non-expiration days (MSCI_nonExp), by size ranking. The same measure for the sample of the non-MSCI stocks (nonMSCI_Exp and nonMSCI_nonExp) is also plotted by size ranking. Table V reports the pooled average of the proportional volume for (i) all 63 size ranks together; (ii) ten deciles of size ranks from rank 2 to 61; and (iii) the first size rank.

Figure 3 and Table V give rise to several interesting points. Firstly, higher proportional volume is apparent on expiration days than on non-expiration days for individual MSCI stocks, of all size ranks. This indicates that the concentrated volume in the last five minutes on expiration days is common to all index stocks, regardless of their weight in the index, thereby implying that the expiration-day effects are primarily caused by index arbitrage activities using the entire MSCI portfolio.

Secondly, there is a clear U-shaped pattern in Figure 3 in the proportional volume of MSCI stocks on expiration days, across size ranks. The same pattern is also observed across the ten size deciles, in the second column of Table V: the proportional volume monotonically declines from the first to the fifth

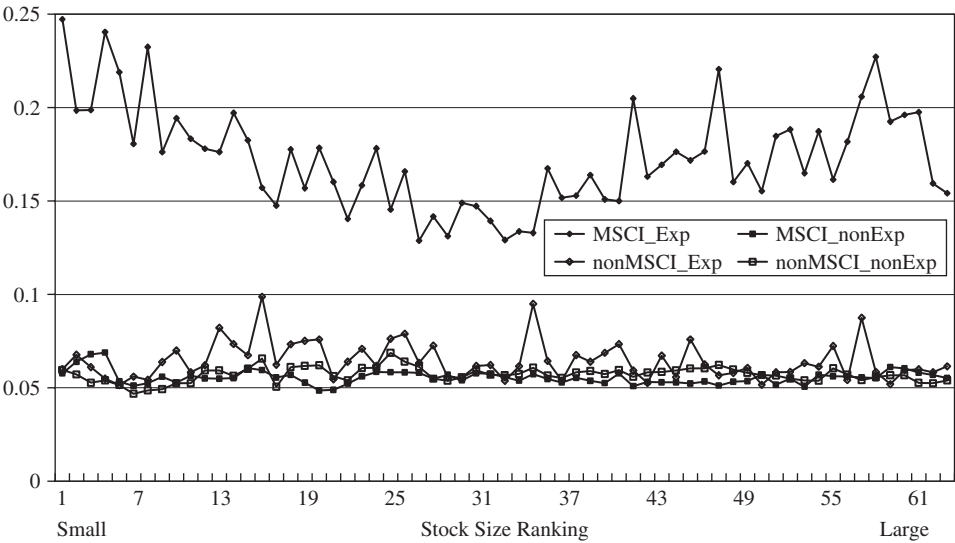


FIGURE 3

Proportional volume for sub-samples of MSCI and non-MSCI stocks on all expiration and non-expiration days, by size ranking.

The figure illustrates the mean proportional volume (the proportion of the trading volume during the last five-minute interval to the whole day volume) for the sub-samples of MSCI stocks on expiration (MSCI_Exp) and non-expiration (MSCI_nonExp) days and the sub-samples of non-MSCI stocks on expiration (nonMSCI_Exp) and non-expiration (nonMSCI_nonExp) days. The proportional volume of individual stocks is averaged across days by size rank. The stocks are ranked (and re-ranked) each day based upon their market capitalization, with rank 1 containing the highest-weighted stock from each day, rank 2 containing the second highest, and so on.

TABLE V
Pooled Mean Proportional Volume of Individual Stocks, by Size Decile

Stock Rankings	MSCI Stocks			Non-MSCI Stocks				
	Expiration Days	All Non-Expiration days	$E - 1$	$E + 1$	$E - 5$	$E + 5$	Expiration Days	All Non-Expiration Days
All 63 stocks	0.173+	0.056**	0.055**	0.080**	0.054**	0.056**	0.064	0.057**
size deciles								
1 (large)	0.212+	0.060**	0.054**	0.090**	0.055**	0.059**	0.058	0.052**
2	0.184+	0.055**	0.054**	0.085**	0.052**	0.058**	0.068	0.055**
3	0.167+	0.056**	0.058**	0.077**	0.058**	0.053**	0.075	0.060**
4	0.158	0.055**	0.056**	0.078**	0.053**	0.053**	0.068	0.061*
5	0.140	0.056**	0.057**	0.084**	0.055**	0.061**	0.062	0.057*
6	0.145	0.055**	0.054**	0.075**	0.057**	0.053**	0.066	0.057*
7	0.167+	0.053**	0.055**	0.070**	0.052**	0.055**	0.064	0.058**
8	0.179+	0.053**	0.054**	0.076**	0.050**	0.055**	0.062	0.060
9	0.174+	0.055**	0.054**	0.078**	0.051**	0.058**	0.061	0.056
10 (small)	0.200+	0.058**	0.057**	0.082**	0.054**	0.059**	0.062	0.055*
Highest-weighted stocks	0.247+	0.058**	0.050**	0.088**	0.061**	0.061**	0.060	0.060

