Expiration-Day Effects – An Asian Twist

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February 10, 2006

This research work was partly undertaken when Joseph Fung was a Research Fellow at the Hong Kong Institute for Monetary Research (HKIMR). Fung wants to thank HKIMR for providing a highly stimulating and supportive research environment. The authors are grateful to the many insightful comments from Hans Genberg, Leo Goodstadt, Matthew Yiu and seminar participants at the HKIMR research workshop. This study was also funded by a research grant from the Hong Kong Baptist University. Agnes Lee provided excellent research assistance to the study.

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Abstract

We examine the intraday trading activities of index stocks on the common expiration day of index derivatives. In Hong Kong, index futures and index options use an "Asian-style" settlement procedure. All contracts are settled against the Estimated Average Settlement (EAS) price, which is an arithmetic average of the underlying cash index taken every five-minute on the expiration day. We find that expiration-day trading volume and total trade counts are both higher than normal. Most important, when the index is sampled for calculating the settlement price, trading intensifies in terms of both volume and frequency surrounding the 5-minute time marks. However, we do not find significant order imbalance and price reversal patterns. The lack of systematic order imbalance pattern explains the absence of price reversal pattern.

Keywords: Asian-style settlement; expiration-day effects

INTRODUCTION

In Hong Kong, index futures and index options use an “Asian-style” settlement procedure. All contracts are settled against the Estimated Average Settlement (EAS) price, which is an arithmetic average of the underlying cash index taken every five-minute on the expiration day. Throughout the paper we refer to these 5-minute time marks as "EAS time marks."

Hong Kong is not alone in adopting an Asian-style settlement procedure for index derivatives. The London International Financial Futures and Options Exchange (LIFFE) also uses a similar settlement procedure for its FTSE-100 derivatives. However, instead of using an average taken during the entire expiration day, LIFFE uses a median average of the index taken every minute between 10:10 a.m. and 10:30 a.m. on the expiration day. France also uses LIFFE's approach for the settlement of its CAC-40 derivatives.

We examine in this paper how and to what extent such settlement procedure affects the variations of intraday trading activities. The study also tests if there are systematic pattern of order imbalance on expiration day and whether the next day stock returns are related to the intraday pattern of order imbalance (if there is any) on expiration days. To examine the intraday volume distribution and order imbalance in index stocks, we use a complete time-stamped transaction and bid ask quote records of all constituent stocks of the Hang Seng Index (HSI).

Our results show that trading intensifies on expiration days surrounding the five-minute time marks when the index is extracted for calculating the settlement price. We find that this pattern is more pronounced for large index stocks, which supports our hypothesis that arbitrage and index-related trading are concentrated in these stocks. Moreover, we find that both dollar volume and frequency of trades are significantly higher on expiration days than the non-expiration day control sample. However, we do not find systematic intraday pattern of order imbalance on expiration days and return reversal patterns on the following day. These findings suggest that buy and sell programs may neutralize the market impact of each other on expiration days.

REVIEW OF RELATED STUDIES

Previous studies on expiration-day effects focus primarily on the U.S. markets. Stoll and Whaley (1986, 1987) find that on the common expiration day of index derivatives and stock options there is an abnormal concentration of trading volume within the last hour of trading (i.e., the so-called "triple witching hour"), when the contracts are settled against the closing market index. They also find that the volatility of stock returns is significantly higher on expiration days, and systematic price reversal in the following day. However, the exchange changed the rules in June 1987 to settle the contracts against the opening index on the day following the expiration day. Herbst and Maberly (1990), Stoll and Whaley (1991) and Hancock (1993) find that the new settlement procedure shifts the expiration-day effects to the opening on Friday. Moreover, the rule change has reduced or completely eliminated abnormal volume during the triple witching hour.

Researchers observe similar expiration-day effects on stock volumes and returns in other stock markets. Chamberlain, Cheung, and Kwan (1989) study the Toronto Stock Exchange in Canada and find price reversals following contract expiration and significantly higher trading volume and volatility on expiration days. Pope and Yadav (1992) study the impact of option expiration on underlying stocks in the U.K. and find that stock prices generally fall on expiration days. Their study also shows abnormal increase in trading volume immediately prior to option expiration. Other studies report similar findings. For example, Swidler, Schwartz, and Kristiansen (1994) report for the Oslo Stock Exchange, Karolyi (1996) on the expiration of Nikkei 225 index futures in Japan, Schlag (1996) on the expiration of DAX derivatives in Germany, and Stoll and Whaley (1997) on the expiration of AOI futures for the Australian Stock Exchange. All observe large or abnormal stock price volatility and trading volume on expiration days. Recently, Lien and Li (2005) find that options expiration has significant effects on return and volatility on the Australian Stock Exchange. Vipul (2005) finds that in the Indian market, that prices of the underlying stocks are marginally depressed a day before expiration but rebound significantly in the day after.

