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Stability of the day of the week effect in return and in volatility at the Indian capital market: a GARCH approach with proper mean specification

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This paper examines the stability of the day of the week effect in returns and volatility at the Indian capital market, covering the period January 1991–September 2000. The paper specifies a generalized autoregressive conditional heteroscedasticity (GARCH) model on returns and introduces separate dummies for days in alternate weeks in the specification of both the mean and the conditional variance to examine the robustness of the day of the week effect in return and in volatility within a fortnight. Results are compared to those based on ordinary least squares (OLS) procedure to examine how erroneous the inference on day-level seasonality could be when the aspect of volatility is ignored. The paper finds evidence in favour of significant positive returns on non-reporting Thursday and Friday, in sharp contrast to the finding of significant positive returns only on non-reporting Monday by OLS procedure. Separate subperiod analyses reveal that there have been changes in daily seasonality in both returns and volatility since the mid-1990s at the Indian capital market, manifested in the opposite signs and changes in the level of significance of some similar coefficients across periods. These findings on the day of the week effects along with its variation within a fortnight suggest that stock exchange regulations and the nature of interaction between the banking sector with the capital market could possibly throw valuable insights on the origin of the day of the week/fortnight effect in returns, while interexchange arbitrage opportunities due to differences in settlement period could lead to a seasonality in volatility.

I. INTRODUCTION

Seasonalities in security market returns have been extensively documented. Among the different seasonal effects observed in stock markets, an interesting one is the seasonality across the days of a week. Its discovery goes back to Fields (1931). Fields observed that the US stock market consistently experienced significant negative and positive returns on Mondays and Fridays respectively. The observation once again started receiving increasing attention during the 1980s (French, 1980; Gibbons and Hess, 1981; Lakonishok and Levi, 1982), especially when it was discovered that capital markets of many other countries also experience similar seasonality (Jaffe and WesterField, 1985; Peiro, 1994; Agarwal and Tandon, 1994).[1] This 'day of the week effect', in sharp contrast to the theories of efficient market, was considered a puzzle and despite different theories,[2] so far the puzzle has not been satisfactorily resolved yet.

As more and more empirical evidences are obtained from different stock markets all over the world, the puzzle – far from being solved – seems to have increased. Using a long time series from 1962–1993, Wang *et al.* (1997) have shown that for the US market, the well-known Monday effect occurs primarily in the last two weeks of a month. For the US market, Peiró (1994) has, in fact, obtained a positive Monday returns. Of late, studies have incorporated volatility of returns in the framework of analysis (Ho and Cheung, 1994; Choudhry, 2000). However, no satisfactory explanations have been found for the observed day of the week effect in volatility either.

Following Wang *et al.* (1997), this paper examines the stability of the day of the week effect at the Indian capital market. India becomes an interesting case study because since the early 1990s, some very fundamental changes have taken place at the Indian capital market. These include the birth of the Securities and Exchange Board of India (SEBI) as a regulator of the Indian capital market, the birth of the National Stock Exchange (NSE) as a competitor of the Bombay Stock Exchange (BSE), introductions of computerized screen based trading at both the exchanges and dematerialization of shares.[3] These changes have led to substantial improvement in market capitalization, liquidity and efficiency of the Indian capital market, especially during the second half of the 1990s. The pattern of equity returns on different days in a week at the Indian capital market has been examined by many researchers (Chaudhury, 1991; Poshakwale, 1996; Arumugam, 1997; Goswami and Angshuman, 2000; Choudhry, 2000). All these studies, except Choudhry (2000), relate to the period varying between mid-1980s and early-1990s, and use conventional techniques, e.g., first-order autocorrelation test, linear regression with dummy variables representing seasonalities, etc. It is only Choudhry (2000) who has examined seasonality in returns and volatility prevailing at the Indian capital market under a unified framework. The main shortcoming of his work relates to possible misspecification of the conditional mean (of the underlying model) either due to omission of lagged values of returns as explanatory variables or due to structural changes and parameter instability. In fact, recent studies reveal that returns from almost all capital markets are weakly related to their past values (Campbell *et al.*, 1997). It is somewhat surprising that the impact of autocorrelation on the estimated coefficients pertaining to the day of the week effect has not been examined systematically in the literature. It is well-known that in the presence of significant autocorrelation, ordinary least squares (OLS) method would produce biased and inefficient estimates of the coefficients, which in turn might distort the 'true' day of the week effect. Moreover, Woolridge (1991) and Lumsdaine and Ng (1999) have shown that in the framework of ARCH/GARCH model, failure to model the conditional mean correctly can lead to erroneous inference. In fact, Woolridge has considered a more general case where possible misspecification of conditional variance has also been allowed for.

