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Abstract

This is an examination of 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 the arithmetic average of the underlying cash index taken every five minutes on the expiration day. Trading volume and total trade count on the expiration day are found to both be higher than normal. Most important, trading intensifies in terms of both volume and frequency at times close to the five-minute time marks. Significant order imbalance and price reversal patterns are not found. That there is no systematic order imbalance pattern explains the absence of a price reversal pattern.

Keywords: Asian-style settlement; index derivatives; expiration-day effects.

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1. 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 the arithmetic average of the underlying cash index taken every five minutes on the expiration day. We call these five-minute time marks throughout *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) uses a similar settlement procedure for its FTSE-100 derivatives. In that case, rather than an average of the index taken over the entire trading session, the settlement price is an average of the index value observed between 10:10 a.m. and 10:30 a.m. on the expiration day. That is, the average value is calculated from the middle 15 prices within 20 minutes after discarding the three highest and the three lowest values. The settlement price for the CAC 40 futures traded on the Paris Stock Exchange is determined in a similar manner.

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

The results show that trading intensifies on expiration days at times near the five-minute time marks when the index is used to calculate the settlement price. This finding is consistent with the predicted trading pattern due to the Asian-style settlement procedure. The trading pattern is more pronounced for large index stocks, which supports the hypothesis that arbitrage and index-related trading are concentrated in these stocks. Moreover, both the dollar volume and the frequency of trades are found to be significantly higher on expiration days than on non-expiration days (the control sample), although no systematic intraday pattern of order imbalance on the expiration days or return reversal pattern on the following day is found.

These findings suggest that the market impacts of long and short programs may neutralize one another on expiration days.

2. Review of Literature

Authors examining expiration-day effects have focused primarily on the U.S. markets. Stoll and Whaley (1986, 1987) find on the common expiration day of index derivatives and stock options an abnormal concentration of trading volume within the last hour of trading (i.e., the so-called triple witching hour), when contracts are settled against the closing market index. They also find stock returns are significantly more volatile on expiration days, with a systematic price reversal the following day.

In June 1987 the exchange changed the rules to settle 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. The rule change then reduced or completely eliminated abnormal volume during the triple witching hour.

Researchers observe similar expiration-day effects with respect to stock volumes and returns in other stock markets. Chamberlain, Cheung and Kwan (1989) in a study of the Toronto Stock Exchange in Canada, find price reversals following contract expiration and significantly higher trading volume and volatility on expiration days. Pope and Yadav's (1992) study of the impact of option expiration on underlying stocks in the U.K. reports that stock prices generally fall on the expiration days. They also show an abnormal increase in trading volume immediately prior to option expiration.

Authors reporting similar findings include: Swidler, Schwartz, and Kristiansen (1994) on the expiration of securities traded on 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 on the Australian Stock Exchange. All observe high or abnormal stock price volatility and trading volume on the expiration days.

Most recently, Lien and Li (2005) find that options expiration has significant effects on return and volatility on the Australian Stock Exchange. Vipul (2005) reports that in the Indian market, prices of the underlying stocks are marginally depressed one day before expiration but rebound significantly the day after expiration.

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

For the Hong Kong market, Bollen and Whaley (1999) find a higher-than-average growth rate in volume on expiration days. In examination of a longer data set (1990 - 1999), Chow, Yung and Zhang (2003) do not see any significant difference between expiration and non-expiration day volumes. The latter do find higher volatility on the expiration days, unlike Bollen and Whaley (1999). They also find that average five-minute index returns are generally lower on the expiration days (but no pattern of price reversal the day after contract expiration).

3. Propositions and Hypotheses

Expiration-day effects in Hong Kong may have a special twist. The Hong Kong Exchange uses an Asian-style settlement procedure for index options and index futures. The settlement value of the options and futures is 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 expiration) day of the contracts.

This settlement procedure affects the approach arbitrageurs use to unwind index-futures arbitrage positions. For example, to unwind a long futures-short stock arbitrage portfolio on the expiration day, 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.[1] The amount n in the fraction represents the number of index values (sampled every five minutes) included in the calculation. Similarly, to unwind 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 likely causes arbitrage-related trading activities to be concentrated around the five-minute time marks on the expiration day. If major arbitrageurs follow such unwinding procedures, arbitrage-related trading activities should be concentrated near the five-minute time marks on the expiration day.