Per and Hagelin (2004) study the Swedish market, in which the settlement price for the OMX index futures is set equal to an average of volume-weighted index value on the last trading day. They find that stock trading volumes are significantly higher on expiration days, although they find no evidence of price distortions. They conclude that the settlement method prolongs the period during which arbitrageurs can unwind their arbitrage portfolios, and thus helps reduce the congestion effects.

For the Hong Kong market, Bollen and Whaley (1999) find a higher than average growth rate in volume on expiration days. However, by examining a longer data set (from 1990 to 1999), Chow, Yung, and Zhang (2003) do not find a significant difference between expiration and non-expiration day volumes. On the other hand, Chow et al. find higher volatility on expiration days, but Bollen and Whaley (1999) do not. Chow et al. also find that the average five-minute index returns are generally lower on expiration days. However, they find no pattern of price reversal in the day after contract expiration.

PROPOSITIONS AND HYPOTHESES

Expiration-day effects in Hong Kong may have a special twist. HKEx uses an Asian-style settlement procedure for the index options and index futures. The settlement value of the options and futures are determined by an arithmetic average of the cash index (i.e., the Hang Seng Index, HSI) taken at the end of every five-minute interval during the last trading (or expiry) day of the contracts.

The settlement procedure affects the approach arbitrageurs use to unload the index-futures arbitrage portfolios. For example, to unload a long-futures short-stock arbitrage portfolio on the expiration day,[1] to mimic the settlement value of the cash index, the arbitrageur should cover the short stock position by buying back a fraction 1/*n* of the index portfolio at the end of each five-minute interval. The number "*n*" in the fraction represents the number of index (sampled every five minutes) included in the calculation. Similarly, to unload a short-futures long-stock arbitrage portfolio, the arbitrageur should sell 1/*n* of the index portfolio at the end of each five-minute interval.[2] Hence, the settlement procedure would induce arbitrage-related trading activities to concentrate around the five-minute time marks on the expiration day. If major arbitrageurs follow such unwinding procedure, then arbitrage-related trading activities should be concentrated in the vicinities of the five-minute time marks on the expiration day.

Moreover, the impact on the intraday trading pattern could be aggravated by the trading strategies of speculators who have taken outright positions in either the futures and/or options, and who try to affect the settlement price by buying or selling the index stocks around the five-minute time marks. Our study tests this hypothesis by examining

[1]There are, of course, many other ways to unwind an arbitrage portfolio. For instance, arbitrageurs could "early" unwind their positions before the contract matures (Brenan and Schwartz, 1990).

[2] For a formal proof of the statement, please refer to Fung and Fung (1997a, 1997b). See also Bollen and Whaley (1999).

the intraday volume and trade distribution throughout the expiration day of the index derivatives.

But arbitrage-related trading activities and expiration-day effects could instead be concentrated in a subset of index stocks. To enhance execution efficiency, arbitrageurs might construct a proxy portfolio that contains only a subset of the stocks that are among the largest in the index portfolio. Speculators who want to affect the settlement price may also concentrate only on similar stock subsets that have greater impact on the index. Our study provides a direct test of this proposition.

We expect price reversal when arbitrage-related trades are skewed towards one side of the market. However, dynamic trading strategies that are essentially bets on the future direction and magnitude of the basis imply that there could be both buy and sell arbitrage-related trades at expiration (Mackinlay and Ramaswamy, 1988; Brenan and Schwartz, 1990). Moreover, speculators on the opposite side of the derivatives market may also try to influence the index price. Although these factors indicate that both volume and frequency of trades should increase on expiration days, the countervailing trading forces exerted by parties that have opposite arbitrage or outright derivative positions may offset each other, which would result in little (net) impact on stock prices. Hence, we test if there are systematic pattern of order imbalance on expiration day and whether the next day stock returns are related to the intraday pattern of order imbalance (if there is any) on expiration days. It is expected that order imbalance surrounding the EAS time marks should mostly be positive if buy programs dominate, and vice versa.

