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Impact of Derivatives Trading on Emerging Capital Markets: A Note on Expiration Day Effects in India*

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Abstract:
The impact of expiration of derivatives contracts on the underlying cash market – on trading volumes, returns and volatility of returns – has been studied in various contexts. We use an AR-GARCH model to analyse the impact of expiration of derivatives contracts on the cash market at the largest stock exchange in India, an important emerging capital market. Our results indicate that trading volumes were significantly higher on expiration days and during the five days leading up to expiration days ("expiration weeks"), compared with non-expiration days (weeks). We also find significant expiration day effects on daily returns to the market index, and on the volatility of these returns. Finally, our analysis indicates that it might be prudent to undertake analysis of expiration day effects (or other events) using methodologies that model the underlying data generating process, rather than depend on comparison of mean and median alone.

Keywords**:** derivatives contracts, expiration day effect, India

JEL classification**:** G14

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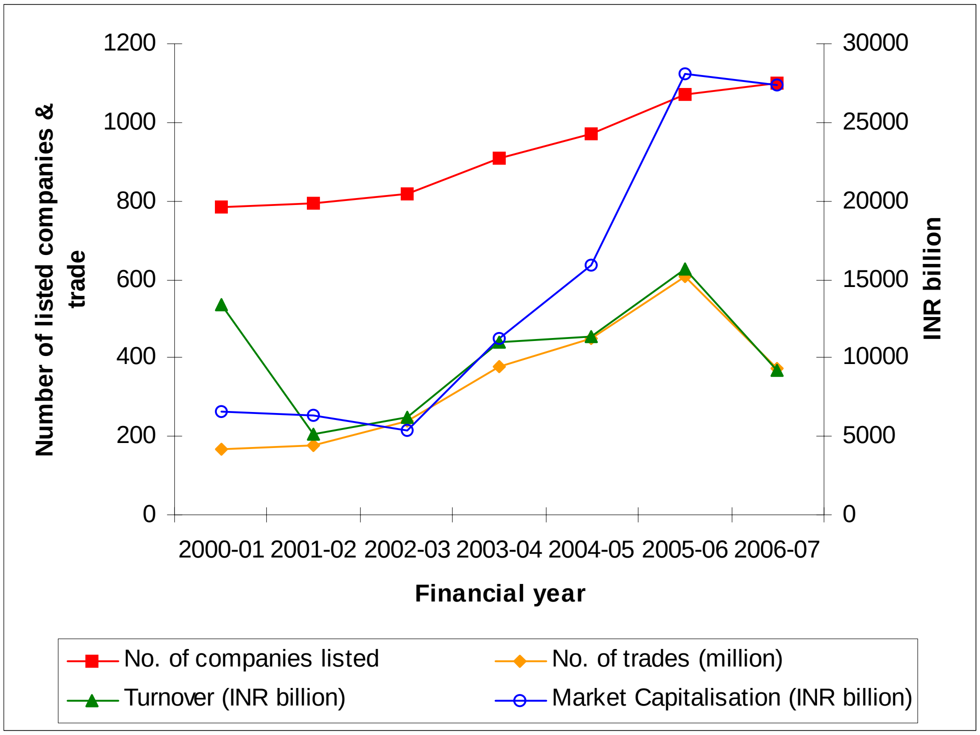
1. Introduction

Even though the 1987 stock market crash in the United States was not attributed to futures and options trading *per se*, there was some concern among regulators that programme trading and index arbitrage that link the derivatives and cash markets to each other may have exacerbated the crisis (Edwards and Ma, 1992, Chapter 11). By its very nature, arbitrage between the cash and (especially) futures markets require investors to unwind positions in the latter market on the day of expiration of contracts, in order to realise arbitrage profits. The consequent increase in the number of large buy and sell orders, and the temporary mismatch between these orders, can significant affect prices and volatility in the underlying cash market. Not surprisingly, regulators around the world have responded with a number of measures aimed at reducing price volatility on account of the so-called expiration effect of index derivatives.

The importance of expiration day effects on the cash market to regulators has, in turn, generated interest on such effects within the research community. As a consequence, the impact of expiration of futures and options contracts on the underlying cash market has been examined in a number of contexts: Australia (Stoll and Whaley, 1997), Canada (Chamberlin, Cheung and Kwan (1989), Germany (Schlag, 1996), Hong Kong (Bollen and Whaley, 1999; Kan, 2001, Chow, Yung and Zhang, 2003), Japan (Karolyi, 1996), Norway (Swidler, Schwartz and Kristiansen, 1994), Spain (Corredor, Lechon and Santamaria, 2001), Sweden (Alkeback and Hagelin, 2004), the United Kingdom (Pope and Yadav, 1992), and the United States of America (Stoll and Whaley, 1987, 1991; Hancock, 1993; Chen and Williams, 1994). The nature of the impact of expiration of derivatives on underlying cash prices remains an open question. For example, while Kan (2001) does not observe significant price volatility and price reversal in Hong Kong, in the same market, Chow, Yung and Zhang (2003) observe a negative price effect and some return volatility of cash prices on account of expiration day effects. Similarly, while Chen and Williams (1994) found no effect of expiration on mean returns and volatility of the underlying asset prices in the cash market, Chamberlin, Cheung and Kwan (1989) found significant impact of derivatives contract expiration on both mean returns and volatility.

Figure 1
Growth of the cash equity market at National Stock Exchange



Note: 2006-07 figures correspond to the first two quarters, i.e., April-September.