Based on daily data on stock returns of BSE 100 index from January 1991 to September 2000, in this paper the stability of the day of the week effect in returns and in volatility – if any – across weeks and across different time periods is examined. Appropriate GARCH specifications are considered by incorporating lagged returns as explanatory variables in the conditional mean, so that there are no specificational inadequacies either in the conditional mean or in the conditional variance of returns. Based on the findings it is asserted that the day of the week effect could be different for the first and the second week in a fortnight. The analysis also suggests that stock exchange regulations, and the linkage between the banking sector and the capital market could play important roles in generating seasonality of this kind. It may be relevant to state here that in India, the cash reserve ratio (CRR) is maintained by the banking sector on average basis for a fortnight and reported to the Reserve Bank of India (RBI) every alternate Fridays called *Reporting Fridays*. A strong difference is observed in the Friday effects between *reporting* and *non-reporting* weeks at the Indian capital market. Further, the effect appears to have changed significantly during the 1990s. It is difficult to identify the precise reason behind the change in the day of the week effect in returns. However, the observations could potentially narrow the search for a plausible explanation. So far as seasonality in volatility is concerned, based on the empirical evidence, the paper argues that its change during the 1990s could be

[1] For example, the lowest and negative return falls on Tuesday in Japan and Australia and a significant positive return falls on Tuesday in Luxembourg. Moreover, Agarwal and Tandon (1994) find that the day of the week effect exists in 16 out of 18 countries with either Monday or Tuesday being the day of lowest returns.

[2] Some of the theories on the emergence of the 'day of the week effect' are different trading patterns of individual and institutional investors (Lakonishok and Maberly, 1990), the daily seasonality in the release of new information (Penman, 1987), concentration of certain investment decisions (Miller, 1987), country-specific settlement procedures (Solnik, 1990), risk-return tradeoff (Hoa and Cheung, 1994) and a spill-over effect from the US or other large markets (Jaffe and Westerfield, 1985; Agarwal and Tandon, 1994).

[3] Misra (1997) provides a brief survey of the historical transition of the Indian capital market from 1947, the year of India's independence, to the first half of the 1990s.

explained by interexchange arbitrages at the Indian capital market.

The plan of the paper is as follows: Sections II and III present the analytical framework and the empirical results respectively. Finally, Section IV summarizes the main findings with some concluding comments.

II. THE ANALYTICAL FRAMEWORK

In this paper, the day of the week effect in returns is studied using a GARCH framework. Also included are proper lagged values of returns as explanatory variables so that the conditional mean part of the model is appropriately specified. The GARCH model by Bollerslev (1986), generalized from a seminal paper of Engle (1982) that introduced the ARCH model, has been found to be a model that could incorporate the underlying volatility of financial variables adequately (Bera and Higgins, 1995).

The model used in this paper is specified as follows:

$$r_t = \sum_{k=1}^{m} \alpha_k r_{t-k} + \sum_{j=1}^{5} \beta_{1j} D_{1jt} + \sum_{j=1}^{5} \beta_{2j} D_{2jt} + \varepsilon_t$$

$$t = 1, 2, \ldots, T \tag{1}$$

$$\varepsilon_t | \psi_{t-1} \sim N(0, h_t) \tag{2}$$

$$h_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i h_{t-i} + \sum_{l=1}^{5} \theta_{1l} D_{1,t} + \sum_{l=1}^{5} \theta_{2l} D_{2lt} + \sum_{i=1}^{q} \delta_i \varepsilon_{t-i}^2 \tag{3}$$

where $r_t = \ln p_t - \ln p_{t-1}$ represents the continuously compounded rate of return for holding the (aggregate) securities for one day, p_t is the log of stock price index at time t, β_{1j} and β_{2j}'s [$j = 1$ (Monday), 2 (Tuesday), 3 (Wednesday), 4 (Thursday), 5 (Friday)] respectively denote the day of the week effect in a reporting and non-reporting week, D_{1jt} and D_{2jt}'s are corresponding values of the dummy variables taking values 0 and 1, ψ_{t-1} is the information set at time $t-1$ and h_t's are conditional variances specified as a GARCH(p, q) process. h_t is also assumed to be affected by day of the week effects – both reporting and non-reporting – represented by θ_{1l}'s and θ_{2l}'s $(l = 1, 2, \ldots, 5)$.

It may be noted at this stage that the specification in Equation 1 entails whether the so-called 'day of the week effect' should actually be called 'day of the fortnight effect'. In the Indian context such an approach could be more meaningful because of the possibility of an indirect impact of the account period settlement cycles on returns and volatility.