Note. The proportional volume of individual stocks is measured by the proportion of the last five-minute volume to all-day volume. Stocks are ranked each day based on their market capitalization, with size rank 1 containing the highest-weighted stocks on each day, size rank 2 containing the second highest, and so on. Observations are further categorized into ten deciles according to their size rank. The proportional volume on expiration and non-expiration days coming from different populations is indicated by *at the 5% confidence level, and **at the 1% confidence level, using the Wilcoxon rank sum test. A "plus" sign in the second column indicates that the expiration-day proportional volume of the decile is significantly greater than that of the 5th decile at the 5% confidence level.

deciles, followed by a monotonic increase to the tenth decile. Evidence suggests that the magnitude of the volume impact does have relevance to firm size, with a smaller impact on medium-sized firms and a greater impact on small- and large-cap firms. The greater volume impact on large-cap firms may be the result of certain program trading strategies that use only a subset of index stocks, typically large-cap stocks.

Thirdly, the highest-weighted stocks have an average of 24.7% volume concentration on expiration days, which is the highest for all size ranks. To assess the volume impact of the highest-weighted stocks to overall market, we further calculate the ratio of dollar volume of individual stock to the entire MSCI portfolio (not shown in the table). The last five-minute trading volume of the highest-weighted stocks accounts for 11.4% of overall market volume on expiration days, which nearly doubles their 6.1% volume contribution on regular days. For any other size ranks, the volume contribution on expiration days is substantially smaller (less than 6%) and shows little incremental (less than 50%) from non-expiration days.

The greater volume impact on the largest-cap stocks is not readily attributable to the unwinding of index arbitrage positions but raises concerns of potential

price manipulation. Index arbitrageurs will typically use either the entire index portfolio or a basket of large-cap index stocks. In either case, the highest-weighted stock would not exhibit such a large volume contribution disproportionate to that of other index stocks. A possible explanation is that some traders may be manipulating the final settlement index by placing heavy pressure on the highest-weighted stock, given that this is the stock with the greatest influence on the index value.

Uniformity of Price Change

We have demonstrated in the section “The Overall Market Effects” that the MSCI index becomes more volatile during the last five-minute interval on expiration days. The greater index volatility may stem from the greater volatility of individual stocks, the increased uniformity of movement of stocks, or both; it is, however, important to distinguish the source of index volatility because small investors are affected more by the increased volatility of individual stocks than by the co-movement of stocks. In Table VI, we perform an examination of whether there is a greater likelihood of index stocks moving in the same direction on expiration days as compared to non-expiration days.

In the last five minutes on expiration days, about 55% of firms move in the same direction as the MSCI index, a proportion that is significantly greater than that for non-expiration days, when it ranges between 34 and 40%. Meanwhile, fewer stocks move in the opposite direction to the index on expiration

TABLE VI
Proportion of Firms Moving in the Same or Opposite Direction to the MSCI Index

Direction Relative to MSCI Index	Expiration Days	All Non- Expiration Days	<i>E</i> − 1	<i>E</i> + 1	<i>E</i> − 5	<i>E</i> + 5
Panel A: MSCI index stocks						
% same direction	0.55	0.35**	0.34**	0.40**	0.35**	0.36**
% opposite direction	0.15	0.22**	0.22**	0.22**	0.20**	0.22**
C-S return std.	0.0068	0.0052**	0.0051**	0.0073	0.0048**	0.0052**
Panel B: Non-index stocks						
% same direction	0.28−	0.28	0.29	0.29	0.29	0.28
% opposite direction	0.27+	0.26	0.26	0.27	0.25	0.26
C-S return std.	0.0097+	0.0092	0.0090	0.0102	0.0093	0.0091