Figure 2
Trends in the cash market at the National Stock Exchange

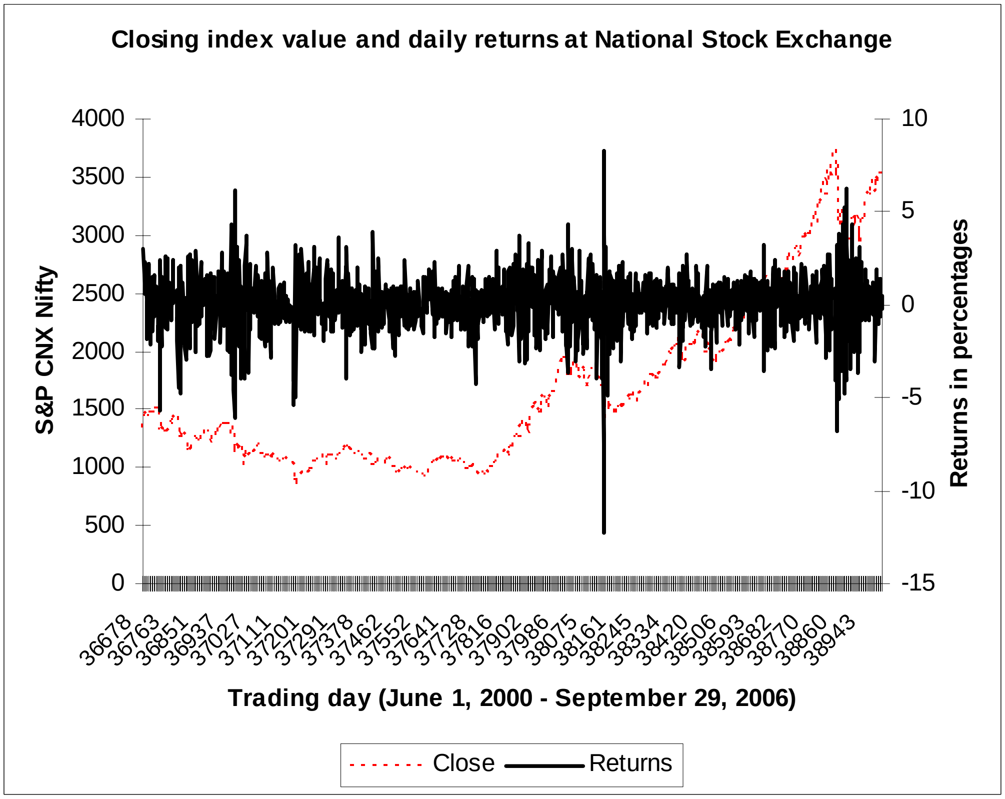
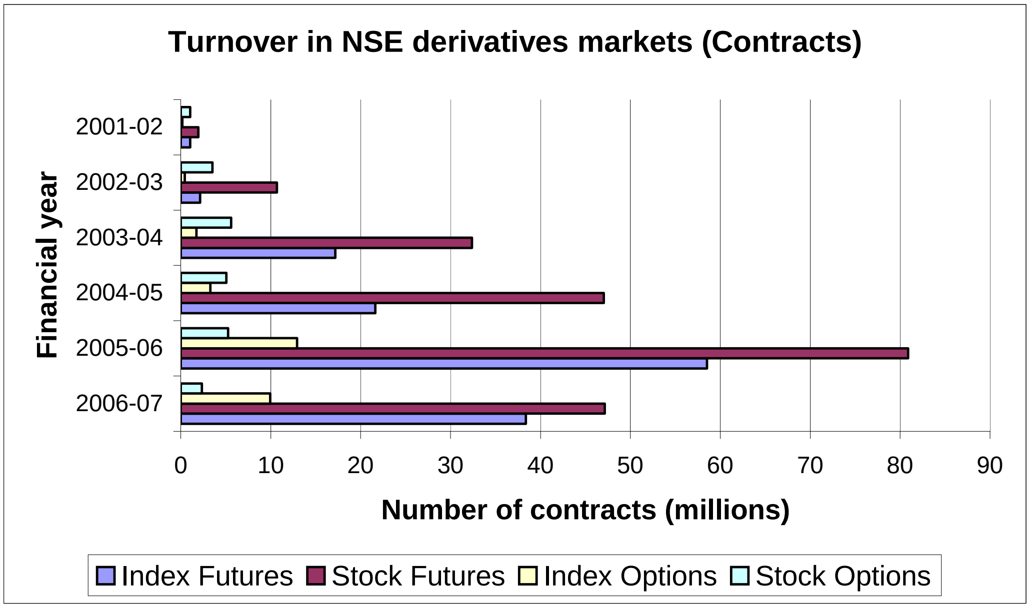
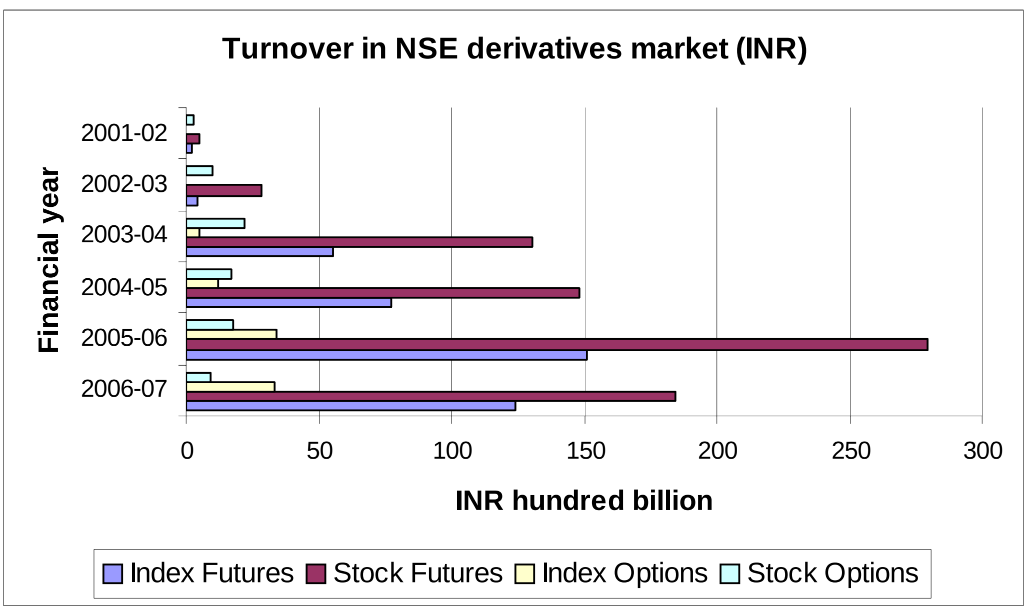


