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Expiration-Day Effects of Equity Derivatives in India

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Abstract

This study examines the presence of expiration-day effects of equity derivatives in India, which is reflected through sharp price movements of underlying stocks/indices at and around expiration-dates on which derivatives contracts on these stocks/indices expire. The study is using high frequency index value data of S&P CNX Nifty (sampled at frequency of 1-minute) for the purpose of analysis. For empirical analysis, this study is employing time series "ARMA model with EGARCH errors" framework finding evidence on expiration-day effects. The results of the study indicated presence of some significant expiration-day effects in India.

***Keywords**: expiration-day effect, price reversal, volatility, heteroscedasticity*

Introduction

Since 1991, due to liberalization of economic policy, the Indian economy has entered an era in which Indian companies cannot ignore global markets. Before nineties, the prices of many commodities, exchange-rates, interest rates, security prices, etc. were controlled or regulated. After liberalization, market-determined exchange rates, interest rates, security prices, etc., have created volatility and instability in portfolio values. This induced market participants to search for ways to manage these financial risks. Hence, for hedging these risks, the concept of derivatives came into picture in India.

The effective functioning of derivatives market in any country mainly depends upon the existence of a strong underlying stock market because derivatives extract their value from the stock market assets. Due to a formal link between spot and futures prices, the actions of derivative players do affect cash prices. The temporal relationship between spot and futures prices naturally brings up the various issues of interest for academicians, researchers, traders as well as regulators, like, leads and lags in stock index prices, the day of the week effect and expiration-day effects. The issue of expiration-day effects has not been adequately explored in the Indian context as yet. Therefore, the present study attempts to examine expiration- day effects of equity derivatives on cash segment of the Indian stock market.

The expiration-day effect is a temporary distortion of the underlying asset prices due to an order imbalance of trades on those days when the relevant derivative contracts on such assets expire. Price distortions caused by trading activities around the expiration day are transient in nature and prices are expected to revert to their previous levels after expiration-days over. This is called as price reversal effect .In India, "expiration-day" refers to the last Thursday of the month, when all contracts (index futures, index options, stock futures, stock options) expire and "expiration-hour" refers to the last half-hour of the expiration day as the last half-hour weighted average price of the underlying index/stock is used in cash-settling all open equity derivatives contracts.

Literature Review

Studies on expiration-day effects in United Stated are wide-ranging and many have addressed jointly the return, the volatility, and the trading volume on the so-called "triple-witching hour" expiration-Fridays (see, Feinstein and Goetzman,1988; Stoll and Whaley, 1991; Hancock,1993). In their pioneer work, Stoll and Whaley (1987) found abnormally high trading volume of the underlying asset on expiration-days and investigated the effect of these large transactions on prices, and found significant price volatility on expiration-days. The findings from studies conducted in other countries are somewhat similar to those of U.S. markets with few exceptions. For instance, Chamberlin, Cheung, and Kwan (1989), found price reversals and higher volatility were associated with expiration-days for derivatives written on the TSE 300 Index on the Toronto stock exchange in Canada. Pope and Yadav (1992) reported some evidence of downward price pressure and an abnormal increase in trading volume of underlying stocks immediately prior to options expiration in the United Kingdom. Karloyi (1996) for Nikkei 225 index futures in Japan and Schlag (1996) for DAX derivatives in Germany found large trading volumes and insignificant price reversals near the expiration. Stoll and Whaley (1997) for SPI futures contracts in Australia found no evidence of price reversals, but observed the volume effect for certain expiration-days. In conformity with this, Lien and yang (2003) observed no effect of ISF contracts' expiration on the volume, volatility and stock return in Australia. Chow, Yung, and Zhang (2003), for Hong Kong market, found some evidence of return volatility but no effect on trading volume on expiration-days in sharp contrast with Fung and Yung (2006) who observed high trading volume and insignificant price effect. Illucea and Lafunte (2006) for the Spanish market indicated significantly high trading volume and significant return and volatility effects on expiration-days. Chou et al. (2003) and Chaung, Chen, and Su (2008) for Taiwan showed that expiration-day effects of index derivatives on return and volume were not significant on expiration-days, but signs of abnormal volatility were observed in stock market during first 15-minutes on settlement day, the day succeeding the expiration-day on which final settlement price is determined from the first 15-minute volume-weighted average of each component stock's prices in the index.