Note. The mean (across days) proportion of MSCI firms moving in the same and opposite direction to the MSCI index in the last five-minute interval on expiration and non-expiration days is reported in Panel A. The mean (across days) proportion of the non-MSCI firms moving in the same and opposite direction to the MSCI index is reported in Panel B. “C-S return std.” refers to the cross-sectional standard deviation of the last five-minute returns for all MSCI index stocks. Note that the sum of the proportion of firms moving in the same and opposite directions is less than 100% because some firms have zero returns in the last five-minute interval. Significant difference between the proportion on expiration and non-expiration days is indicated by *at the 5% confidence level, and **at the 1% confidence level, using the Wilcoxon rank sum test. A “plus” (“minus”) sign in the second column indicates that the expiration-day proportion of the index stocks is significantly greater (smaller) than the expiration-day proportion of the MSCI stocks at the 5% confidence level.

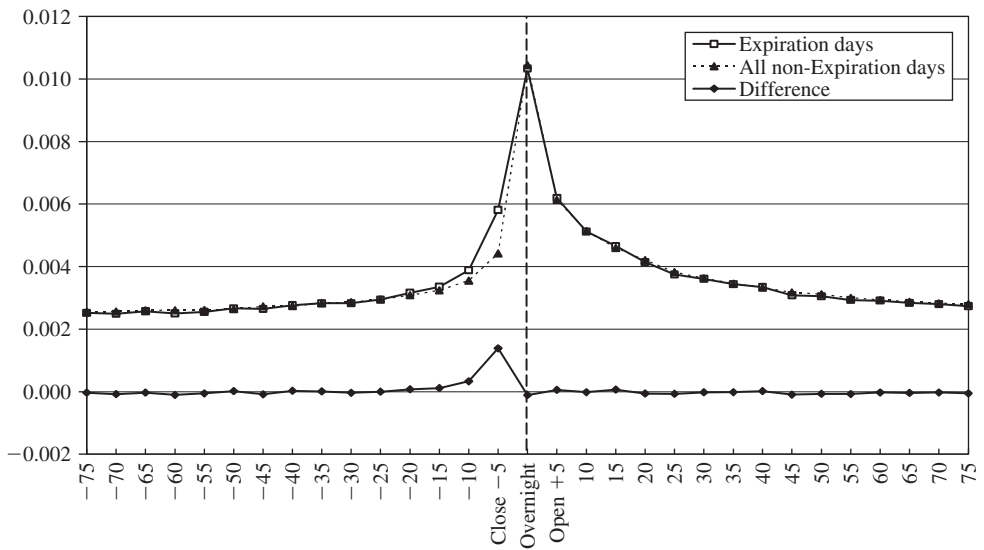


FIGURE 4

Average MSCI stock volatility on expiration and non-expiration days.

This figure illustrates the intraday pattern of average stock volatility for each five-minute interval, where volatility is measured by the absolute return for the five-minute interval. For each five-minute interval, the volatility of individual MSCI stocks is first averaged across stocks, and then across both expiration and non-expiration days. The bold line indicates the difference between the expiration-day and non-expiration-day pattern.

days (15%) than on non-expiration days (22%). Conversely, for the non-index stocks, the tendency for movement in the same and opposite directions to the index is essentially equal on both expiration and non-expiration days.

Although the evidence indicates a tendency for stock prices to move together on expiration days, the magnitude of the impact on individual stocks is less than equal. This can be observed by the greater cross-sectional standard deviation of stock returns during the last five-minute interval of expiration days, denoted as “C-S return std” in Table VI. If the magnitude of the influence of the expiration-day effect is similar for all index stocks, the cross-sectional variability should be less for expiration days than for non-expiration days; however, this is not the case. The higher cross-sectional volatility for individual stocks is consistent with the findings on the U.S. market reported by Stoll and Whaley (1990).

Abnormal Volatility of Individual Stocks

Individual stock volatility is measured by the absolute return in each five-minute interval ($|\text{ret}|$).¹⁵ For every five-minute interval, we first of all calculate

¹⁵We also assess intraday volatility using the measure developed by Daigler (1997) and Parkinson (1980) and obtain similar results.

the equal-weighted mean volatility across stocks, then average this across both expiration and non-expiration days.