Figure 3
Growth of the equity derivatives market at the National Stock Exchange



Note: 2006-07 figures correspond to the first two quarters, i.e., April-September.



Note: 2006-07 figures correspond to the first two quarters, i.e., April-September.

In this paper, we examine the expiration day effects of derivatives at the National Stock Exchange (NSE) in India. The Indian stock market has grown rapidly since its liberalisation in the early 1990s. Since its inception in 1994, the market capitalisation at the NSE has grown by 828 percent; growth since the turn of the century has been 412 percent. The growth in the derivatives segment of the exchange, which was introduced in June 2000, has kept pace with the growth in the cash market.

Between April 2002 and March 2006, the total turnover of the derivatives segment increased by 4,633 percent, while the average daily turnover increased by 4,587 percent. At the end of November 2006, 1098 companies were listed on the exchange, and 1014 of these stocks were regularly traded. The meteoric growth of the cash and derivatives segments of the NSE is graphically highlighted in Figures 1-3. Of the 1098 listed securities, 123 act as underlying assets for futures and options contracts. In addition, three indices are used as the underlying assets for futures and options trading at the exchange. Details about the nature of these equity derivative contracts are reported in Table 1. In November 2006, the latest month for which figures are available, the turnover in the derivatives segment of the equity market was 342 percent of the corresponding turnover in the underlying cash market. Most importantly, the Indian stock market experiences the “quadruple witching hour”. On the last Thursday of every month, index futures and options as well as futures and options contracts on individual securities expire.

Table 1
Derivatives contracts at National Stock Exchange

Parameter	**Index futures**	**Index options**	**Futures on individual securities**	**Options on individual securities**
Underlying	S&P CNX Nifty[a] CNX IT[b] CNX Bank Nifty[c]	S&P CNX Nifty CNX IT Bank Nifty	123 securities	123 securities
Contract size	Minimum lot sizes are as follows: S&P CNX Nifty 100 CNX IT 50 CNX Bank Nifty 100 The minimum value of a contract is INR 200,000 at inception.		Minimum lot sizes vary by security but the minimum value of a contract at inception remains INR 200,000.	
Trading cycle	3-month trading cycle: the near month (one), the next month (two) and the far month (three).			
Expiry day	Last Thursday of the expiry month. If the last Thursday is a trading holiday, then the expiry day is the previous trading day.			
Option type	--	European	--	American
Base price	Theoretical futures price on first day of trading, and equal to the settlement price on all other days.	Black-Scholes based theoretical price on first day of trading, and equal to the close price on all other days.[d]	Theoretical futures price on first day of trading, and equal to the settlement price on all other days.	Black-Scholes based theoretical price on first day of trading, and equal to the close price on all other days.[d]
Strike price intervals	--	INR 10	--	Vary by security.
Price steps	INR 0.05			
Price bands	Operating range of 10% of the base price	Operating range of 99% of the base price	Operating range of 10% of the base price	Operating range of 99% of the base price

Source: National Stock Exchange (http://www.nseindia.com)

Notes: a) The S&P CNX Nifty is the market index for National Stock Exchange. The 50-stock index that covers 22 sectors of the economy has 1995 as the base year, and 1000 as the base value.
b) The CNX IT is a 20-stock index covering the information technology sector, and was introduced on January 1, 1996, with base value of 100 with effect from May 28, 2004.
c) The CNX Bank Nifty is a 12-stock index covering 79% of the market capitalisation of the banking sector, and was introduced on January 1, 2000, with base value of 1000.
d) The interest rate used to calculate the option price is the Mumbai Inter-Bank Offer Rate (MIBOR). The closing price is calculated as follows: (i) If the contract is traded in the last half an hour, the closing price shall be the last half an hour weighted average price. (ii) If the contract is not traded in the last half an hour, but traded during any time of the day, then the closing price will be the last traded price (LTP) of the contract. (iii) If the contract is not traded for the day, the base price of the contract for the next trading day shall be the theoretical price of the options contract arrived at based on Black-Scholes model of calculation of options premiums.