The settlement process at the Indian capital market is further complicated because of *badla*. *Badla* is a carry-forward system that exists at the Indian capital market for specific individual stocks. By this mechanism, a buyer or a seller can carry forward the transaction for a limited period through a financier. In the past *badla* trading at the Indian capital market was almost always singled out for criticism for 'excessive' speculation.

On 12 December 1993, SEBI banned *badla* trading on the BSE and at the Calcutta, Delhi and Ahmedabad stock exchanges. In October 1995, SEBI introduced a modified *badla* system which began on the BSE in January, 1996 and subsequently revised it further in October 1997. Taking advantage of this ban, some researches were conducted to assess the impact of *badla* trading on returns, volatility and market efficiency, revealing that *badla* trading had no impact on stock price volatility and that it was, in fact, slightly beneficial for short-horizon market efficiency.[4] The study of Goswami and Angshuman (2000) also revealed that *badla* trading had no impact on the day-of the-week pattern of returns.

The model specified in Equations 1–3 is estimated by the method of maximum likelihood using TSP software. It is well-known that the standard asymptotic results would hold and usual asymptotic tests may be used to carry out relevant hypotheses of interest. Insofar as the determination of the appropriate value for the number of lags m in the conditional mean is concerned, we use the usual information-based criteria like AIC and BIC and/or Hall's (1994) procedure. With regard to the choice of p and q, the maximum value of each of p and q is fixed at 3 and 2 respectively and the six possible combinations are considered. In both these cases, appropriate diagnostic tests are finally used to check the appropriateness of the specification of both the conditional mean and variance.

III. EMPIRICAL RESULTS

In an earlier study on day of the week effect in returns at the Indian capital market, Chaudhury (1991) examined the behaviour of the Bombay Stock Exchange (BSE) Sensitive Index (SENSEX) between June 1988 and January 1990. He found that average return pertaining to Monday was significantly negative and highest returns were usually on Fridays. Poshakwale (1996) studied the BSE National Index between January 1987 and October 1994. He found that mean returns except for Monday and Wednesday were positive and that weekend effects on returns support the presence of first order autocorrelation. While Chaudhury's

[4] Endo (1998) provides a discussion on the issue.

results were based on the Kruskal–Wallis test, Poshakwale's findings were based on various autocorrelation tests. Arumugam (1997), using regression analysis, found that Friday returns at the Indian stock market were significantly positive, with no significant returns on Mondays except in bear phase. Recently, Goswami and Angshuman (2000), using disaggregate data on 70 individual stocks from 1991 to 1996, obtained a positive return at the BSE on Friday. Their study revealed that the excess returns at the Indian capital market were related to firm size. For post-1994 data, Goswami and Angshuman (2000) also obtained a significantly negative Tuesday returns. In another recent study, Choudhry (2000) examined the week-day patterns in return and volatility of seven emerging markets including India. Choudhry specified a GARCH model of returns for all countries. For the Indian market, using the daily data of returns from January 1990 to June 1995, he obtained a positive Friday effect in returns and a positive Thursday effect in volatility.

In this paper, the daily data on the BSE 100 index are used from January 1991 to September 2000, comprising 2222 observations. The BSE 100 Index, formerly known as the BSE National Index is a market value weighted index of 100 stocks. The BSE started publishing the index from 3 January 1989. The index was initially intended to reflect stock price movements on a national scale and for that purpose the 100 stocks were selected from the five major stock exchanges (viz., Mumbai, Calcutta, Delhi, Ahmedabad and Madras) at that time. However, fast advancement in communication as well as trading technologies quickly diminished the price differences among the Indian stock exchanges. Consequently, the BSE redesigned the index based only on prices quoted on the BSE and renamed it as the BSE 100 Index, effective from 14 October 1996.

Figure 1 shows the plot of the return data based on BSE-100 index covering the aforesaid period. It is clear from this plot that the data exhibit strong volatility. In Table 1 some of the basic features of the returns series are presented. To examine the implications of some of the phenomenal changes which took place at the Indian capital market during the early 1990s, the features for the periods of 1991–1995 and after 1995 are separately examined. These two subperiods are respectively called Period 1 and Period 2.