Figure 4 provides an illustration of the average individual stock volatility for each five-minute interval on both expiration and non-expiration days. The intraday pattern closely resembles the index volatility illustrated in Figure 2, with a discernible spike in the difference between the expiration day and the non-expiration day occurring only in the last five-minute interval. It is therefore clear that the expiration of MSCI-TW contracts results in an increase in the volatility of individual stocks in much the same way as it does for the portfolio of overall market.

Table VII presents the results of the statistical tests for the difference in the last five-minute $|ret|$ between expiration and non-expiration days, along

TABLE VII
Volatility of Individual Stocks

	MSCI Stocks						Non-MSCI Stocks	
	Expiration Days	All Non- Expiration Days	$E - 1$	$E + 1$	$E - 5$	$E + 5$	Expiration Days	All Non- Expiration Days
Panel A: Average of individual stock volatility								
lretl	0.00562	0.00331**	0.00326**	0.00467*	0.00310**	0.00342**	0.00490	0.00466*
%lretl	0.26044	0.14018**	0.14134**	0.19843*	0.12252**	0.14099**	0.15194	0.14044*
Panel B: Pooled mean proportional volatility (% ret) of 63 stocks, by size decile								
All 63 stocks	0.220+	0.132**	0.134**	0.172**	0.119**	0.139**	0.139	0.128**
size deciles								
1 (large)	0.258+	0.151**	0.148**	0.204**	0.121**	0.176**	0.122	0.105
2	0.239+	0.141**	0.151**	0.193*	0.123**	0.160**	0.134	0.128
3	0.203	0.129**	0.124**	0.155*	0.127**	0.136**	0.141	0.135
4	0.211+	0.127**	0.117**	0.189*	0.117**	0.115**	0.161	0.128*
5	0.175	0.113**	0.122*	0.156	0.086**	0.119**	0.117	0.123
6	0.190	0.118**	0.116**	0.160	0.101**	0.107**	0.166+	0.131**
7	0.205	0.129**	0.128**	0.155**	0.120**	0.129**	0.146	0.137
8	0.240+	0.134**	0.141**	0.157**	0.129**	0.140**	0.137	0.133
9	0.233+	0.140**	0.153**	0.183*	0.119**	0.149**	0.127	0.123
10 (small)	0.234+	0.143**	0.145**	0.168**	0.148**	0.164**	0.116	0.128
Highest-weighted stocks	0.318+	0.141**	0.097**	0.211**	0.137**	0.178**	0.195	0.197

Note. The table reports the average volatility of individual stocks for the expiration days and for the various non-expiration day periods. Panel A assesses individual stock volatility by the absolute return in the last five-minute interval (*lretl*) as well as the ratio (*%lretl*) of the absolute return in the last five-minute interval over the range return for the whole day. Individual stock volatility is initially averaged across the stocks for each day, and then across both expiration and non-expiration days. Panel B ranks the stocks on each day based on their market capitalization, with size rank 1 containing the highest-weighted stocks on each day, size rank 2 containing the second highest, and so on. Observations are further categorized into ten deciles according to their size rank. The volatility on expiration and non-expiration days coming from different populations is indicated by *at the 5% confidence level, and **at the 1% confidence level, using the Wilcoxon rank sum test. A “plus” sign in the expiration-day columns indicates that the expiration-day volatility of the decile is significantly greater than that of the 5th decile at the 5% confidence level.

with the ratio ($\%|ret|$) of the last five-minute absolute returns to the whole-day absolute range returns defined as the daily highest price minus the lowest price divided by the daily mean.

Panel A reveals that on expiration days, $|ret|$ is 0.00562 and $\%|ret|$ is 0.26, both of which are significantly greater than the corresponding figures on non-expiration days using the Wilcoxon rank sum test. Together with the findings reported in Table VI, this result suggests that not only do the expiration-day effects cause an increase in the co-movement of the index stocks, but that they also lead to higher volatility for individual stocks. The latter of these two effects is of particular concern, essentially because it implies that retail investors engaging in transactions around the expiration period will trade at a price that may be some distance from its fair value.

In order to further explore whether these effects are more pronounced on large-cap stocks than smaller ones, we perform the same size ranking as in the section “Abnormal Volume of Individual Stocks” and report the $\%|ret|$, by size rank, on expiration days and non-expiration days for both MSCI and non-MSCI stocks.