DATA AND METHOD

Data

We use time-stamped tick-by-tick transaction and bid/ask quote records of all index constituent stocks, which we obtain from the "Trade Record" CDs published by the Hong Kong Exchanges and Clearing Ltd. (HKEx). The data covers the period 1 May 1996, when such data is first available, to 31 May 2000. To alleviate the measurement problem of returns due to bid/ask price bounce, we use the midquote index, based on bid and ask index prices that we reconstruct from synchronous quotes of the index component stocks.[3]

Following Blume, Mackinlay, and Terker (1989), we define the order imbalance of an individual stock as equal to its dollar volume crossed at the ask price minus the dollar volume crossed at the bid price within a particular interval. Following Lee and Ready's (1991) approach, we identify a trade as a bid (ask) trade if the traded price is below (above) the midpoint of the nearest bid and ask quotes. In cases in which the traded price falls exactly on the midpoint of the quotes, we identify the trade according to the

[3] For details concerning the construction of the index, please refer to Draper and Fung (2003).

usual tick test. If the current traded price is below (above) the previous traded price, then we classify it as a bid (ask) trade. If the current traded price is equal to the previous traded price, then we classify the trade according to the trade before the previous one. We obtain the aggregate order imbalance for the index within a particular time interval by summing the individual order imbalance of the constituent stock of the index within the same time interval. We calculate the aggregate order imbalance for each 30-second interval during the expiration day.

Method

Test on expiration-day volume and trade count

To study whether there are expiration-day abnormal stock trading activities, we compare the dollar volume and frequency of trades of all index stocks between their expiration day and a non-expiration day control sample. We use the dollar volume to facilitate aggregation across different index stocks. The non-expiration day sample represents an average of volume or trade on the trading days one and two weeks before the expiration day. We use a binomial test to find out if expiration days indicate higher trading volume. Denoting the probability that the expiration day volume is higher (lower) than the control sample is p (q), then $p > q$ if trading volume on expiration day is generally higher. We repeat this test for number of trades for all index stocks.

Test on intraday distribution of trading activities

To test whether trading intensified in the vicinity of the five-minute EAS time marks on expiration days, we examine the following ratios:

$$\text{EAS volume concentration ratio} = \frac{EAS_{volume}}{NonEAS_{volume}} \tag{1}$$

$$\text{EAS trade concentration ratio} = \frac{EAS_{trade}}{NonEAS_{trade}} \tag{2}$$

The EAS volume is equal to the average of the aggregate dollar volume of all index constituent stocks recorded within time intervals starting at 30 seconds before and ending at 30 seconds after each five-minute time marks on the expiration day. Non-EAS volume is equal to the per-minute average of the aggregate dollar volume of all index constituent stocks recorded during the expiration-day trading sessions, except for those time intervals we use to calculate the EAS volume. We use similar definitions of the variables in our formula for calculating the EAS trade concentration ratio. If there is substantial arbitrage-related trading on expiration days, these ratios will significantly exceed unity. To establish the control sample for comparison purpose, we repeat this procedure for non-expiration days in the sample period. We also repeat the tests for each index stock.

Test for price reversal

Following Stoll and Whaley (1991), we define the expiration day index return (R_t)

and the return in the following day (R_{t+1}), respectively, as

$$R_t = \frac{P_{close,t} - P_{close,t-1}}{P_{close,t-1}} \quad \text{and} \quad R_{t+1} = \frac{P_{open,t+1} - P_{close,t}}{P_{close,t}} \tag{3}$$

where $P_{close,t}$ is the closing price on the expiration day, $P_{close,t-1}$ is the closing price on the day before the expiration day, and $P_{open,t+1}$ is the opening price of next trading day after expiration. We then define the price reversal measure as

$$\text{Rev} = \begin{cases} R_{t+1} & \text{if } R_t < 0, \\ -R_{t+1} & \text{if } R_t \geq 0. \end{cases} \tag{4}$$

The reversal is positive when the sign of the index return after expiration is the opposite of the sign of the index return on the expiration day. The reversal is negative when the signs of the index return on the expiration and the following days are the same. We repeat the test for each index stock.