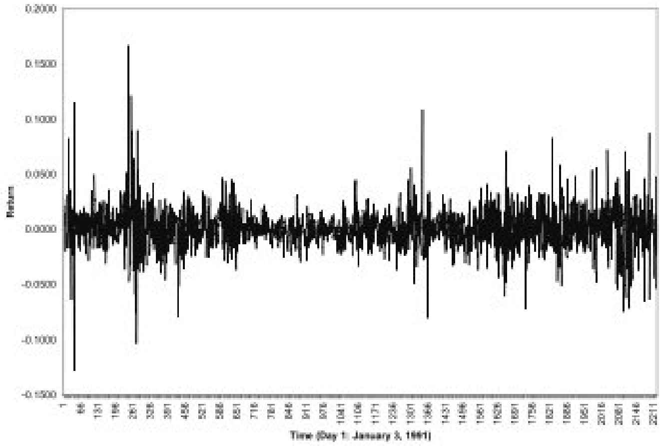

Fig. 1. *Daily return in BSE100*

Table 1 indicates substantial changes in the distributional structure of the returns between Period 1 and Period 2. Both Period 1 and Period 2 reveal the presence of zero mean returns with near identical variance. However, during Period 1, the returns used to be positively skewed, indicative of a less developed market moving asymmetrically to 'news'. The distribution was also highly leptokurtic, i.e., the return series used to have a thicker tail and a higher peak than a normal distribution, indicating the presence of very large movements of share prices on either side. In the Indian context, these movements were typical products of 'euphoria to despondency cycles' (Gupta, 1997, p. 3). However, for Period 2, the return series appears to be symmetric and its kurtosis, while still higher than that pertaining to a normal distribution, has dropped down considerably.

OLS-based results

Table 2 presents the mean and the standard deviations of returns for each working days of the week. As in Table 1, the results are presented separately for Period 1 and Period 2. Table 2 reveals some interesting features. First, it reveals that the significant positive mean return on Fridays at the Indian market obtained by many researchers primarily occurred on non-reporting Fridays. While for the Entire Period, Table 2 reveals the existence of significant positive

Table 1. *Basic statistics for returns*

Period	No.	Mean	Variance	Skewness	Kurtosis
Period 1 (January 1991–December 1995)	1065	0.0010	0.00034	0.8093 #	13.8836 #
Period 2 (January 1996–September 2000)	1156	0.0003	0.00035	0.1140	2.9973 #
Entire period	2221	0.0006	0.00035	0.4308 #	7.9150 #

Note: # implies significance at 1% level.

Table 2. *Mean and standard deviation of returns based on days of a week/fortnight*

Day of the week	Mean return: Period 1 (Jan 1991 to Dec 1995)	Mean return: Period 2 (Jan 1996 to Sep 2000)	Mean return: Entire period	Standard deviation of returns: Period 1 (Jan 1991 to Dec 1995)	Standard deviation of returns: Period 2 (Jan 1996 to Sep 2000)	Standard deviation of returns: Entire period
Reporting Monday	0.0019	0.0020	0.0019	0.0255	0.0242	0.0248
Non-reporting Monday	0.0011	0.0058#	0.0037#	0.0190	0.0251	0.0225
All Monday	0.0016	0.0039#	0.0028#	0.0226	0.0246	0.0237
Reporting Tuesday	−0.0005	−0.0013	−0.0009	0.0196	0.0180	0.0187
Non-reporting Tuesday	0.0004	−0.0003	0.0000	0.0199	0.0132	0.0167
All Tuesday	−0.0001	−0.0008	−0.0004	0.0197	0.0158	0.0177
Reporting Wednesday	−0.0016	0.0030†	0.0007	0.0155	0.0171	0.0164
Non-reporting Wednesday	0.0009	0.0014	0.0012	0.0168	0.0186	0.0177
All Wednesday	−0.0004	0.0022†	0.0009	0.0162	0.0178	0.0171
Reporting Thursday	−0.0021	−0.0008	−0.0014	0.0156	0.0171	0.0164
Non-reporting Thursday	0.0027	−0.0014	0.0005	0.0139	0.0174	0.0160
All Thursday	0.0002	−0.0011	−0.0005	0.0150	0.0172	0.0162
Reporting Friday	−0.0001	−0.0016	−0.0009	0.0193	0.0175	0.0184
Non-reporting Friday	0.0071#	−0.0037*	0.0017	0.0136	0.0158	0.0156
All Friday	0.0035#	−0.0026*	0.0004	0.0170	0.0167	0.0171
Reporting week	−0.0005	0.0003	−0.0001	0.0194	0.0190	0.0192
Non-reporting week	0.0025	0.0004	0.0014	0.0169	0.0187	0.0179
All days of all week	0.0010	0.0003	0.0006	0.0183	0.0188	0.0186

Note: #, * and † imply significance at 1%, 5% and 10% levels respectively.

returns only on Mondays (especially non-reporting Mondays), subperiod-wise break-ups present a different story. During 1991–1995, the returns were significantly positive for non-reporting Fridays. However, post-1995 returns pertaining to non-reporting Fridays were significantly negative. Also returns corresponding to Mondays, especially non-reporting Mondays, were significantly positive in Period 2.