Figure 5 shows that across size ranks, the volatility impact on expiration days exhibits a U-shaped pattern, similar to the volume effect. This pattern is confirmed by the results reported in the second column in Panel B of Table VII,

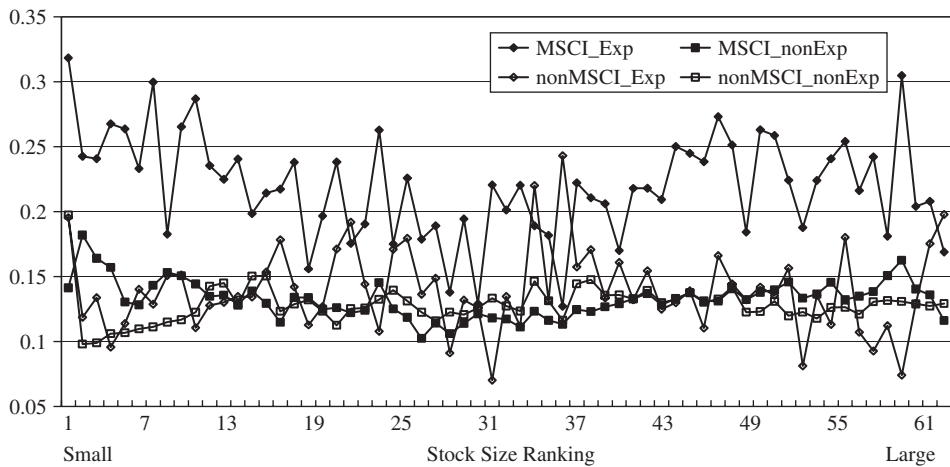


FIGURE 5

Proportional volatility for sub-samples of MSCI and non-MSCI stocks on expiration and non-expiration days, by size ranking.

This figure illustrates the cross-day mean proportional volatility for the sub-samples of MSCI stocks on expiration (MSCI_Exp) and non-expiration (MSCI_nonExp) days, and the sub-samples of non-MSCI stocks on expiration (nonMSCI_Exp) and non-expiration (nonMSCI_nonExp) days. The mean proportional volatility is the ratio of the absolute return during the last five-minute interval to the absolute return over the entire day, averaged across days, by size ranking. Stocks are ranked (and re-ranked) each day based on their market capitalization, with rank 1 containing the highest-weighted stock from each day, rank 2 containing the second highest, and so on.

from which we can see that there is a decline in the pooled mean $\%|\text{ret}|$ from 0.258 in the largest size decile, to 0.175 in the fifth size decile, and then a subsequent increase to 0.240 in the eighth decile.

Although all individual index stocks become more volatile immediately prior to futures expiration, the greatest volatility occurs in the highest-weighted stocks. As shown in the last row of Table VII, the last five-minute price changes in the highest-weighted stocks on expiration days account for 31.8% of the whole-day price range, which is twice the level of non-expiration days and significantly greater than stocks with lower weight. Our main concern is whether the exceptionally large volatility of the highest-weighted stock can actually destabilize the entire market.

To answer the question, we propose a calculation for the volatility contribution to the index by individual stocks. We assess the volatility contribution of a stock in terms of the difference between the absolute return of the value-weighted index comprising all MSCI-TW stocks and that of the index with the stock in question having been excluded. The volatility contribution (VCB_i) of stock i , is

$$VCB_i = |R^{idx}| - |R^{idx-i}| \quad (7)$$

where R^{idx} is the return of the MSCI-TW index portfolio in the last five-minute interval and R^{idx-i} is the return of the index portfolio with stock i excluded. A positive VCB_i indicates that the inclusion of stock i increases the volatility of the index, whereas a greater VCB_i indicates a higher volatility contribution from stock i .¹⁶

The volatility contribution is calculated on a daily basis for individual stocks, and then averaged out, first of all across stocks by their daily size ranks, and then across days. Figure 6 provides a graphical illustration of the mean volatility contribution on expiration days (gray and black bars) and non-expiration days (white bars), by stock size ranking. A black bar indicates that the volatility contribution of a particular stock size is significantly higher on expiration days than on non-expiration days.

The highest capitalization stock, as expected, is the major contributor to volatility within the index on both regular days and expiration days, as the first white bar is the highest among all white bars and the first black bar is the highest among all black and gray bars. What is interesting is that the first black bar (0.000237) is three times greater than the first white bar (0.000067), indicating a substantial rise in the volatility contribution of the highest-weighted stocks on expiration days as compared to that on non-expiration days. This suggests that

¹⁶The interpretation of the volatility contribution of individual stocks is analogous to that of the incremental VAR, which measures the change in portfolio VAR attributable to a new position by the difference in VARs between portfolios with and without the position in question.