Test on order imbalance pattern and next-day returns

After determining if there is a general price reversal after contract expiration, we examine whether there is any intraday pattern of order imbalance on expiration days. We study whether expiration days are marked with persistently negative or positive aggregate order imbalances surrounding each -minute EAS time mark. Then we check to see if there is any relation between the pattern of order imbalance and the next-day return. We expect that a persistent positive order imbalance on the expiration day should be associated with a negative next-day return, and vice versa.

EMPIRICAL RESULTS

Expiration-day volume and trading intensity

There are a total of 48 expiration days during the period May 1996 to May 2000. Panel A in Table 1 shows the results for the aggregate dollar volume of all index stocks. Out of 48 observations, there are 28 (31) cases in which the aggregate dollar volume (total trade count) for all index stocks on expiration days is higher than it is for the non-expiration days control sample. Our binomial test results reject the null that the volume and total trade counts on expiration days are not different from non-expiration days, with p-values of 0.0967 and 0.015, respectively. Panel C shows that expiration-day volume and trade are respectively about 19% and 13% higher than normal. Our result on volume supports the findings of Bollen and Whaley (1999).

Intraday volume and trading intensity on expiration days

Table 2 summarizes our results for volume and trade concentration ratios on expiration days. There are 37 (41) cases in which the volume (trade) concentration ratio exceeds one on expiration days. Our binomial probability tests reject the null hypothesis that the ratio is equally likely to be greater than or less than unity, at all reasonable levels of significance. The average of the expiration-day mean EAS volume concentration ratio is 1.1745, and significantly different from unity with a *t*-value of 4.59. The trade concentration ratio is 1.2035, and significantly different from zero with a *t*-value of 5.88. These results show that both dollar volume and the number of trades exhibit significant concentration around the five-minute EAS time mark on expiration days. Moreover, such patterns are potentially caused by index-related trading activities due to arbitrage and speculative positions in index derivatives.

Table 3 shows the ratios for the non-expiration day control sample. The result shows that no pattern of concentration around the five-minute time mark is observed on the non-expiration day control sample.

We also examine whether there are higher volume and number of trade for the non-EAS intervals during the expiration days. Our results show there are no significant differences between the volume and number of trades in these (non-EAS) intervals on expiration days and non-expiration days, but the ratios are slightly below unity. This finding indicates that trading activities gravitate towards the EAS time intervals on expiration days.

Intraday volume and trading intensity for individual index stocks on expiration days

We repeat the above tests on each of the index stocks. Table 4 summarizes our results. Of the 17 stocks that exhibit high turnover concentration on expiration day, six of them are among the top ten in market capitalization, and ten of them are among the twenty most actively traded stocks. On the other hand, of the twenty-four stocks that show high trade concentration, nine of them are among the top ten in market capitalization, and fourteen of them are among the twenty most actively traded stocks.[4]

Our findings also show that the largest stocks have more significant volume and trade concentration. These stocks include the Hong Kong and Shanghai Banking Corporation (HSBC, stock code 5), Hong Kong Telecom (HKT, stock code 8), Cheung Kong (stock code 1), Hang Seng Bank (stock code 11), Sun Hung Kei Properties (stock code 16), Hutchison (stock code 13), China Telecom (stock code 941). Thus, the results support our hypothesis that expiration day volume and trade concentrations are magnified in a select subset of large index stocks.

Price Reversal

Table 5 summarizes the frequencies of index reversals. Out of 48 expiration day samples, there are 17 cases in which the index reverses direction in the day after expiration day, but the results from the binomial test shows no significant pattern.

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[4] These results are based on the trading statistics reported in Exchange Fact Book 1999.

Table 6 summarizes the results for stock-level tests. In only 10 of the 48 expiration days do more than 50% of the index stocks exhibit price reversal in the next day. Hence, consistent with Chow, Yung ,and Zhang (2003), we find no significant price reversal pattern in either index and individual stock levels for the Hong Kong market.

Persistence of order imbalance

We study whether there are persistent order imbalance patterns on expiration days. The absence of price reversals could imply that neither sell nor buy stock programs dominate trading on expiration day.

Table 7 summarizes the results for order imbalance measured within the 30-second intervals before and after the EAS time marks. We find that, at the 5% level of significance, 13 days exhibit persistent positive order imbalance, and 11 days show persistent negative order imbalance. We define persistence in order imbalance according to a binomial test against the null that the number of time intervals with positive imbalance is equal to that with negative imbalance. At the 1% level of significance, the number of days with persistent positive order imbalance drops to six and that for negative imbalance drops to two.