Impacts on intraday trading patterns could be heightened by the trading strategies of speculators who have uncovered positions in either the futures or options, and who may try to affect the settlement price by buying or selling the index stocks around the five-minute time marks. We test this hypothesis by examining intraday volume and trade distribution throughout the expiration days of the index derivatives.

Arbitrage-related trading activities and expiration-day effects could of course be concentrated in a subset of index stocks. To enhance execution efficiency, arbitrageurs might construct a proxy portfolio that includes only a subset of stocks, perhaps 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 impacts on the index. Our study provides a direct test of this proposition.

We would expect price reversals when arbitrage-related trades are skewed toward one side of the market. Dynamic trading strategies that are essentially betting on the future direction and size of the basis, however, imply that there could be both buy and sell arbitrage-related trades at expiration (MacKinlay and Ramaswamy, 1988; Brennan 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 contract expiration days, the countervailing trading forces exerted by parties with opposite arbitrage or uncovered derivatives positions may be offsetting, in which case there would be little (net) impact on stock prices. Hence, we examine systematic patterns of order imbalance on the expiration day and whether the next-day stock returns are related to the intraday pattern of order imbalance (if any) on the expiration days. We would expect that order imbalance near the EAS time marks should mostly be positive if buy programs dominate (and vice versa).

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

2 For a formal proof of the statement, see Fung and Fung (1997a, 1997b). See also Bollen and Whaley (1999).

4. Data

The data consist of time-stamped tick-by-tick transaction and bid/ask quote records of all index constituent stocks from the “Trade Record” CDs published by the Hong Kong Exchanges and Clearing Ltd. (HKEx). The sample period is 1 May 1996, when such data are first available, through 31 May 2000. To alleviate measurement problems due to the bid/ask price bounce, we use index midquotes. The midquotes are based on bid and ask index prices that are reconstructed from synchronous quotes of the index component stocks.[3]

5. Methodology

To investigate abnormal trading activities on the expiration days, we compare the dollar volume and frequency of trades (in terms of trade count) of all index stocks on the expiration days with these measures on non-expiration-day control samples. The non-expiration-day control sample represents the average of dollar volume or trade count on trading days one and two weeks before the expiration day.

Binomial test and Wilcoxon matched-pairs signed rank tests are used to determine whether expiration days see higher trading volumes and frequency. The null hypothesis is that the observation of a higher trading volume (or trade count) on expiration days occurs randomly, that is, 50% or less than 50% of the time. The tests are repeated for number of trades for all index stocks.

Intraday distribution of trading activities

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

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

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

EAS_{volume} is equal to the average of the aggregate dollar volume of all index constituent stocks recorded starting at 30 seconds before and ending at 30 seconds after each five-minute time mark on the expiration days. $NonEAS_{volume}$ is equal to the per-minute average of the aggregate dollar volume of all index constituent stocks recorded on the expiration days after removing all dollar volume at the EAS time marks. We replace dollar volume with trade count for the EAS trade concentration ratio.

If there is any substantial arbitrage-related trading on the expiration days, these ratios will significantly exceed unity. To establish a control sample for comparison purposes, the procedure is repeated for the non-expiration days in the sample period and for each index stock.

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

Price reversal

Following Stoll and Whaley (1991), we define the expiration-day index return (R_t) and the return on the next day (R_{t+1}) as:

$$R_t = \frac{P_{close,t} - P_{close,t-1}}{P_{close,t-1}}$$

and

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

where $P_{close,t}$ is the closing price on the expiration day, $P_{close,t\text{-}1}$ is the closing price on the day before the expiration day, and $P_{open,t+1}$ is the opening price on the next trading day after expiration.

The price reversal measure are then defined 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 day and the following days are the same. The tests are repeated for each index stock.

Return compression

The conventional price reversal test looks at reversals of returns; it ignores potential return compression if the direction of the price change remains the same on both the expiration day and the following days. A large positive (negative) return on the day following a small positive (negative) expiration day return, however, may indicate that the expiration day return is suppressed.[4]

The return ratio we use to test for this form of return compression is:

$$\Delta_{\text{Return}} = \frac{R_{t+1}}{R_t}\text{; when sgn}(R_t) = \text{sgn}(R_{t+1})$$

where R_t and R_{t+1} are, respectively, the expiration day and the next day returns. The test focuses on cases where the two (consecutive) returns share the same sign. A high ratio may indicate significant return compression on an expiration day.