Table 2 also reveals the changing pattern of volatility across the days of the week at the Indian market. Volatility, measured in terms of standard deviation of returns, appears to be stable in the aggregate across Period 1 and Period 2. However, after 1995 the volatilities corresponding to Monday, Wednesday and Thursday have increased and that for Tuesdays has reduced considerably, the direction of change being generally similar for reporting and non-reporting weeks.

It may be noted that as $D_{11}, D_{12}, \ldots, D_{15}, D_{21}, \ldots, D_{25}$ defined in Section II are orthogonal, an OLS regression of returns involving only these ten dummies as independent variables (and obviously without consideration to conditional heteroscedasticity) would yield identical estimates corresponding to day of the week/fortnight effect of returns in Table 2. From Table 2, therefore, inferences could be drawn on results from simple dummy variable regressions, a tool frequently employed by previous researchers to estimate the nature and the extent of the day of the week effect in returns (Solnik, 1990; Peiró, 1994; Arumugam, 1997; Wong *et al*., 1999). To analyse the effect of *badla*, another set of regressions were run with an additional explanatory variable, namely a dummy named BADLA which took the value unity during the *badla* period and zero elsewhere. It may be noted that as *badla* was reintroduced during January 1996, the variable BADLA took the value unity for almost all the observations in Period 2. For Period 2, therefore, the variable BADLA was not considered.

When the regressions were actually done, the presence of significant autocorrelations in the residuals was noted. Autocorrelations were high at lag one for the Entire Period and both the subperiods while they were moderate and significant – either for the Entire Period, Period 1 or Period 2 – at lags 3, 7, 8, 9, 10, 12, 15 and 19. The autocorrelation structures were fairly similar in all the equations. In all the regressions, the estimated coefficient of BADLA turned out to be insignificant. The specifications were, therefore, changed to include these lags of return in the regression equations for the Entire Period as well as for both Period 1 and Period 2 and drop BADLA from all the equations.

Table 3 presents the results of these regressions. In the estimated regression equations, most of the lags chosen turn out to be significant for the Entire Period as well as for both Period 1 and Period 2. The first lag of return, in fact, turns out to be highly significant in all the regressions. Estimated values of $Q(40)$ were 51.02, 24.10 and 28.97 for Period 1, Period 2 and the Entire Period respectively. Thus, while the process of inclusion of lags led to improved Ljung–Box Q statistic for all periods, the estimated residuals for Period 1 still showed evidences of autocorrelation. However, significantly, it was found that the estimated day of the week/fortnight effects in returns in Table 3 are similar to those in Table 2.

So far as the stabilities of the estimated equations are concerned, Hansen's tests (Hansen, 1992) confirm the presence of instability in all of them. Hansen's joint statistics for the estimated equations corresponding to Period 1, Period 2 and the Entire Period are 5.73, 6.62 and 8.53 respectively, all of them being significant at the 1% level. In all the equations, the estimated variances of the error term appear as highly unstable (cf. Table 3). Given the highly volatile and unpredictable nature of returns, such a result is not surprising. Individually, most of the other estimated coefficients, however, are found to be stable. Instability is more prominent in the equation for the Entire Period, where coefficients pertaining to non-reporting Thursday, non-reporting Friday and the seventh and eighth lags are found to be unstable. Among the estimated coefficients for Period 1 and Period 2, however, only the coefficient of non-reporting Monday in Period 1 appears as significantly unstable.