The binomial test statistics does not reject our null hypothesis that observing a persistent order imbalance on expiration day is a random event. We repeat the test by dividing the sample in two. The first sample contains order imbalances measured within the 30-second interval before the EAS time mark. The second sample contains those after the time mark. Both sets of results are similar to those reported in Table 7. (These results are not reported here but are available on request.)

Order imbalance and the next-day return

Following the results from table 7, we examine whether the next-day return can be explained by persistent order imbalance observed on expiration days. Panels A and B in Table 8 shows the result when we define persistence in order imbalance at the 5% and 1% levels of significance, respectively. The results from the chi-square tests do not reject the null hypothesis that expiration-day order imbalances is not associated with the next-day return.

CONCLUSION

In this paper we examine how and to what extent the HKEx's Asian-style settlement procedure affects the intraday trading activities of the cash stock markets on expiration days.

Our results show that expiration-day trading volume and total trade counts are both higher than normal. Most important, when the index is sampled for calculating the settlement price, trading intensifies in terms of both volume and frequency surrounding the five-minute time marks. This pattern is more pronounced for large-capitalization stocks in the index. This finding provides support for our hypothesis that arbitrage and direction-related trading activities are concentrated in large-cap stocks.

Moreover, the evidence suggests that increases in volume surrounding the five-minute EAS time marks may also be due to a shift of trading volume from the other (non-EAS) intervals.

Consistent with prior studies on the Hong Kong market, we do not find a significant price reversal pattern on the day following contract expiration. This result supports with our conjecture that due to dynamic arbitrage strategies conducted by different traders during the contract life, both long and short stock arbitrage portfolios can be established. If that is the case, then the market impact from unwinding the cash index leg of the arbitrage positions would be significantly reduced as these trades offset each other. Moreover, speculators on either side of the derivatives market may also try to influence the index price to opposite directions. Hence, index-related trades on the expiration day may offset each other, and the resulting price impact could become not significant.

Our findings on order imbalances show that there is no significant persistent pattern of order imbalance on expiration days. This finding further supports the proposition that arbitrage- and speculation-related index trades might largely offset each other. Furthermore, we find no predictable price reversal pattern, even after there is a significant expiration-day order imbalance pattern. This result indicates that the price compression or inflation effect due to index-related trading on expiration days is not significant in the Hong Kong market.

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Table 1: Total dollar volume and trades for all index stocks for the period May 1996 - May 2000

Panel A	Number of cases in which expiration day turnover is greater than non-expiration day turnover (N=48)	Number of cases in which expiration day trade count is higher than non expiration trade count (N=48)
	28	31
(p-value)	(0.0967)	(0.015)

Panel B: Ratio of expiration day to non expiration day turnover, and ratio of expiration day to non expiration day trade count for all index stocks

Expiration Month	Total dollar volume ratio	Trade ratio	Expiration Month	Total dollar volume ratio	Trade ratio
199605	1.218	1.591	199805	1.032	1.068
199606	0.727	0.764	199806	1.176	1.091
199607	0.636	0.701	199807	0.957	1.155
199608	1.045	1.077	199809	1.155	1.35
199609	1.37	1.542	199810	1.711	1.492
199610	0.982	0.961	199811	1.412	1.029
199611	2.345	2.061	199812	0.757	0.683
199612	1.447	1.661	199901	0.772	0.827
199701	0.87	1.002	199902	1.614	1.344
199702	0.816	0.993	199903	2.188	1.35
199703	0.694	0.688	199904	0.991	0.92
199704	1.23	1.104	199905	1.253	1.3
199705	1.118	1.269	199906	1.012	0.797
199706	1.19	1.17	199907	0.817	0.828
199707	1.251	1.201	199908	1.491	1.615
199708	2.096	1.794	199909	0.956	1.001
199709	1.411	1.026	199910	1.139	1.104
199710	0.845	1.086	199911	0.789	0.699
199711	0.809	0.795	199912	0.7	0.848
199712	0.976	1.079	200001	1.56	1.147
199801	0.924	0.666	200002	0.928	0.694
199802	1.895	1.58	200003	1.533	1.263
199803	1.46	1.564	200004	0.558	0.606
199804	2.137	1.874	200005	1.093	0.993