Vipul (2005) uses data on 14 equity shares to examine expiration day effects in the Indian stock market. The underlying stocks are selected in a manner that reflected a range of different liquidities for the associated derivative products; the ratio of turnover in the derivatives market to turnover in the underlying cash market ranged from 55 percent to 344 percent. Thereafter, the price, volatility and volume of the underlying shares in the cash segment of the exchange 1 day prior to expiration (of derivatives contracts), on the day of expiration and 1 day after expiration are compared with the corresponding values of these variables 1 week and 2 weeks prior to the expiration days, using the Wilcoxon matched-pairs signed-rank test. The study concludes that prices in the cash market are somewhat depressed a day before the expiration of the derivatives contracts, and they strengthen significantly the day after the expiration. However, for most of the shares, this does not tantamount to price reversals. Finally, volumes are higher on expiration days than on the benchmark non-expiration days.

We extend and improve upon the aforementioned research on expiration day effects in India in the following two ways: First, we examine the expiration effects on the market index as opposed to prices of individual stocks. This allows us to mitigate problems that might arise on account of information that affect prices of individual stocks much more than a broader market index. Also, broad market indices are much less likely to be affected by liquidity effects than prices of individual stocks. Further, as evident from Figure 3, the turnover in the index derivatives markets is much greater than that in the market for derivatives products associated with individual stocks, and therefore expiration day effects is likely to be much more prominent for market indices than for individual stocks. Second, we use generalised autoregressive conditional heteroskedasticity (GARCH) models to jointly model the data generating process underlying the mean and variance of returns in the cash market over an extended time period, thereby taking a more sophisticated approach to capturing the expiration day effect than comparison of measures of central tendency and dispersion.

Our results indicate that trading volumes were significantly higher on expiration days and during the five days leading up to expiration days ("expiration weeks"), compared with non-expiration days (weeks). We also find significant expiration day effects on daily returns to the market index, and on the volatility of these returns. Finally, our analysis indicates that it might be prudent to undertake analysis of expiration day effects (or other events) using methodologies that model the underlying data generating process, rather than depend on comparison of mean and median alone.

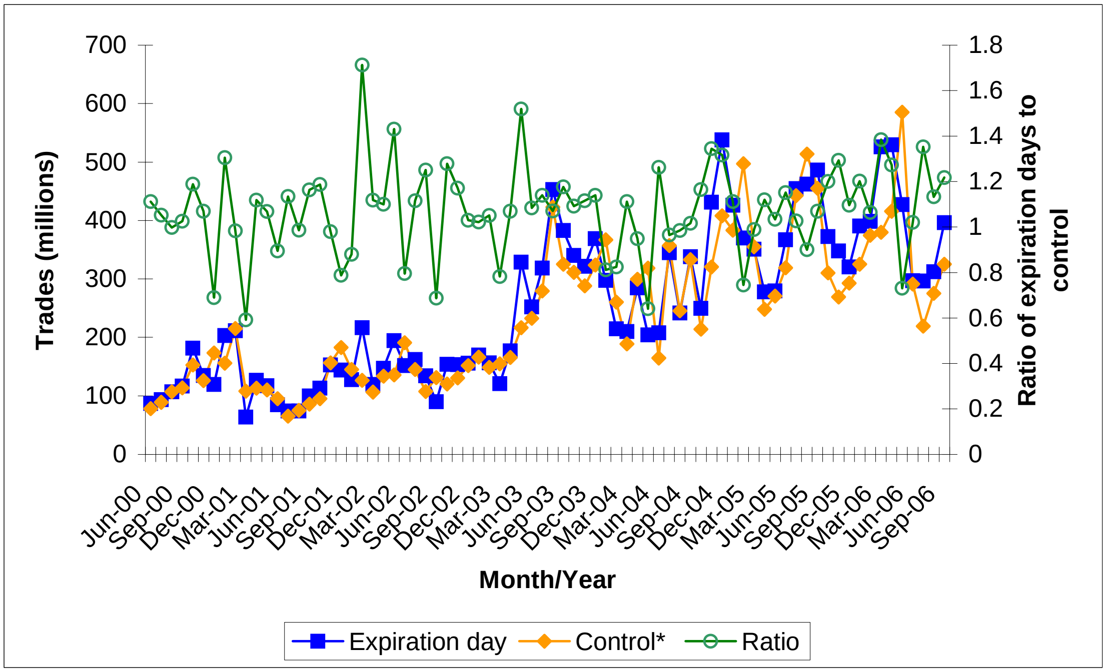
The rest of the paper is as follows: In Section 2, we describe the data, and perform some basic tests for expiration day effects. In Section 3, we discuss the GARCH models and the associated coefficient estimates. Section 4 concludes.

2. Data and initial results

For our analysis, we use daily data for the market index for NSE – the "Nifty" – for the June 2000 through September 2006 period. The Nifty is a 50-stock market capitalisation weighted index whose component companies cover 22 different industries. Currently, the stocks included in the Nifty account for about 60 percent of market capitalisation of all NSE listed companies. Overall, we have data for 1518 trading days, of which 76 were days on which derivatives contracts expired at the exchange. We repeat all empirical exercises using a subset of this data, namely, for the February 2002 through September 2006 period. The significance of this sub-period is that foreign institutional investors (FIIs) were allowed access to the derivatives segment of the exchange from February 2002. Given that purchase and sell orders of FIIs currently account for 51 percent of the turnover in the cash market, and reportedly a significant proportion of the turnover in the derivatives market, this distinction is clearly important. The sub-sample accounts for 1121 trading days, of which 56 days witnessed the quadruple witching hour.