In India, the studies conducted to establish the presence of expiration-day effects gave mixed evidences too. Thenmozhi and Thomas (2004) for Indian market observed that spot market volatility declined during expiration-weeks than on non-expiration-weeks, but expiration-day effect was insignificant in explaining the spot market volatility. Vipul (2005) reported that though high volume of trading activity in stock market was observed on expiration-days, the volatility of underlying shares did not get significantly affected by expiration of options and futures. The results exhibited no clear pattern for returns of the underlying shares on expiration-days. Bhaumik and Bose (2007) found significant expiration-day effects on trading volume, daily returns to the market index and on the volatility of these returns in case of Indian stock market. Maniar, Bhatt, and Maniyar (2009) observed that while there was no price pressure on index returns on expiration-days, the volatility was significantly affected by the expiration of derivatives contracts. Tripathy (2010) reported significantly large trading volume on expiration-days, but insignificant return and volatility effects in case of Indian market.

Objectives and Rationale of the Study

The main objectives of the present study are:

1. To measure the expiration-day effects of derivatives trading on returns, and volatility of Indian stock market.
2. To examine the presence of price reversal on days following the expiration-days for establishing transient nature of expiration-day stock market aberrations.

Testable Hypotheses

- There is no significant difference between returns on expiration days (expiration-hour) and the returns on non-expiration days (non-expiration hour).
- The variance of returns for expiration-day (expiration-hour) is not significantly different from variance of return during non-expiration day (expiration-hour).
- There is no price reversal on days/hours following the expiration-days/expiration-hours.

Data and Methodology

Data

In the study, for finding evidences on the expiration-day effects of derivatives on Indian stock market behaviour, the NSE's broad-based index, S&P CNX Nifty, is selected as proxy for stock market behaviour. For empirical analysis, the high frequency index value data on S&P CNX Nifty for 1st July, 2007 to 30th June, 2008 is used. This data is obtained from historical data DVDs made available by the NSE. This database provided tick- by- tick index value data for the S&P CNX Nifty which is sampled at an interval of 1- minute each. The last value of Nifty appeared at each 1-minute interval is taken for analysis. Each trading day is divided into 335 intervals of 1-minute each starting from 09:56 a.m. to 3:30 p.m. omitting the first 1-minute interval to remove any perceived abnormalities relating to close-to-open returns, known as overnight returns. For 248 days sample period from July, 2007 to June, 2008, there are 83080 observations. In this study, 1-minute Nifty values are first log transformed and then their first differentials i.e. returns are used for the analysis.

Methodology

The modelling of stock market returns and volatility continues to be one of the key areas of financial research. To model the empirical distribution of financial assets returns, temporal dependencies in the returns series should be taken into consideration. Traditionally, serial dependence in time series has been modelled with autoregressive integrated moving average (ARIMA) structures (Box and Jenkins,1976). However, given the homoscedastic nature of the conditional distribution implicit in the model, it is unable to capture the volatility clustering that is common in financial asset returns. As heteroscedasticity is a common characteristic of returns, therefore, to take into account for heteroscedastic effects of the time series process typically observed in form of fat tails, as clustering of volatilities, Engle [1982] introduced the Autoregressive Conditional Heteroscedastic model, named ARCH, later generalized by Bollerslev [1986], named GARCH. The GARCH model, in combination with an ARMA specification for the mean equation, is referred to as an ARMA model with GARCH errors. The empirical evidence reported by Black (1976) and Schwert(1989b) and others suggested stock price movements are negatively related with the change in volatility. This stylized fact is called the leverage effect. Nelson (1991), taking into account asymmetric relationship between conditional volatility and conditional mean proposed an exponential GARCH (EGARCH) based on a logarithmic expression of the conditional volatility in the variable. In the present study, an ARMA model with EGARCH errors is also used for finding expiration-day effects.