Panel C

	Dollar volume ratio	Trade ratio
Mean	1.1893	1.1344
(*t*-statistics)	(3.05)***	(2.67)***
Std Dev	0.4295	0.3495
Min	0.558	0.606
Median	1.106	1.083
Max	2.345	2.061

Panel A shows the number of cases in which the aggregate dollar volume (or number of trades) of all index stocks on expiration days is higher than that for the non-expiration day control sample. The non-expiration day control figure is the average of the reported volume (or trade) one week and two weeks prior to the expiration day. We calculate the p-value by using a binomial distribution against the null that the number of cases that the ratio is above or below unity are about equal. Panel B shows the concentration ratios by expiration month. Panel C summarizes the distribution of the ratios and *t*-statistics show whether the mean of the ratios significantly deviates from unity.

*** indicates significant at 1%

Table 2: Expiration-Day Volume/Trade Concentration ratio at the 5-minute EAS time mark May 1996 – May 2000 (N=48)

Panel A	Number of cases in which EAS volume concentration ratio >1	Number of cases in which EAS trade concentration ratio >1
	37	41
(p-value)	(0.000)	(0.000)

Panel B

Expiration Month	EAS Volume ratio	EAS Trade ratio	Expiration Month	EAS Volume ratio	EAS Trade ratio
199605	1.76	1.60	199805	0.88	1.05
199606	1.24	1.53	199806	0.96	1.03
199607	1.24	1.39	199807	1.24	1.03
199608	0.86	1.35	199809	1.59	1.52
199609	1.15	1.84	199810	1.09	1.15
199610	1.37	1.75	199811	1.20	1.37
199611	1.40	1.78	199812	1.02	1.10
199612	1.61	1.78	199901	1.09	1.08
199701	0.87	1.04	199902	1.23	1.25
199702	1.04	1.14	199903	1.85	1.17
199703	0.98	1.08	199904	1.15	1.11
199704	1.53	1.20	199905	1.18	1.22
199705	1.05	0.99	199906	1.23	1.10
199706	1.01	1.02	199907	1.41	1.44
199707	1.03	1.01	199908	1.00	1.04
199708	0.93	1.07	199909	1.18	1.21
199709	0.84	0.91	199910	1.36	1.23
199710	0.97	0.91	199911	1.38	1.19
199711	1.08	1.16	199912	0.97	1.02
199712	1.11	1.11	200001	1.07	1.10
199801	1.39	1.25	200002	1.02	1.07
199802	1.01	0.97	200003	1.71	1.34
199803	0.88	0.95	200004	1.20	1.16
199804	1.05	0.98	200005	0.95	0.98

Panel C		
Mean	1.1745	1.2035
(*t*-statistics)	(4.59)***	(5.88)***
Std Dev	0.2469	0.2398
Min	0.8404	0.9082
Median	1.1025	1.1282
Max	1.8490	1.8370

We define the EAS volume ratio as $EAS_{volume}/NonEAS_{volume}$. EAS_{volume} equal to the average of the aggregate dollar volume of all index constituent stocks recorded within time intervals starting at 30 seconds before and ending at 30 seconds after each five-minute time marks on the expiration day. The non-EAS volume is equal to the per-minute average of the aggregate dollar volume of all index stock during the rest of the expiration-day trading sessions (i.e., excluding all the time intervals for calculating the EAS volume). We calculate the EAS trade concentration ratio ($EAS\ ratio_{trade}$) by replacing dollar volume with number of trades. Panel A summarizes the number of EAS ratios that exceed unity for the 48 expiration months studied. The null hypothesis is that the chance of the EAS ratio being greater than 1 occurs randomly, i.e., less than or equal to 50% of the sample. The p-value (in parentheses) indicates that the null hypothesis can be rejected at all reasonable levels of significance. Panel B shows the EAS ratio by expiration months. Panel C summarizes the distribution of the ratios. The *t*-statistics show whether the mean of the ratios deviates significantly from unity.