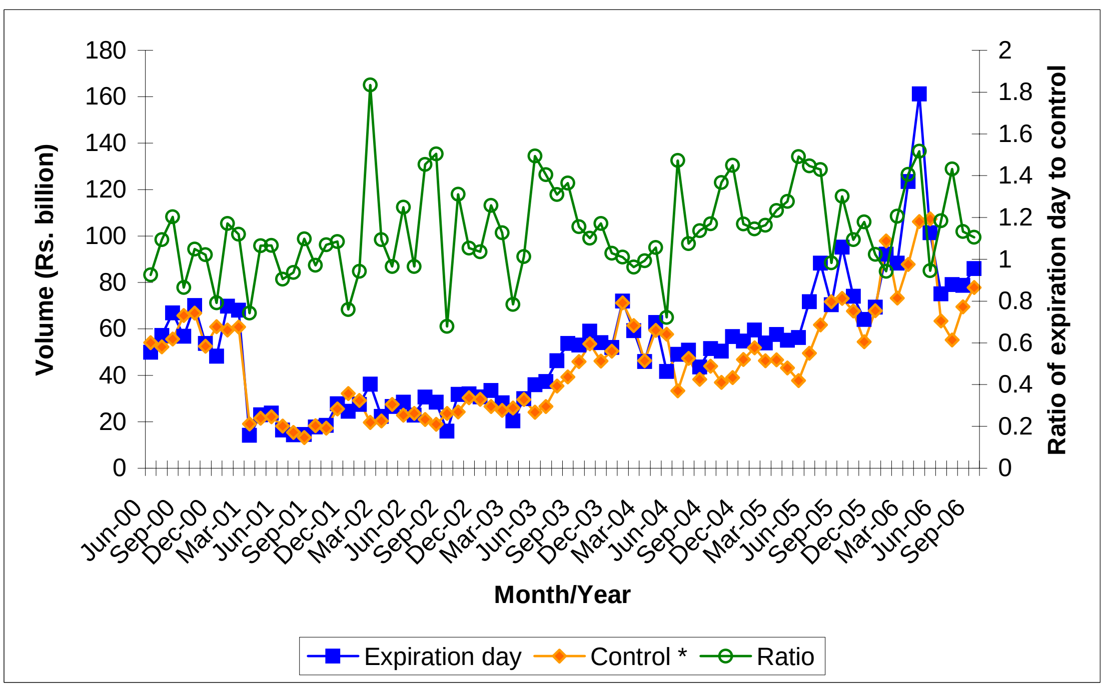
Figure 4
Comparative trading: Expiration day vs. control

Panel A



Note: * Average of reported volume on Thursdays 1 and 2 weeks prior to expiration Thursday.

Panel B



Note: * Average of reported volume on Thursdays 1 and 2 weeks prior to expiration Thursday.

The total number of trades executed in the cash segment of the exchange, and the ratio of the trades concluded on expiration (Thurs)days to the trades concluded on a control category of non-expiration days are highlighted in Panel A of Figure 4. The control category is the average of concluded trades on Thursdays one and two weeks prior to the expiration Thursday. Three things are evident from the figure: First, the numbers of trades on expiration days and the control category are closely correlated; the correlation coefficient is 0.91. Second, as noted earlier in the paper, there was a significant increase in the number of trades executed in the cash segment of the market over time. Not surprisingly, therefore, the ratio of number of trades on the expiration day to the number of trades included in the control category average (r) is close to unity, namely, 1.07. However, the null hypothesis that $r = 1$ is rejected at the 1 percent level, the alternative hypothesis being $r > 1$. In other words, in the cash market, the number of trades on the expiration day, on average, significantly exceeds the average number of trades on the Thursdays of the previous two weeks of trading.

Panel B reports the impact of expiration of derivatives contracts on the volume of trade that is measured in Indian rupees (INR or Rs.) billion. It is evident that the patterns and trends reported in Panel B are very similar to those reported in Panel A. As in the case of number of trades, the volume of trade increases significantly over time, and the volume of trade on expiration days is highly correlated (0.92) with the volume of trade on the control days. The ratio of the volume of trade on expiration days to the volume of trade on control days has an average of 1.13, and the null hypothesis that this ratio equals 1 is rejected at the 1 percent level, when the alternative hypothesis is that the ratio exceeds 1.

Table 2
Expiration day effects

Panel A: Growth rate of volumes (No. of shares traded)

	Expiration day	**Non-expiration day**	**Significance for t- or z-statistic**	**Expiration week**	**Non-expiration week**	**Significance for t- or z-statistic**
June 2000 – September 2006						
Mean	0.05	- 0.002	**	0.02	- 0.004	--
Median	0.09	0.001	***	0.30	- 0.002	**
Standard deviation	0.25	0.24	--	0.30	0.22	***
No. of obs.	76	1518		380	1214	
February 2002 – September 2006						
Mean	0.14	- 0.01	***	0.02	- 0.01	*
Median	0.16	- 0.002	***	0.03	- 0.003	**
Standard deviation	0.15	0.21	**	0.24	0.20	***
No. of obs.	56	1119		280	895	

Panel B: Returns

	Expiration day	Non-expiration day	Significance for t- or z-statistic	Expiration week	Non-expiration week	Significance for t- or z-statistic
June 2000 – September 2006						
Mean	0.003	0.001	--	0.0003	0.001	--
Median	0.003	0.002	--	0.001	0.002	--
Standard deviation	0.012	0.015	**	0.014	0.015	--
No. of obs.	76	1518		380	1214	
February 2002 – September 2006						
Mean	0.003	0.001	--	0.001	0.001	--
Median	0.005	0.002	--	0.002	0.002	--
Standard deviation	0.012	0.014	**	0.014	0.014	--
No. of obs.	56	1119		280	895	