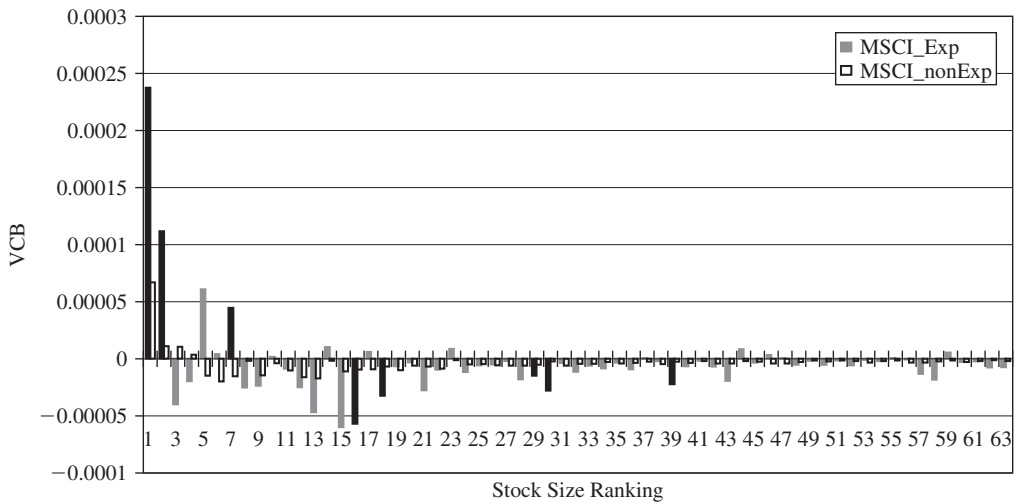


FIGURE 6

Volatility contribution of individual MSCI stocks on expiration and non-expiration days, by size ranking.

The volatility contribution of an individual stock is the difference between the last five-minute absolute returns of two value-weighted indexes, one that includes and the other that excludes the stock. Stocks are ranked (and re-ranked) each day based upon their market capitalization, with the mean volatility contribution being calculated across days by size ranking. A gray (white) bar in the figure represents the expiration (non-expiration) cross-day mean volatility contribution for a particular size ranking. A black bar indicates that within the particular size ranking, the expiration day volatility is significantly greater than the non-expiration day volatility.

the abrupt movement of the single stock on expiration days causes considerable disturbance in the overall market, a finding that is consistent with potential market manipulation through the use of the highest-weighted index stocks.

Return Reversal of Individual Stocks

Following the abnormal price pressure experienced by individual stocks prior to futures expiration, the prices of these stocks will tend to reverse once the pressure subsides. Table VIII reports the magnitude and frequency of *REV1* reversals for individual stocks by size ranking.¹⁷

Individual stock reversals are significantly larger on expiration days than on non-expiration days. This is true for all but the smallest size decile, as shown in Panel A of Table VIII. Furthermore, the frequency of the reversals is also found to be significantly greater on expiration days (33.3%) than on non-expiration days (22.2%); this is confirmed for all of the non-expiration day sub-samples and for most of the size deciles in Panel B.

¹⁷For the sake of brevity, we do not report the results using *REV0* and *REV2*. The reversals measured using *REV2* provide results, which are almost identical to those using *REV1*, whereas the reversals on expiration days for individual stocks are less apparent using *REV0*.

TABLE VIII
Pooled Mean Frequency of Reversals in Individual Stocks, by Size Decile