Order imbalance pattern and next-day returns

4 We are indebted to an anonymous referee for suggesting this test.

Following Blume, MacKinlay, and Terker (1989), we define the order imbalance of an individual stock as its dollar volume traded at the ask price minus the dollar volume traded at the bid price within a particular interval. Following Lee and Ready's (1991) approach, we identify a trade as a bid (an ask) if the traded price is below (above) the midpoint of the nearest bid and ask quotes. If the traded price falls exactly on the midpoint of the quotes, the trade is identified according to the usual tick test. If the current traded price is below (above) the previous traded price, it is classified as a bid (ask) trade. If the current traded price is equal to the previous traded price, the trade is classified according to the trade before that previous one.

We obtain the order imbalance for the index within a particular time interval by summing the individual order imbalance of the constituent stocks of the index within the same time interval. The order imbalances for each 30-second interval near the EAS time marks during the expiration day are calculated.

After determining whether there is a general price reversal after contract expiration, we examine whether there is any intraday pattern of order imbalance on expiration days; that is, whether expiration days are marked by persistently negative or positive order imbalances surrounding each minute of the EAS time mark. Then we check for any relationship 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.

6. Empirical Results

There are a total of 48 expiration days from May 1996 through May 2000. Panel A in Table I shows the results for the aggregate dollar volume of all index stocks. Of 48 observations, there are 28 (31) cases when the aggregate dollar volume (total trade count) for all index stocks on the expiration days is higher than on the non-expiration days control sample. The binomial test result shows that expiration-day dollar volume is marginally significantly higher (at 10%) than non-expiration-day volume. The difference is more significant in the Wilcoxon signed-rank test. Test results for total trade counts are consistent for both tests. The p-values of the binomial test (0.015) and the Wilcoxon signed-rank test (0.0303) indicate that the number of trades on expiration days is significantly higher than on non-expiration days.

Panel C shows that expiration-day volume is on average about 19% higher, and expiration-day trades are 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 II summarizes the results for volume and trade concentration ratios on the expiration days. There are 37 (41) cases when the volume (trade) concentration ratio exceeds 1.0 on the expiration days. At the 1% level of significance, both the binomial test and the Wilcoxon signed-rank test allow rejection of the null hypothesis that the ratio is equal to unity. These results show that both the dollar volume and the number of trades are significantly concentrated around the five-minute EAS time mark on the expiration days. Such patterns are potentially caused by index-related trading activities due to arbitrage and speculative positions in index derivatives.

The mean of the expiration-day EAS volume concentration ratio is 1.1745, which is significantly different from unity with a t-value of 4.59. The trade concentration ratio is 1.2035, significantly different from unity, with a t-value of 5.88. These results show that both dollar volume and number of trades are significantly concentrated around the five-minute EAS time mark on expiration days. These findings are consistent with the predicted pattern of index-related trading activities due to the Asian-style settlement procedure.

Table III shows the ratios for the non-expiration-day control sample. Both ratios are lower than 1.0 at the 1% significance level, which indicates that both the dollar volume and the number of trades are actually less concentrated around the five-minute time mark on non-expiration days. Hence, the trade concentration surrounding the EAS time marks on expiration days is unique compared to other trading days.

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

We repeat all these tests on each index stock. Table IV summarizes the results. At the 10% level of significance, 17 out of the 38 stocks exhibit high turnover concentration, and 24 stocks show high trade concentration. The binomial test indicates a significant trade concentration for index stocks. The p-values of turnover concentration and trade concentration are 0.314 and 0.036 (figures not shown in the table), respectively.

Of the 17 stocks with high turnover concentration on expiration day, 6 are among the top 10 in market capitalization, and 10 are among the 20 most actively traded stocks. Of the 24 stocks with high trade concentration, 9 are among the top 10 in market capitalization, and 14 are among the 20 most actively traded stocks.[5]

The findings also show that the largest stocks have more significant volume and trade concentration: 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); and China Telecom (stock code 941). Thus, the results support the hypothesis that expiration-day volume and trade concentrations are magnified in a select subset of large index stocks.

Price reversal

Table V summarizes the frequencies of index reversals. Of the 48 expiration-day samples, in 17 cases the index reverses direction the day after the expiration day, but the results from the binomial test show no significant pattern of price reversal.