Note: Foreign Institutional Investors (FIIs) were allowed to trade in futures and options contracts from February 2002.
Expiration "week" refers to the 5 consecutive trading days that end on the day of expiration of the contract.
***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

The (positive) impact of the expiration day effect on the volume of trading in the underlying cash market, measured in terms of the number of shares traded, is further evident from the results reported in Panel A of Table 2. Our measure of the growth rate of volumes is the difference between the natural logarithm of the volume on a given trading day and the volume on the previous trading day. We report the mean growth rate of volumes for expiration and non-expiration days, as well as the mean growth rate of volumes for the expiration and non-expiration weeks.[1] We test the following null hypotheses:[2]

[a1] mean (median) growth rate of volume on expiration days = mean (median) growth rate of volume on non-expiration days

[b1] mean (median) growth rate of volume during expiration weeks = mean (median) growth rate of volume during non-expiration weeks

[c1] variance of volume growth for expiration days = variance of volume growth for non-expiration days

[d1] variance of volume growth for expiration weeks = variance of volume growth for non-expiration weeks

[1] An "expiration week" in our sample corresponds to five days of trading ending on an expiration day. Hence, if there are *n* expiration days in the time period under consideration, the sample for expiration weeks would have *5n* observations. Correspondingly, the sample for non-expiration weeks has *4n* fewer observations than the sample for non-expiration days.

[2] Jarque-Bera test statistics, not reported in the paper, indicate that the distributions of these growth rates are non-normal for expiration days and weeks, as well as for non-expiration days and weeks, and hence we use the t-test for testing equality of means and variances. The equality of medians was tested using the aforementioned Wilcoxon test.

We repeat the exercise for both the full sample period (June 2000 – September 2006), as well as the sub-sample during which FIIs were active participants in the Indian equity derivatives market (February 2002 – September 2006). It can be seen that, by and large, the aforementioned null hypotheses were rejected, indicating that the volume of trade in the cash market is affected by expiration of equity futures and options contracts. Specifically, the volumes of trade on expiration days (weeks) were significantly higher than the volumes observed on non-expiration days (weeks).

Next, we undertake a similar exercise for the returns on the Nifty index, and the results are reported in Panel B of Table 2. Our measure of the returns for a given trading day is the difference between the natural logarithm of the value of the Nifty on that day and the natural logarithm of the value of the index on the previous trading day. The mean returns for the expiration non-expiration days, as well those for the expiration and non-expiration weeks are reported in the table. In addition, we report the variance of the return during expiration and non-expiration days and weeks. Once again, we test for equality between means and variances of returns on expiration days (weeks) using the t-test, given that the distributions of returns are non-normal, for both the entire sample period and the sub-period during which FIIs were active participants. Specifically, we test the following hypotheses:

[a2] mean (median) return on expiration days = mean (median) return on non-expiration days

[b2] mean (median) return during expiration weeks = mean (median) return during non-expiration weeks

[c2] variance of returns for expiration days = variance of returns for non-expiration days

[d2] variance of returns for expiration weeks = variance of returns for non-expiration weeks

It can be seen that we can reject null hypothesis [c2], but not the others. In other words, while the difference in mean (median) returns for expiration days (weeks) and non-expiration days (weeks) are not statistically significant, the volatility of returns decreases significantly on the expiration days.

3. Expiration day effects and price reversals

Our simple (unconditional) descriptive statistics suggest that there are expiration day effects on the volatility of returns, but that there is no such effect on the returns themselves. In this section, we pursue a more careful examination of the likely impact of derivatives contracts expiration on returns to a market portfolio. In addition, we aim to identify not only the impact of these contracts on the returns on the expiration day itself, but also the average trend in returns on the day after the expiration of the derivatives contracts. Price reversals can occur if the expiration day effect results in a significant divergence between the trend in returns and the actual returns observed on the expiration days, thereby necessitating reversal to the trend on the day after the expiration of the derivatives contracts. They have been examined in several other contexts (Stoll and Whaley, 1987; Alkeback and Hagelin, 2004; Vipul, 2005), and there are mixed evidence in the literature about such reversals.

To begin with, we hypothesise that the returns to the market portfolio are the outcome of a data generating process that is best captured by a ARIMA(p, n, q), which reduces to a ARMA(p, q) process since the augmented Dickey-Fuller test indicates that the returns series are I(0).[3] We experiment with various values of *p* and *q*, and the Ljung-Box statistics associated with the residuals of the various ARMA(p, q) models, as well as the information criteria associated with the models themselves indicate that a AR(4) model best fits the data.[4] The choice of the best-fit model using information criteria is consistent with the views summarised in de Gooijer et al. (1985) and Granger, King and White (1995).