MSCI Stocks		Non-MSCI Stocks				
Expiration Days	All Non-Expiration Days	E - 1	E + 1	E - 5	E + 5	Expiration Days
Panel A: Pooled mean individual stock reversal (REV1), by size decile						
All 63 stocks size deciles	0.00339	0.00242**	0.00234**	0.00295**	0.00223**	0.00213**
1 (large)	0.00337	0.00228**	0.00237**	0.00217	0.00246**	0.00219*
2	0.00326	0.00222**	0.00221**	0.00313	0.00181**	0.00184**
3	0.00323	0.00234**	0.00206**	0.00255	0.00242	0.00167**
4	0.00394	0.00258**	0.00208**	0.00315**	0.00218**	0.00229**
5	0.00335	0.00256**	0.00254**	0.00331	0.00219**	0.00247**
6	0.00367	0.00244**	0.00234*	0.00366	0.00206**	0.00339
7	0.00290	0.00240**	0.00277	0.00285	0.00255*	0.00343
8	0.00324	0.00235**	0.00250*	0.00284	0.00223**	0.00236
9	0.00388	0.00249**	0.00250**	0.00328	0.00227**	0.00259
10 (small)	0.00255-	0.00241	0.00193	0.00266	0.00234	0.00254
Highest-weighted stocks	0.00759+	0.00333**	0.00287*	0.00448	0.00252**	0.00217
Panel B: Pooled mean frequency of reversal on individual stocks, by size decile						
All 63 stocks size deciles	0.333	0.222**	0.224**	0.275**	0.207**	0.216**
1 (large)	0.341	0.234**	0.222**	0.278	0.198**	0.238*
2	0.337	0.222**	0.206**	0.310	0.206**	0.230**
3	0.317	0.223**	0.218*	0.238*	0.250	0.206**
4	0.429	0.229**	0.246**	0.286**	0.194**	0.210**
5	0.377	0.228**	0.238**	0.302	0.218**	0.222**
6	0.310	0.226**	0.218*	0.306	0.222*	0.246
7	0.313	0.214**	0.242	0.254	0.198**	0.274
8	0.333	0.217**	0.222**	0.270	0.190**	0.222
9	0.329	0.211**	0.194**	0.254	0.187**	0.226
10 (small)	0.234-	0.220	0.230	0.258	0.238	0.206
Highest-weighted stocks	0.500+	0.231**	0.238*	0.333	0.214**	0.187
						0.190
						0.286*
						0.223
						0.213
						0.231
						0.239
						0.225
						0.217
						0.210*
						0.233
						0.221
						0.228
						0.218
						0.229

Note. The table presents the pooled average of the individual stock reversals on expiration and non-expiration days. A reversal is recognized if stock prices move in the opposite direction between the last five-minute interval and the overnight interval. Panel A reports the magnitude of the reversals measured by REV1 as defined in Stoll and Whaley (1987). Panel B reports the frequency of the reversal proportionate to all days. Stocks are sorted and regrouped each day according to their market capitalization, with size rank 1 containing the highest-weighted stock on each day, size rank 2 containing the second highest, and so on. Observations are further categorized into ten deciles according to their size ranking. The reversals on expiration and non-expiration days containing from different populations are indicated by *at the 5% confidence level, and **at the 1% confidence level, using the Wilcoxon rank sum test. A "plus" ("minus") sign in the expiration-day columns indicates that the expiration-day reversal of the decile is significantly greater (smaller) than that of the 5th decile at the 5% confidence level.

It should be noted that the price reversals for the individual stocks reported in Table VIII are much more pronounced than the moderate index reversals reported in Tables III and IV. The abnormal transactions on expiration days appear to affect individual stock prices in a way that cannot be observed by the examination of the index in isolation. This further emphasizes the need for evidence from individual stocks before drawing any concrete conclusion.

There is an L-shaped pattern across size deciles for return reversals, with the highest-weighted stocks exhibiting a larger magnitude and a greater probability of reversals in excess of the level for the remaining stocks. The average reversal for the highest-weighted stocks is 0.00759, a return that is over twice the stocks' normal level on non-expiration days (0.00333) and also over twice the average level on expiration days for all stocks (0.00339). This magnitude of reversals, when evaluated against the quoted half-spread (which is approximately 0.15% for the highest-weighted stocks) is of economic significance: about 0.6% of the abnormal return reversal (0.00759–0.0015) cannot be attributed to the normal bid–ask bounce.¹⁸ When evaluated by the frequency of reversals, stocks of the highest index weight reverse on 50% of the expiration days, a probability level that is significantly greater than that for all the other size deciles.

Our evidence suggests that the expiration-day effects have much greater impacts on the highest-weighted stocks than on any other stocks. Such concentration of impact on a single stock cannot be easily explained by program trading, which trades in either all index stocks or a basket of large stocks. On the other hand, however, the disproportionate impact on the largest stocks is consistent with the notion that some traders use such stocks as a vehicle to manipulate the index on expiration days. Although a thorough analysis of the price manipulation hypothesis is beyond the scope of this study, our results do point to an important source of expiration-day effects. A surveillance mechanism focusing on large-cap stocks may be necessary if we are to provide appropriate protection for retail investors trading in individual stocks.