The mean equation for ARMA (m,n) process is specified as follows:

$$y_t = c + \sum_{i=1}^{m} a_i\, y_{t-i} + \sum_{j=1}^{n} b_j \epsilon_{t-j} + \epsilon_t \quad \textbf{(1)}$$

where, $\varepsilon_t = \sqrt{h_t}\,\eta_t$,

The variance equation of the EGARCH (p,q) process is expressed as follows:

$$\ln(h_t) = \omega + \sum_{i=1}^{q} \alpha_i |\varepsilon_{t-i}/h_{t-i}| + \sum_{k=1}^{r} \gamma_k\, \varepsilon_{t-k}/h_{t-k} + \sum_{j=1}^{p} \beta_{j\ \ln h_{t-j}^2} \quad \textbf{(2)}$$

Where, h_t is the conditional variance of the stochastic error term ε_t and η_t is a sequence of iid random variables with mean zero and variance one .The observation y_1,y_2……………yt are generated by the ARMA model with errors generated by the GARCH /EGARCH process. The c is the constant in equation (1) and a_i and b_j are the coefficients of autoregressive (m) and moving average (n) terms respectively. The ω is the constant is equation (2) and α_i , β_j and γ_k are the coefficients of the ARCH term, GARCH term, and asymmetry component term respectively in conditional variance equation. The size of the parameters α_i and β_j determine the short run dynamics of the resulting volatility time series. Large GARCH coefficient β_j shows that shocks to conditional variance take a long time to die out, so volatility is persistent. Large ARCH coefficient α_i indicate that volatility reacts quite intensely to market movements. In Equation (2) the standardized residuals ε/σ are used. The ARCH effect is produced by the absolute value of the standardized residuals, not by their squares. The asymmetry is also captured by the standardized residuals. For $\gamma \neq 0$, we find ARCH effect $\alpha+\gamma$ for positive residuals and that of $\alpha-\gamma$ for negative residuals. If a leverage effect exists, γ is expected to be negative.

For finding impact of derivatives trading on underlying stock market around expiration of these contracts, the above basic specifications of conditional mean and variance are augmented by two dummy variable, namely DUM_1 and DUM_2 , to capture the expiration-period effects on return and volatility, and price reversal effect respectively. The present study is employing EGARCH (1,1) process[1] with ARMA model selected on the basis of SBC.

The basic specifications of conditional mean and variance equation of **ARMA-EGARCH** framework augmented by two dummy variables, namely DUM1 and DUM2, take the following form respectively.

Mean Equation with ARMA (m,n)

$$y_t = c + \sum_{i=1}^{m} a_i y_{t-i} + \sum_{j=1}^{n} b_j \varepsilon_{t-j} + \lambda_i DUM_1 + \xi_i DUM_2 + \varepsilon_t \quad (3)$$

Variance Equation with EGARCH (1,1)

$$\ln(h_t) = \Phi + \alpha|\varepsilon_{t-1}/h_{t-1}| + \gamma\,\varepsilon_{t-1}/h_{t-1} + \beta\ln\left(h_{t-1}^2\right) + \lambda DUM_1 + \xi DUM_2 \quad (4)$$

Where DUM_1 is the dummy variable for expiration-day/expiration-hour, and DUM_2 is the dummy variable for the next day/ next half an hour succeeding the expiration-day/ expiration-hour. λ_i and ξ_i are the parameters of dummy variables in conditional mean and variance equation which need to be estimated along with other parameters as discussed above.

If the coefficient of DUM turns up significant and negative in mean equation, then it indicate the presence of downward pressure on return during the expiration period. However, if the coefficient of dummy DUM turns up significant and positive , then it affirm the presence of upward pressure on return during the expiration period. Similarly, if the coefficient of DUM turns up significant and negative in variance equation, it indicates a decline in conditional variance i.e. volatility during expiration-period and if DUM turns up significant and positive, it implies that volatility has increased during expiration-period. If coefficients of both DUM and DUM turn up significant and have different sign in mean equation, then the presence of return reversal can be accepted. Similarly, if coefficients of both DUM and DUM turn up significant and have opposite signs in variance equation, then the presence of volatility reversal can be accepted otherwise not.

Empirical findings

The high frequency 1- minute interval return series for S&PCNX Nifty is constructed for the period 1st July,2007 to 30th June, 2008 consisting of 83080 observations as shown in figure 1 given below:

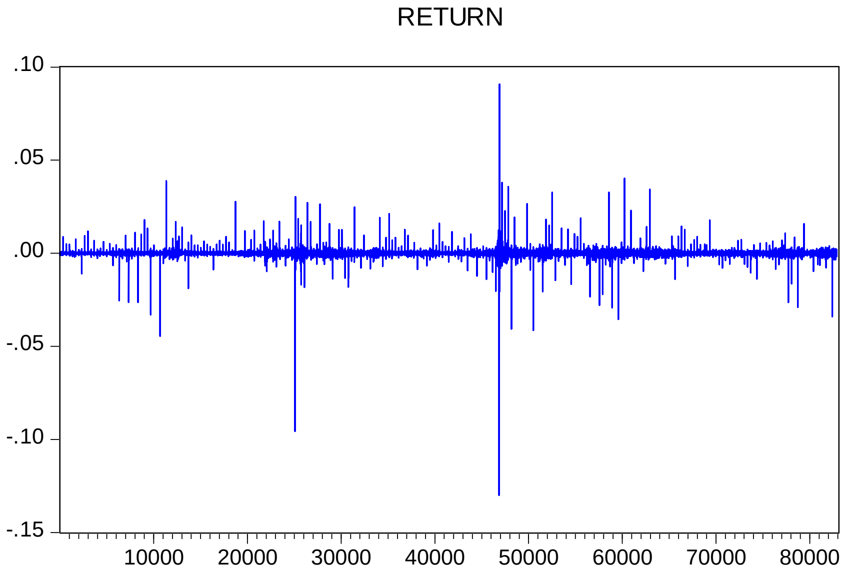

Figure 1: Graph of Nifty Return Series of Nifty at 1-Minute Interval

The descriptive statistics of the 1-minute return series of S&PCNX Nifty for the same period are shown in Table 1.

Table 1: Descriptive Statistics of Nifty 1-minute Return Series

Statistic	Nifty Returns
No. of Observations	83080
Mean	-8.89e-07
Standard Deviation	0.001237
Skewness	-14.63597
Kurtosis	2448.922
Jarque-Bera statistic	2.07e+10 (0.000000)
ACF at lag 1	0.078 (Asymptotic Bound=0.0069)
PACF at lag 1	0.078 (asymptotic bound=0.0069)
Q(1)	503.32 (0.00000)
ADF test statistic	-167.2621 (prob.=0.0001) Critical ADF at 1% (-3.430260)
ARCH-LM Statistic at lag 10	186.4096 (0.020)

Table1 indicates that the mean is very small and standard deviation is also small but large compared to mean, the return series for Nifty is negatively skewed indicating that the return distribution is not symmetric and, kurtosis is very large suggesting that the underlying data is leptokurtic or heavily tailed. The Jarque-Bera statistic calculated to test the null hypothesis of normality rejects the normality assumption. The table also shows strong autocorrelation coefficient (ACF) and partial autocorrelation coefficient (PACF) at lag 1 being outside the asymptotic bound ($1.99/\sqrt{T}=0.0069$). Further, significant value of the Q(1) statistic indicates that there is evidence for autocorrelation in return series which should be accounted for in the mean equation. In the present case Schwarz Baysian Criterion (SBC) is employed to select the number of AR terms and MA terms for fitting ARMA (m,n) model to return series. An ARMA (2,1) model with minimum SBC is selected for Nifty 1-minute return series. Then the integratedness of Nifty 1-minute return series determined with the help of Augmented Dickey Fuller (ADF) test. It indicates that the return series is stationary as ADF test statistic is within the range of critical ADF at 1 percent significance level. The table further indicates that the LM test for ARCH effects rejects the null of homoscedasticity in the error distribution as the estimated test statistic value is significantly different from the critical value at 5% level of significance. Hence, it is established that ARCH effect is present in the 1-minute return series and the conditional volatility can be expressed as an GARCH/EGARCH process. The regression results associated with the fitted ARMA model with EGARCH errors are reported in Table 2 and Table 3 for expiration-day effects and for expiration-hour effects respectively.

Table 2: Results of expiration-day effects with ARMA-EGARCH

Mean Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	9.63E-05	1.32E-06	73.10521	0.0000
Dummy1	-0.000101	1.45E-05	-6.987642	0.0000
Dummy2	-0.000109	1.47E-05	-7.443797	0.0000
AR(1)	0.724285	0.025257	28.67704	0.0000
AR(2)	-0.217905	0.006692	-32.56306	0.0000
MA(1)	-0.405452	0.025368	-15.98280	0.0000
Variance Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-2.779906	0.012998	-213.8645	0.0000
RESID(-1)^2 (α_1)	0.162693	0.000947	171.7521	0.0000
Asymmetry Component (γ_1)	-0.022550	0.000785	-28.71758	0.0000
GARCH(-1) (β_1)	0.799574	0.000939	851.5673	0.0000
DUM1	-0.202401	0.001801	-112.3960	0.0000
DUM2	-0.075886	0.000760	-99.81192	0.0000