An examination of the errors of the residuals of the AR(4) model indicates that our data have ARCH effects. To begin with, the unconditional error terms associated with the AR(4) model are non-normal, with a high value of 2158.8 for the Jarque-Bera statistics which rejects the null hypothesis of normality at the 1 percent level, and have large kurtosis (8.55). The Ljung-Box squared statistic has the value 661.9 that rejects the null hypothesis of conditional homoskedasticity at the 1 percent level. Finally, we use the ARCH-LM test whereby we first estimate the model

$$\varepsilon_t^2 = \alpha_0 + \sum_{i=1}^{m} \beta_i \varepsilon_{t-i}^2 + \kappa \qquad [1]$$

when ε is the error term from the AR(4) filtered series, and then compute the ARCH-LM test statistic which is given by $(N - m)R^2$, where N is the number of observations in the time series, m is the number of lags used in equation [1], and R^2 is the goodness-of-fit measure of the model. The test statistic is distributed as a chi-squared with m degrees of freedom. The value of our ARCH-LM test statistic is 148.5 and it rejects the null hypothesis of no ARCH effects at the 1 percent level. We, therefore, extend our AR(4) model to take into consideration these ARCH effects.

The ARCH model, first proposed by Engle (1982), is characterised by the following model:

$$y_t = \alpha_0 + \sum_{j=1}^{4} \phi_j x_{t-j} + u_t \qquad [2]$$

$$u_t = \sqrt{h_t}\, v_t \qquad [3]$$

$$h_t = \beta_0 + \beta_1 u_{t-1}^2 \qquad [4]$$

[3] The ADF test statistic was –14.3, thereby rejecting the null hypothesis of unit root at the 1 percent level.

[4] The Ljung-Box test statistic for our AR(4) model was 24.41, and hence the null hypothesis of no serial correlation could not be rejected. Other specifications for the ARMA(p, q) model, e.g., AR(2) and ARMA(2, 2) had larger Ljung-Box statistics that led to the rejection the aforementioned null hypothesis.

when equation [2] is our now familiar AR(4) model, h_t is the conditional variance of the error term, and v_t is an *iid* term that has a standard normal distribution with zero mean and a variance of one. Bollerslev (1986) extended and generalised Engle's specification by restating equation [4] as follows:

$$h_t = \beta_0 + \beta_1 u_{t-1}^2 + \beta_2 h_{t-1} \qquad [4a]$$

and equations [2], [3] and [4a] together constitute the generalised ARCH (or GARCH) model. In our illustration, we have outlined the commonly used ARCH(1) and a GARCH(1, 1) models. However, in principle, ARCH(x) and GARCH(x, y) models can be of higher orders, i.e., $x > 1$ and $y > 1$. The choice between AR(x) and GARCH(x, y) models can be made on the basis of information criteria. Typically, a GARCH(1, 1) is found to be a reasonable generalisation of higher order ARCH(x) models.

We further extend the above (G)ARCH model to account for possible expiration day effects and price reversals on the day(s) after. The extended model is given by

$$y_t = \alpha_0 + \sum_{j=1}^{4} \phi_j x_{t-j} + \gamma_1 XPD + \gamma_2 NXTD + u_t \qquad [2a]$$

$$u_t = \sqrt{h_t}\, v_t$$

$$h_t = \beta_0 + \beta_1 u_{t-1}^2 + \beta_2 h_{t-1} + \lambda_1 XPD + \lambda_2 NXTD \qquad [4b]$$

when *XPD* is a dummy variable that takes the value 1 for all expiration days and is zero otherwise, while *NXTD* is a dummy variable that takes the value 1 for all days that immediately follow expiration days and is zero otherwise. We experiment with various values of x and y, as also with variation of the GARCH model that assumes a *t*-distribution for v_t, thereby generating a measure of platykurtosis of the data (Bollerslev, 1987). Finally, we estimate a threshold GARCH (or TGARCH) model that takes into account the possibility that overpricing and underpricing in the mean equation may affect volatility differently, i.e., we have

$$h_t = \beta_0 + \beta_1 u_{t-1}^2 + \beta_2 h_{t-1} + \beta_3 S_{t-1}^- u_{t-1}^2 + \lambda_1 XPD + \lambda_2 NXTD \qquad [4c]$$

when S^- is a dummy variable that takes the value 1 when $u_t < 0$ (Glosten, Jagannathan and Runkle, 1992).

Table 3
Expiration day effect and price reversal (June 2000 – September 2006)

Panel A

	Coefficient	Std. Error	z-Statistic	p-value
Mean equation				
α_0	0.001	0.0003	3.84	0.00
ϕ_1	0.098	0.028	3.55	0.00
ϕ_2	- 0.063	0.028	- 2.29	0.02
ϕ_3	0.053	0.029	1.87	0.06
ϕ_4	0.059	0.025	2.39	0.01
XPD	0.885	0.029	30.67	0.00
NXTD	2.296	2.071	1.11	0.27
Variance equation				
β_0	1.60E-05	4.29E-06	3.74	0.00
β_1	0.176	0.037	4.73	0.00
β_2	0.743	0.045	16.68	0.00
XPD	- 0.003	0.001	- 2.85	0.00
NXTD	0.003	0.036	0.09	0.93
F-statistics (p-value)	8.54 (0.00)			
Durbin-Watson	1.99			
AIC & BIC	- 5.91 & - 5.87			
No. of obs.	1589			

Panel B

	Coefficient	Std. Error	z-Statistic	p-value
Mean equation				
α_0	0.001	0.0003	1.95	0.05
ϕ_1	0.116	0.028	4.17	0.00
ϕ_2	- 0.064	0.027	- 2.37	0.02
ϕ_3	0.067	0.025	2.68	0.01
ϕ_4	0.066	0.026	2.56	0.01
XPD	0.848	0.281	3.02	0.00
NXTD	1.666	1.149	1.45	0.15
Variance equation				
β_0	2.49E-05	2.77E-06	8.98	0.00
β_1	- 0.005	0.019	- 0.25	0.81
β_2	0.706	0.028	24.79	0.00
β_3	0.307	0.038	7.99	0.00
XPD	- 0.005	0.0003	- 14.70	0.00
NXTD	- 0.006	0.008	- 0.77	0.44
F-statistics (p-value)	8.15 (0.00)			
Durbin-Watson	2.02			
AIC & BIC	- 5.95 & - 5.90			
No. of obs.	1589			