CONCLUSIONS

In this study, we provide extensive evidence on the expiration-day effects on the overall MSCI-TW index futures market in Taiwan, as well as on individual stocks. Abnormally large volume and volatility are revealed during the last five-minute trading interval on expiration days for both individual stocks and for the overall market. Close to the contract expiration period, stocks of all size are found to experience higher volatility, and also have a tendency to move in the same direction as the index, with large and small stocks being affected

¹⁸The average return reversal is 0.00427 if assessed by REV2, with the price impact remaining substantial after deducting the size of the half bid–ask spread.

more than medium-sized stocks. Price reversals are found to be more significant in individual stocks than within the index as a whole, a finding that suggests that the expiration-day effects have greater impact on small investors trading in individual stocks, than on institutional traders trading large baskets of stocks.

The expiration-day effects of volume, volatility, and reversals are found to have become more pronounced after the change, on July 1, 2002, from a more continuous auction procedure to a discrete call auction for market close in the TSE. This suggests that if the closing call procedure implemented in Taiwan has not in fact exacerbated the expiration-day effects, then it has certainly failed to mitigate the situation.

Finally, we find evidence that attempts at price manipulation in Taiwan may well have amplified the expiration-day effects. The highest-weighted index stocks experienced substantial volume, volatility, and price reversals at a magnitude that is far above that of the remaining index stocks. There is a discernible surge in the influence of the highest-weighted stock on the index around the expiration period, an effect that is not readily attributable to the unwinding of index arbitrage; however, it may well be the result of trading by price manipulators in their attempts to affect the final settlement index by concentrating the price pressure on the most influential stocks.

BIBLIOGRAPHY

- Alkeback, P., & Hagelin, N. (2004). Expiration day effects of index futures and options: Evidence from a market with a long settlement period. *Applied Financial Economics*, 14, 385–396.
- Brockman, P., Chung, D. Y., & Perignon, C. (2008). Commonality in liquidity: A global perspective. *Journal of Finance and Quantitative Analysis*, forthcoming.
- Chow, Y. F., Yung, H. H. M., & Zhang, H. (2003). Expiration day effects: The case of Hong Kong. *Journal of Futures Markets*, 23, 67–86.
- Chung, H., & Hseu, M. (2007). Expiration day effects of Taiwan index futures: The case of the Singapore and Taiwan Futures Exchanges. *Journal of International Financial Markets, Institutions & Money*, 18, 107–120.
- Comerton-Forde, C., & Rydge, J. (2006). Call auction algorithm design and market manipulation. *Journal of Multinational Financial Management*, 16, 184–198.
- Daigler, R. T. (1997). Intraday futures volatility and theories of market behavior. *Journal of Futures Markets*, 17, 45–74.
- Karolyi, A. (1996). Stock market volatility around expiration days in Japan. *Journal of Derivatives*, 4, 23–43.
- Ke, M., Jiang, C.-H., & Huang, Y.-S. (2004). The impact of tick size on intraday stock price behavior: Evidence from the Taiwan Stock Exchange. *Pacific-Basin Finance Journal*, 12, 19–39.
- Kumar, P., & Seppi, D. J. (1992). Futures manipulation with cash settlement. *Journal of Finance*, 47, 1485–1502.

- Madhavan, A. (1992). Trading mechanisms in securities markets. *Journal of Finance*, 47, 607–641.
- Pagano, M. S., & Schwartz, R. A. (2003). A closing call's impact on market quality at Euronext Paris. *Journal of Financial Economics*, 68, 439–484.
- Parkinson, M. (1980). The extreme value method for estimating the variance of the rate of return. *Journal of Business*, 53, 61–65.
- Stoll, H. R. (1988). Index futures, program trading and stock market procedures. *Journal of Futures Markets*, 8, 391–412.
- Stoll, H. R., & Whaley, R. E. (1987). Program trading and expiration-day effects. *Financial Analysts Journal*, 43, 16–28.
- Stoll, H. R., & Whaley, R. E. (1990). Program trading and individual stock returns: Ingredients of the triple-witching brew. *Journal of Business*, 63, S165–S192.
- Stoll, H. R., & Whaley, R. E. (1997). Expiration-day effects of the All Ordinaries share price index futures: Empirical evidence and alternative settlement procedures. *Australian Journal of Management*, 22, 139–174.
- Vipul (2005). Futures and options expiration-day effects: The Indian evidence. *Journal of Futures Markets*, 25, 1045–1065.