Index stocks can move in opposite directions, which may offset any price reversal on the index level; looking at the individual stock level can reveal any such movements. Table VI summarizes the results for stock-level tests. In only 10 cases of the 48 expiration days do more than 50% of the index stocks

5 These results are based on the trading statistics reported in the Exchange Fact Book, 1999.

exhibit price reversal on the day after expiration. Hence, consistent with results in Chow, Yung and Zhang (2003), no significant price reversal pattern on either the index level or the individual stock levels is found for the Hong Kong market.

Return compression

Table VII summarizes test results for the index and for individual index stocks that do not exhibit price reversal on the day following expiration. Panel A shows the result for the index. In only 12 of 31 cases is the ratio greater than unity. Panel B shows that mean returns of index stocks on the expiration days and the day following are similar in size. These results are consistent with those in the test of price reversal.

To save space, only the results for the 10 largest stocks are reported here; the results for other index stocks are similar. These findings show that when no price reversals are observed, there is no pattern of return compression.

Persistence of order imbalance

We also see whether there are persistent order imbalance patterns on the expiration days. An absence of price reversals could imply that neither sell nor buy stock programs dominate trading on the expiration days.

Table VIII summarizes the results for order imbalance measured within the 30 seconds before and after the EAS time marks. The results show that, at the 5% level of significance, there is persistent positive order imbalance on 13 days and persistent negative order imbalance on 11 days. Persistence in order imbalance is defined according to a binomial test of the null hypothesis that there are the same number of time intervals with a positive imbalance as a negative imbalance. At the 1% level of significance, the number of days with a persistent positive order imbalance drops to six and the number with a negative imbalance drops to two.

The binomial test statistic does not allow rejection of the null hypothesis that a persistent order imbalance on expiration day is a random event. The tests are repeated by dividing the sample in two. The first sample is order imbalances measured within the 30-second interval before the EAS time mark. The second sample is imbalances after the time mark. Both sets of results are similar to those reported in Table VIII. (These results are not tabulated here but are available on request.)

Order imbalance and the next-day return

We finally examine whether the next-day return can be explained by persistent order imbalance observed on the expiration days. Panels A and B of Table IX show the result at 5% and 1% levels of significance. The results of the chi-square tests do not allow rejection of the null hypothesis that expiration-day order imbalance is not associated with the next-day return.

7. Concluding Remarks

We have asked how and to what extent the Hong Kong Exchange's Asian-style settlement procedure for derivatives contracts affects the intraday trading activities of the cash stock markets on the expiration days.

The 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. The pattern is most pronounced for large-capitalization stocks in the index. This finding provides support for the 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.

Like other researchers in the Hong Kong market, we find no significant price reversal pattern on the day following expiration. This result supports our conjecture that both long and short stock arbitrage portfolios can be established by dynamic arbitrage strategies conducted by different traders during a contract's life. If that is the case, there would be less of a market impact from unwinding the cash index leg of the arbitrage positions, as these trades offset each other. Moreover, speculators on either side of the derivative market may also try to influence the index price in opposite directions. Hence, index-related trades on the expiration days may offset each other, and the resulting price impact could become insignificant.

The findings on order imbalance show there is no significant persistent pattern of order imbalance on contract expiration days. This finding further supports the proposition that arbitrage- and speculation-related index trades might largely offset each other. Nor is there a predictable price reversal pattern, even if there is a significant expiration-day order imbalance pattern. This result indicates no significant price compression or inflation effect due to index-related trading on contract expiration days in the Hong Kong market.

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Table 1. Expiration-Day versus Non-Expiration Day 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 that on non-expiration day (N=48)	Number of cases in which expiration day trade count is higher than that on non expiration's (N=48)
	28	31
Binomial (p-value)	(0.0967)	(0.015)
Wilcoxon (p-value)	(0.0239)	(0.0303)

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	Dollar ratio	volume Trade ratio	Expiration Month	Dollar ratio	volume 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 Summary statistics of the distribution of the ratios

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

Note: 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. 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 Surrounding 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
Binomial (p-value)	(0.000)	(0.000)
Wilcoxon (p-value)	(0.002)	(0.000)

Panel B: Expiration-day EAS Volume/Trade concentration Ratio

Expiration Month	**EAS Volume Concentration ratio**	**EAS Trade Concentration ratio**	**Expiration Month**	**EAS Volume Concentration ratio**	**EAS Trade Concentration 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 Summary Statistics of the distribution of the ratios

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

Note: The EAS volume concentration ratio is defined 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). The EAS trade concentration ratio is calculated 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. Panel B shows the EAS ratio by expiration months. Panel C summarizes the distribution of the ratios. The t-statistics in Panel C shows whether the mean of the ratios deviates significantly from unity. *** indicates significant at 1%.