*** indicates significant at 1%

Table 3: Non-Expiration Day Concentration ratios surrounding the 5-minute EAS time mark May 1996 – May 2000 (N=48)

Panel A	Number of EAS $ratio_{volume}$ >1	Number of EAS $ratio_{trade}$ >1
	11	9
(p-value)	(1.00)	(1.00)

Panel B

Expiration Month	EAS $ratio_{volume}$	EAS $ratio_{trade}$	Expiration Month	EAS $ratio_{volume}$	EAS $ratio_{trade}$
199605	0.84	0.93	199805	1.11	0.98
199606	0.89	0.96	199806	0.96	0.94
199607	0.89	0.89	199807	0.88	0.98
199608	1.06	1.00	199809	0.95	0.97
199609	0.85	0.88	199810	0.92	0.93
199610	0.96	1.00	199811	0.99	0.95
199611	0.95	0.96	199812	0.96	0.98
199612	0.95	0.98	199901	0.93	0.97
199701	0.97	0.93	199902	0.94	1.02
199702	1.06	1.00	199903	0.93	1.01
199703	0.94	0.94	199904	0.92	0.97
199704	0.91	0.95	199905	0.81	0.86
199705	0.99	1.04	199906	0.92	0.97
199706	1.02	0.97	199907	1.05	0.98
199707	0.96	1.01	199908	0.86	0.97
199708	1.00	0.96	199909	0.87	0.91
199709	1.11	1.06	199910	0.98	0.98
199710	1.03	1.01	199911	0.97	0.96
199711	1.02	0.98	199912	1.04	1.00
199712	0.97	0.96	200001	0.92	0.97
199801	1.00	0.98	200002	0.97	0.96
199802	0.96	0.97	200003	0.97	0.96
199803	0.96	1.03	200004	0.96	1.00
199804	1.01	1.00	200005	1.09	1.06

Panel C

Mean	0.9617	0.9722
(t-statistics)	(-3.91)***	(-4.78)***
Std Dev	0.0680	0.0403

We define the EAS volume ratio as $EAS_{volume}/NonEAS_{volume}$, EAS_{volume} equal to the average of the aggregate dollar volume of all index constituent stocks recorded within time intervals starting at 30 seconds before and ending at 30 seconds after each five-minute time marks in the non-expiration day control sample. The non-expiration day control sample consist of the data one and two weeks before the expiration day. The non-EAS volume is equal to the per-minute average of the aggregate dollar trading volume of all index stocks during the rest of the non-expiration day trading sessions, excluding all the time intervals for calculating the EAS volume. We calculate the EAS trade concentration ratio ($EAS\ ratio_{trade}$) by replacing dollar volume with number of trades. Panel A summarizes the number of EAS ratios that are higher than one for the 48 expiration months studied. We conduct a binomial test to test with the null hypothesis that *EAS ratio* being greater than 1 occurs randomly, i.e., less than or equal to 50% of the sample. The *p*-value (in parenthesis) indicates that we are unable to reject the null hypothesis at all reasonable significance levels. Panel B shows the EAS ratio by expiration months. ***indicates significant at 1% level. The result shows that the mean of the ratios is significantly below unity on non-expiration days.

Table 4: EAS volume concentration ratio for individual index stocks

The percentage figures show the relative frequency for the case in which the EAS turnover (or trade) concentration ratio exceeds unity for each component stocks from May 1996 to May 2000

Stock code and name	Turnover	Trade
1 Cheung Kong	58%*	71%***
2 CLP Hldgs	67%***	71%***
3 HK & China Gas	69%***	69%***
4 Wharf (Hldgs)	50%	56%*
5 HSBC Hldgs	63%**	79%***
6 HK Electric	58%*	54%*
8 HK Telecom	65%**	75%***
10 Hang Lung Dev	46%	56%*
11Hang Seng Bank	46%	58%*
12 Henderson Land	58%*	71%***
13 Hutchison	58%*	73%***
14 Hysan Dev	44%	48%
16 SHK Prop	40%	56%*
17 New World Dev	56%*	65%**
18 Oriental Press	67%*	80%**
19 Swire Pacific 'A'	58%*	50%
20 Wheelock	58%*	52%
23 Bank of E Asia	52%	52%
41 Great Eagle Hldgs	46%	60%**
45 HK & S Hotels	52%	55%
54 Hopewell Hldgs	54%	56%*
69 Shangri-La Asia	54%*	54%*
83 Sino Land	40%	50%
97 Henderson Inv	48%	50%
101 Hang Lung Prop	52%	54%*
142 First Pacific	43%	50%
79 Johnson Elec H	43%	64%
242 Sun Tak Hldgs	62%*	62%*
267 CITIC Pacific	54%*	58%*
270 Guangdong Inv	62%**	71%***
291China Resources	36%	52%
293 Cathay Pac Air	44%	65%**

315 SmarTone Telecom	83%*	83%*
363 Shanghai Ind Hldgs	56%	56%
511 Yue Yuen Ind	35%	52%
583 SCMP	52%	57%
941 China Telecom	52%	70%**
1038 CKI Hldgs	45%	42%

We test the relative frequency against the null hypothesis that the chance of observing a concentration of greater than(less than) one is about equal.