Table 3. *OLS regression results with lagged returns as explanatory variables*

Coefficients	Period 1	Period 2	Entire Period
β_{11}	0.000 087 909 (0.05)	0.002 053 126 (1.20)	0.001 314 256 (1.08)
β_{21}	0.001 830 825 (1.00)§	0.005 652 397 (3.26)#	0.003 740 247 (2.96)#
β_{12}	−0.001 606 508 (−0.94)	−0.001 334 133 (−0.79)	−0.001 378 323 (−1.14)
β_{22}	0.000 571 861 (0.32)	−0.000 698 549 (−0.40)	−0.000 257 421 (−0.21)
β_{13}	−0.002 235 668 (−1.29)	0.002 938 875 (1.72)†	0.000 613 461 (0.50)
β_{23}	0.000 965 633 (0.55)	0.001 817 136 (1.05)	0.001 005 163 (0.81)
β_{14}	−0.001 530 459 (−0.89)	−0.001 328 062 (−0.78)	−0.001 245 198 (−1.02)
β_{24}	0.002 400 949 (1.34)	−0.001 364 826 (−0.79)	0.000 272 632 (0.22) §
β_{15}	−0.000 157 713 (−0.09)	−0.001 482 032 (−0.87)	−0.000 765 034 (−0.62)
β_{25}	0.006 193 142 (3.56)#	−0.003 856 865 (−2.19)*	0.001 215 452 (0.98) ‡
α_{t-1}	0.152 341 502 (4.97)#	0.088 685 026 (3.02)#	0.120 401 726 (5.70)#
α_{t-3}	0.089 316 783 (2.91)#	0.040 055 582 (1.37)	0.059 003 041 (2.80)#
α_{t-7}	−0.039 043 992 (−1.27)	0.060 311 833 (2.04)*	0.014 579 367 (0.68) ‡
α_{t-8}	−0.063 059 940 (−2.03)*	0.054 291 692 (1.83)†	−0.004 358 117 (−0.20) ‡
α_{t-9}	0.100 801 869 (3.23)#	0.065 757 400 (2.21)*	0.089 439 412 (4.16)#
α_{t-10}	0.044 199 788 (1.43)	0.052 587 665 (1.77)†	0.053 254 677 (2.48)*
α_{t-12}	0.043 179 999 (1.42)	0.005 935 379 (0.20)	0.019 112 645 (0.90)
α_{t-15}	0.051 546 086 (1.70)†	−0.016 362 352 (−0.55)	0.024 649 818 (1.17)
α_{t-19}	−0.029 027 741 (−0.95)	−0.111 524 263 (−3.79)#	−0.070 243 037 (−3.31)#
Observations	1065	1156	2221
R^2	0.074 2	0.057 2	0.042 4
R-BAR^2	0.058 0	0.042 3	0.034 5

Notes: (1) The bracketed figures are values of *t*-statistics. (2) #, * and † represent significance at 1%, 5% and 10% levels respectively. (3) ‡ and § indicate that Hansen's stability test statistic for the coefficient is significant at 1% and 5% levels respectively.

GARCH-based results

The empirical findings are now discussed of the complete model incorporating GARCH process for the conditional variance, as specified in Equations 1–3. The estimates of the parameters along with their *t*-statistic values for the Entire Period as well as for Period 1 and Period 2 are presented in Table 4. Table 4 reveals that returns based on the entire sample have significant positive effect on both non-reporting Thursday and non-reporting Friday, the *t*-statistic values being 2.244 and 2.305, respectively. The findings for Period 1 and Period 2, however, reveal a different story. In Period 1 four significant coefficients have been observed, namely non-reporting Monday (negative), reporting Wednesday (negative), non-reporting Thursday (positive) and non-reporting Friday (positive). The day-level seasonality corresponding to Period 2 has been found to be of the similar type namely, significant non-reporting Monday (positive), reporting Wednesday (positive) and non-reporting Friday (negative). While in Period 1, non-reporting Thursday has also been found to be significant, what is very contrasting to note is that the significant day effects are of opposite signs across Period 1 and Period 2. Possible explanations are provided for such findings later. What is, however, relevant to note at this stage are (i) the importance of 'reporting' and 'non-reporting' aspects of market microstructure of Indian stock market

Table 4. *The estimated GARCH model*

Coefficients	Period 1	Period 2	Entire period
α_1	0.3080 (8.537)#	0.1415 (4.276)#	0.1810 (7.748)#
α_2	−0.0850 (−2.341)†	–	–
α_3	0.0780 (2.171)†	–	0.0450 (1.932)‡
α_6	–	−0.0830 (−3.58)#	−0.0610 (−2.94)#
α_8	–	0.0515 (1.836)‡	–
α_{10}	–	0.0511 (2.123)†	0.0500 (2.461)#
α_{11}	–	−0.0470 (−2.046)†	−0.0410 (−2.027)†
α_{13}	–	–	−0.0390 (−1.98)†
α_{18}	–	−0.0439 (−1.831)‡	–
α_{19}	–	−0.0860 (−3.41)#	–
β_{11}	−0.001150 (−0.937)	0.002980 (1.662)	0.001000 (1.138)
β_{21}	−0.003380 (−2.906)#	0.006260 (2.925)#	0.001000 (1.295)
β_{12}	−0.000097 (−0.065)	−0.000925 (−0.698)	−0.000045 (−0.419)
β_{22}	−0.000478 (−0.404)	−0.001610 (−1.22)	−0.001100 (−1.052)
β_{13}	−0.002680 (−1.96)†	0.003280 (2.377)†	−0.000325 (−0.305)
β_{23}	0.001110 (0.865)	0.001770 (1.125)	0.001590 (1.643)
β_{14}	−0.001790 (−1.724)	−0.000740 (−0.521)	−0.000960 (−0.995)
β_{24}	0.003170 (2.79)#	0.0005170 (0.372)	0.002080 (2.244)†
β_{15}	0.000375 (0.395)	−0.000881 (−0.683)	−0.000610 (−0.734)
β_{25}	0.005640 (5.767)#	−0.002970 (−2.287)†	0.002080 (2.305)†
γ_0	*	0.000065 (3.008)#	*
γ_1	0.193 (8.218)#	0.209 (5.571)#	0.187 (10.136)#
γ_2	–	0.133 (3.901)#	–
γ_3	–	0.0842 (3.197)#	–
δ_1	0.084 (2.3)#	–	0.098 (3.281)#
δ_2	0.716 (16.959)#	–	0.665 (18.006)#
θ_{11}	0.0000234 (1.552)	0.000295 (5.95)#	0.0000656 (6.164)#
θ_{21}	*	0.000436 (8.650)#	0.0000806 (6.014)#
θ_{12}	*	0.000050 (1.685)†	*
θ_{22}	*	0.000010 (0.382)	*
θ_{13}	*	0.000063 (1.827)†	*
θ_{23}	*	0.000150 (3.369)#	*
θ_{14}	0.0000958 (0.462)	0.000098 (3.043)#	0.0000246 (2.007)#
θ_{24}	0.00001174 (0.788)	0.000097 (2.71)#	*
θ_{15}	0.00000143 (0.133)	0.000061 (1.984)†	*
θ_{25}	0.00000484 (0.512)	0.000024 (0.000)	*
L	3025.74	3086.85	6016.89