Table 3. Non-Expiration Day Volume/Trade Concentration Ratios at 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
Binomial (p-value)	(0.000)	(0.000)
Wilcoxon (p-value)	(0.001)	(0.000)

Panel B:

Expiration Month	EAS Volume Concentration ratio	EAS Trade Concentration ratio	Expiration Month	EAS Volume Concentration ratio	EAS Trade Concentration ratio
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 Summary statistics of the distributions of the ratios

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

Note: EAS volume concentration ratio = $EAS_{volume}/NonEAS_{volume}$, 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 in the non-expiration day control sample. The non-expiration day control sample consists 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. The EAS trade concentration ratio ($EAS\ ratio_{trade}$) is calculated by replacing dollar volume with number of trades.

***indicates significant at 1% level.

Table 4. EAS Volume/Trade 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 (5.4%)	58%*	71%***
2 CLP Hldgs (2.9%)	67%***	71%***
3 HK & China Gas (1.9%)	69%***	69%***
4 Wharf (Hldgs) (1.9%)	50%	56%*
5 HSBC Hldgs (27.8 %)	63%**	79%***
6 HK Electric (1.9%)	58%*	54%*
8 HK Telecom (7.6%)	65%**	75%***
10 Hang Lung Dev	46%	56%*
11 Hang Seng Bank (6.3%)	46%	58%*
12 Henderson Land (2.2%)	58%*	71%***
13 Hutchison (10.6%)	58%*	73%***
14 Hysan Dev	44%	48%
16 SHK Prop (5.1%)	40%	56%*
17 New World Dev (1.2%)	56%*	65%**
18 Oriental Press	67%*	80%**
19 Swire Pacific ‘A’ (1.3%)	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 (1.7%)	54%*	58%*
270 Guangdong Inv	62%**	71%***
291 China Resources	36%	52%
293 Cathay Pac Air (2.0%)	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 (11.3%)	52%	70%**
1038 CKI Hldgs (1.3%)	45%	42%

Figures in the brackets are percentage weight (1999 October figures) of the index stocks. Only those stocks with weight of more than 1% are reported.

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%
Binomial test (p-value)	(0.0297)	
May - December 1996	3	0.1146%
1997	2	0.3786%
1998	2	0.6031%
1999	7	0.6849%

Note: 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.

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%

Note: This table presents the percentage of index stocks that exhibit a price reversal pattern following the expiration days. 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.

Table 7. Return Compression: An Analysis of the Ratio of the Following-Day Return R_{t+1} to the Expiration-Day Return R_t (i.e., $\Delta_{\text{Return}} = R_{t+1} / R_t$)

Panel A: Results for the index

	Number of cases where $\Delta_{\text{Return}} > 1$	Total number of cases without price reversal
Binomial test p-value in bracket	12 (0.14)	31
	Mean	St. dev.
	3.7	7.1

Panel B: Results for individual index stocks with market capitalization greater than 1% of the Hong Kong stock market

Stock code and name	Mean	St. dev.
1 Cheung Kong (5.4%)	1.15	1.22
2 CLP Hldgs (2.9%)	0.93	0.77
5 HSBC Hldgs (27.8 %)	1.18	1.13
8 HK Telecom (7.6%)	0.68	0.41
11 Hang Seng Bank (6.3%)	0.84	0.57
12 Henderson Land (2.2%)	1.43	1.18
13 Hutchison (10.6%)	1.40	1.31
16 SHK Prop (5.1%)	1.00	0.97
293 Cathay Pac Air (2.0%)	0.96	0.99
941 China Telecom (11.3%)	3.37	2.93

Note: Figures in the brackets are percentage weight (1999 October figures) of the index stocks. Only the ten stocks with largest weight in Hang Seng Index are reported.

Table 8. 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

Table 9. 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