* Significant at 10% level

** Significant at 5% level

*** Significant at 1% level

Table 5: Index Price Reversal from May 1996-May 2000

Year	Number of reversals	Mean magnitude
May 1996 - May 2000	17	0.6176%
	(0.9849)	
May - December 1996	3	0.1146%
1997	2	0.3786%
1998	2	0.6031%
1999	7	0.6849%

This table presents the number of cases in which the next-day return to the index is opposite to its return on expiration day. We measure the expiration day return with the closing index levels on the day before and on the expiration day itself. We measure the next day return with the closing index on expiration day and the opening index on the day after. The null hypothesis is that price reversals occur randomly, i.e., less than or equal to 50% of the time. We calculate the p-value by using a binomial distribution and is reported in parenthesis. We are unable to reject the null hypothesis at any conventional significance level based on p-values.

Table 6: Stock Price Reversal from May 1996-May 2000

Expiration month	Percentage of index stocks under reversals	Expiration month	Percentage of index stocks under reversals
199605	37%	199805	28%
199606	40%	199806	59%
199607	58%	199807	30%
199608	47%	199809	30%
199609	24%	199810	30%
199610	9%	199811	19%
199611	39%	199812	25%
199612	30%	199901	72%
199701	44%	199902	64%
199702	41%	199903	58%
199703	27%	199904	25%
199704	50%	199905	33%
199705	24%	199906	30%
199706	25%	199907	56%
199707	17%	199908	70%
199708	0%	199909	39%
199709	34%	199910	45%
199710	27%	199911	27%
199711	38%	199912	73%
199712	9%	200001	58%
199801	40%	200002	69%
199802	19%	200003	33%
199803	27%	200004	45%
199804	24%	200005	42%

This table presents the percentage of index stocks that exhibit a price reversal pattern following an expiration day. The total number of index stocks should be 33 under a normal situation, but it can be less than 33. This difference is due to the change of index stocks around expiration day, e.g., replacing Oriental Press and Johnson Electric with China Resources and CKI Holdings on 31 July 1997. In this case we do not count the two newly added stocks. The null hypothesis is that stock price reversals occurs randomly, i.e., less than or equal to 50% of the index stocks have price reversals. In only 10 out of the 48 expiration months are there over 50% of index stocks that exhibit price reversals. This result indicates that price reversals on individual stock base also occur randomly.

Table 7: Persistence of Order Imbalance Surrounding the EAS Time Marks on Expiration Days

	Positive order imbalance	Negative order imbalance	Total number of expiration day
Number of expiration day with persistent order imbalance determined at 5% level of significance (p-value)	13 (1.00)	11 (1.00)	48
Number of expiration day with persistent order imbalance determined at 1% level of significance (p-value)	6 (1.00)	2 (1.00)	48

The null hypothesis is that the number of measured intervals with positive or negative order imbalance is about equal. We base the p-value reported in parentheses on a test with binomial distribution. The test result shows that the null hypothesis cannot be rejected at any conventional confidence level.

Table 8: Association between expiration-day order imbalance (OI) and next-day return (R)

Panel A: Persistent order imbalance determined at 5% level of significance

	R > 0	R < 0	TOTAL	chi-squared Stat	0.9063
OI > 0	6	7	13	df	1
OI < 0	3	8	11	p-value	0.3411
TOTAL	9	15	24	chi-squared Critical	3.8415

Panel B: Persistent order imbalance determined at 1% level of significance

	R > 0	R < 0	TOTAL	chi-squared Stat	1.6
OI > 0	3	3	6	df	1
OI < 0	0	2	2	p-value	0.2059
TOTAL	3	5	8	chi-squared Critical	3.8415

We measure the next-day return with the closing price on expiration day and the opening price on the day after. The null hypothesis for the chi-square test is that the next-day return is not associated with the sign of order imbalance on the expiration day. The test result shows that the null hypothesis cannot be rejected.