Continued

Table 4. *Continued*

Notes:
1. Bracketed figures are values of *t*-statistics.
2. – indicates that the corresponding parameter is not relevant for the series.
3 * shows that the computed value of the coefficient is so small that its value and the corresponding value of the *t*-statistic are treated as zero.
4. #, † and ‡ imply significance at 1%, 5% and 10% levels respectively.
5. L represents values of the log-likelihood function.

on the day of the week effect on returns, and (ii) the observed differences in day-level seasonality between Period 1 and Period 2 leading thereby to the conclusion that there has indeed been a change effected in mid-1990s. The results in Table 4 *vis-à-vis* Table 3 reveals how the day of the week effect could be found to be erroneous if due consideration to volatility is not taken care of in the model.

Insofar as the day of the week effect on the volatility i.e., conditional variance is concerned, it is observed that in the full-sample period, both reporting and non-reporting Monday and only reporting Thursday are found to have significant effect. The t-statistic values are 6.164, 6.014 and 2.007, respectively. The results concerning Period 1 and Period 2 are, as in the case of conditional mean, quite varying. While no significant day of the week effect has been observed in Period 1, significant positive effect has been found to be present on both reporting and non-reporting Monday, reporting Tuesday (at the 5% level only), both reporting (at the 5% level only) and non-reporting Wednesday, both reporting and non-reporting Thursday and reporting Friday (at the 5% level only) in Period 2. It is thus observed that day of the week effect is an important factor in explaining observed volatility at the Indian capital market and that there has been a significant difference in day of the week effect in volatility in Period 2 as compared to Period 1.

Finally, the values of the Q-test of the estimated models are reported to find that the residuals of these models are significant in the three models based on entire sample and those for Period 1 and Period 2. In each case 40 lags have been considered and only the Q-test statistic values with the lags 10, 20, 30 and 40 have been reported. From the Q-test statistic values in Table 5 it is noted that for standardized residuals, no significant autocorrelation was observed in Period 1, Period 2 and Entire Period. Standardized-squared residuals, however, displayed evidences of autocorrelation only in Period 2.

Also reported in Table 5 are the values of skewness and kurtosis coefficients of the above three residuals, and the LM test statistic value for testing for ARCH/GARCH. It has been observed, as reported in Table 4 that GARCH(1,2) has been found to be the most adequate GARCH specification for the data corresponding to the Entire Period and to Period 1; ARCH(3) has been found to be the best specification for Period 2. The LM test statistic values based on the standardized residuals of the three models are 0.059, 0.412 and 0.079 respectively. Thus it is clear that the hypothesis of no ARCH/

Table 5. *Properties of the residuals from the estimated GARCH models*

Residuals	Period 1	Period 2	Entire period
1. Non-standardized (ε_t)			
Skewness	1.424	0.028	0.574
Kurtosis	18.339	2.918	8.626
$Q(10)$	65.028#	20.155	38.774#
$Q(20)$	77.555#	30.935	56.778#
$Q(30)$	93.238#	35.265	67.876#
$Q(40)$	120.076#	40.994	80.694#
ARCH	66.630#	44.794#	95.598#
2. Standardzed ($\varepsilon_t/h_t^{0.5}$)			
Skewness	0.185	0.033	0.307
Kurtosis	4.627	1.091	3.691
$Q(10)$	11.191	16.283	18.115
$Q(20)$	18.901	22.967	23.221
$Q(30)$	27.586	24.985	30.136
$Q(40)$	40.927	29.613	37.192
ARCH	0.059	0.412	0.079
3. Standardized squared (ε_1^2/h_t)			
Skewness	10.882	4.302	9.725
Kurtosis	160.318	25.748	134.340
$Q(10)$	15.731	33.881#	15.734
$Q(20)$	24.217	44.369#	25.283
$Q(30)$	28.695	50.600#	30.824
$Q(40)$	33.513	61.061#	38.899
ARCH	0.000	0.034	0.023

Notes:
1. # implies significance at 1% level.
2. $Q(k)$ represents the Ljung–Box statistic with k number of lags after adjusting the number of parameters.