The regression results associated with the best-fit models are reported in Table 3. Panel A of Table 3 reports the coefficient estimates for the AR(4)-GARCH(1, 1) model and Panel B reports the coefficient estimates of the AR(4)-TGARCH(1, 1) model. While there is little to choose between these two models on the basis of the Akaike and Schwartz information criteria, β_3 is positive and significant at the 1 percent level in the AR(4)-TGARCH(1, 1) equation, i.e., in Panel B, indicating that overpricing and underpricing of the market portfolio do indeed have different impact on the volatility of the cash market. Once we take that into account, AR(4)-GARCH(1, 1) is perhaps the model that best fits the data.

Both the AR(4)-GARCH(1, 1) and AR(4)-TGARCH(1, 1) models indicate that there is a significant expiration day effect. In both the mean and the variance equations, *XPD* has a statistically significant coefficient, albeit with opposite signs. The return to the market index on expiration days is higher, on average, than the returns on non-expiration days, while the volatility of the NSE market index is lower on expiration days than on other days. However, there is no evidence of significant over-shooting or under-shooting of the index on account of expiration of derivatives contracts; the *NXTD* variable has an insignificant coefficient in both the mean and variance equations, indicating that there is neither a positive nor a negative price (and volatility) reversal following the expiration of the derivatives contracts. The results were unchanged for the June 2002-Septmber 2006 sub-period during which FIIs were operating in the cash and derivatives markets at NSE. The coefficient estimates for these sub-periods have been reported in the Appendix; coefficients for the AR(4)-GARCH(1, 1) model in Panel A-A, and those for the AR(4)-TGARCH(1, 1) model in Panel A-B.

4. Concluding remarks

Our results indicate that there is significant expiration day effect in India. To begin with, the volume of trading is higher on expiration days than on non-expiration days. Both the mean and volatility of the returns to the market index at the National Stock Exchange were significantly different on expiration days, compared with other days. These results are consistent with those of Vipul (2005). However, unlike Vipul, we do not find evidence of price reversals following the expiration day. In other words, either the price reversal takes place on the expiration days themselves,[5] or the magnitudes of the changes in the aforementioned mean and volatility on account of expiration of the derivatives contracts were not so large as to necessitate a correction on the following day.

[5] Note that a decline in prices on the day before the expiration of the contracts, discovered by Vipul (2005), is consistent with an increase in returns on the expiration day, presumably as the price "reverses" (or returns) to its underlying trend.

Our analysis also suggests that it might be useful to undertake an analysis of expiration day effects (and other events) using an approach that models the underlying data generating process, rather than depend on comparison of means and medians alone. In our analysis, for example, comparison of mean (median) returns for expiration days and non-expiration days did not indicate that these measures of central tendency were significantly different for the two samples. However, a more careful analysis using an AR-GARCH model revealed the presence of a statistically significant impact of expiration of derivatives contracts on both mean and variance of daily returns.

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APPENDIX
Expiration day effect and price reversal (February 2002 – September 2006)

Panel A-A

	Coefficient	Std. Error	z-Statistic	p-value
Mean equation				
α_0	0.001	0.000	3.844	0.000
ϕ_1	0.070	0.032	2.172	0.030
ϕ_2	- 0.069	0.031	- 2.195	0.028
ϕ_3	0.060	0.035	1.716	0.086
ϕ_4	0.081	0.030	2.734	0.006
XPD	0.930	0.033	28.217	0.000
NXTD	- 1.079	1.387	- 0.778	0.436
Variance equation				
β_0	0.000	0.000	3.261	0.001
β_1	0.155	0.042	3.696	0.000
β_2	0.775	0.048	16.177	0.000
XPD	- 0.003	0.001	- 1.988	0.047
NXTD	- 0.001	0.016	- 0.086	0.932
F-statistics (p-value)	6.89 (0.00)			
Durbin-Watson	1.98			
AIC & BIC	- 6.00 & - 5.95			
No. of obs.	1175			

Panel A-B

	Coefficient	Std. Error	z-Statistic	p-value
Mean equation				
α_0	0.0001	0.0004	2.09	0.03
ϕ_1	0.095	0.031	3.03	0.00
ϕ_2	- 0.056	0.029	- 1.87	0.06
ϕ_3	0.072	0.032	2.22	0.03
ϕ_4	0.087	0.029	3.01	0.00
XPD	0.919	0.032	28.29	0.00
NXTD	- 0.949	1.349	- 0.70	0.48
Variance equation				
β_0	1.79E-05	4.34E-06	4.12	0.00
β_1	- 0.002	0.024	- 0.08	0.94
β_2	0.756	0.045	16.69	0.00
β_3	0.261	0.060	4.32	0.00
XPD	- 0.003	0.001	- 2.49	0.01
NXTD	- 0.010	0.016	- 0.64	0.52
F-statistics (p-value)	6.21 (0.00)			
Durbin-Watson	2.03			
AIC & BIC	- 6.03 & - 5.97			
No. of obs.	1175			

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