The parameter estimates of the ARMA (2,1)-EGARCH (1,1) are reported in Table.2. The coefficient of ARCH parameter is larger than 0.1 which means that volatility is sensitive to market shocks. The persistence parameter (GARCH) coefficient is very large implying that the variance moves slowly through time following a crisis in the market. The asymmetry component coefficient is significant and negative which imply that leverage effect exists. . In the mean equation, both the coefficients of Dummy1 and Dummy2 are statistically significant but the sign of Dummy2 is same to the sign of Dummy1. Hence the null hypothesis of no significant difference between returns on expiration-days and returns on non-expiration days is rejected and the null hypothesis of no price reversal is accepted. Similarly, in variance equation Dummy1 and Dummy2 are statistically significant but the sign of Dummy 2 is same as the sign of Dummy1. Thus, the null hypothesis of no significant difference between volatility on expiration-days and volatility on non-expiration days is rejected. However, null of no price reversal is accepted. As price reversal on days following the expiration-days with respect to both return and volatility is not established, it implies that the observed downward pressure on returns and volatility is not due to expiration-day phenomenon but due to certain other reasons.

Table 3: Results of expiration-hour effects with ARMA-GARCH

Mean Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	7.21E-05	1.67E-06	43.29081	0.0000
DUM1	0.000122	0.000336	0.364107	0.7158
DUM2	-5.67E-05	6.19E-05	-0.915859	0.3597
AR(1)	0.781258	0.026076	29.96065	0.0000
AR(2)	-0.217791	0.006663	-32.68513	0.0000
MA(1)	-0.483088	0.026581	-18.17424	0.0000
Variance Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-3.615027	0.022211	-162.7582	0.0000
RESID(-1)^2 (α_1)	0.141411	0.000998	141.7506	0.0000
Asymmetry Component (γ_1)	-0.021446	0.000899	-23.86339	0.0000
GARCH(-1) (β_1)	0.737126	0.001619	455.3338	0.0000
Dummy1	0.580995	0.009806	59.24871	0.0000
Dummy2	-0.185518	0.018813	-9.861302	0.0000

The results for expiration-hour effects with ARMA-EGARCH framework shown in Table.3 indicate that the ARCH parameter coefficient is more than 1 (0.237192), implying volatility is affected by market news and the persistence parameter (GARCH) coefficient β_1 is also quite large (0.957012), implying that the volatility takes a long time to die out. The asymmetry component coefficient is statistically significant with negative which implies that variance goes up more after negative shocks than after positive shocks. In the mean equation, the coefficients of both Dummy 1 and Dummy 2 are statistically insignificant; hence, the null hypotheses of no significant difference between returns during expiration-hours and returns during non-expiration hours and no price reversal are accepted. Dummy1 turns up with statistically significant and positive coefficient in variance equation, which implies that the volatility of the market index during expiration-hours is higher as compared to volatility during non-expiration hours. Dummy2 has a significant coefficient in the variance equation with opposite sign to that of Dummy1 indicating that temporary deviation in market volatility during expiration-hour revert back to its previous level after expiration-hours.

Concluding Remarks

The results of the study indicate existence of significant expiration-day effect in India during expiration-hours but not at expiration-days. Though at expiration-days both returns and volatility are found to be different from returns and volatility at non-expiration days but the change in the behaviour of stock market return and volatility at expiration- days could not be substantiated as temporary due to expiration of derivatives contracts. During expiration-hours, only volatility was turned to be different from volatility at non-expiration hours along with volatility reversal. No upward or downward pressure on market returns is established during expiration-hours but volatility was found to be quite higher during expiration-hours as compared to non-expiration hours. These results indicate that arbitrageurs have spread their liquidation trades over the entire expiration-hour to lessen their basis risk. Due to this, an order imbalance is created during expiration-hour which made market volatile. However, the depth and maturity of Indian stock market absorbed the shocks to demand/supply curve caused by liquidation trade activities of arbitrageurs during expiration-hours and thus returns to market remain unaffected in either direction. The results of this study are a sort of caution for uninformed small investors to refrain themselves from entering stock market investing at expiration-days, particularly during expiration-hours, as whatever is happening during this period is not due to fundamental factors.

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