GARCH can not be rejected, signifying the adequacy of the estimated conditional variance specifications. As regards the values of skewness and kurtosis coefficients, it is found that these values have reduced for the series of residuals of these estimated models as compared to those based on the original return series for the Entire Period, as also for Period 1 and Period 2. For instance, it is found from Table 1 and Table 5 that while for the entire series, the skewness and kurtosis coefficients were 0.4308 and 7.9150 respectively, the same based on the standardized residuals of estimated models are 0.307 and 3.691.

An attempt is now made to provide an interpretation of the results. It may be noted that for the Indian market, the findings pertaining to the early 1990s appear to be consistent with the earlier findings of a significant Friday effect. However, the findings highlight that the Friday effect at the Indian market used to take place mostly on non-reporting Fridays. Among different theories, it appears that in the Indian context, the risk-return tradeoff proposed by Ho and Cheung (1994) does not make sense because high returns at the Indian market on specific days were not always associated with high volatility. Similarly, transmission of shocks from other markets (e.g., the US market) could not be a major factor because during the early 1990s, the Indian economy was relatively closed in nature. Although during the recent period, capital markets in India have become somewhat integrated to the rest of the world, such integration has not been manifested in the seasonalities in returns. For example, if the 'root cause' of seasonality is the transmission of shocks from the US market, the 'Monday Effect' at the US market would have been manifested in the returns at the Indian market on Tuesday, because of the geographical distance and the consequent time-difference between the two markets. Although for post-1994 data, Goswami and Angshuman (2000) have observed evidences of a significantly negative Tuesday returns at the Indian capital market, the present studies do not indicate similar results.

Although it has not been possible to provide a full explanation of the day of the week effect in returns, two factors are identified which could have affected the weekday patterns. The first is the nature and the extent of interaction of the banking system with the capital market in India. During early 1990s in India, the interaction could have led to significant positive returns on specific days of a week. At that time, the banking sector as well as the capital markets in India were not fully computerized, leading to lack of transparency and efficiency which in turn funnelled movements of funds from the banking sector to the capital market. The securities market scam experienced by India in 1992 was a direct result of this type of activity. The Janakiraman Committee subsequently appointed by the Reserve Bank of India to investigate the scam noted widespread use of many irregularities:

> . . . The Committee's terms of reference were largely restricted to the examination of the securities transactions of banks. However, the Committee has identified that there has also been diversion of funds through other means, for example, call money transactions and the discounting of bills. Thus, large payments such as call money placed with other banks, have been found to be credited to individual brokers' accounts. On due date, these alleged call loans have been repaid by payment out of brokers' accounts in the same or other banks. The Committee has also noticed cases where brokers' funds have been placed in the call money market under the banks' names. (Janakiraman, 1993, pp. 292–3)

It is possible that as the CRR is maintained by the banking sector in India is on average basis for a fortnight, irregular availability of funds on specific days within a fortnight used to affect prices of bourses at the Indian capital market on those days, the direction being dependent on the direction of the flow. It is also possible, although difficult to quantify, that after widespread computerization, currently the nature of interaction between the banking sector and capital market, especially the irregular flow of funds, has changed and the said changes have been manifested in the change in the day of the week effect.

The second factor affecting the day of the week effect could be stock exchange regulations.[5] The seasonality in volatility at the Indian capital market could possibly be explained in terms of these regulations allowing arbitrage opportunities across different stock exchanges in India. It may be noted that an account period settlement cycle begins in BSE on Monday and ends after eight working days. Thus a trade done during the week generally settles on the Friday of the next week. However, NSE's accounting period settlement cycle starts every Wednesday and ends on a Tuesday. All open and outstanding positions on Tuesday at the NSE are required to be settled and delivered. This is similar to a futures style settlement wherein shares traded Wednesday onwards are effectively a forward contract for settlement during the next week. Thus on the NSE an investor may take speculative position for a week, i.e., he trades on Wednesday and can reverse the trade by the following Tuesday (close of account period) and book his gains and losses. It is likely that speculative activities are at its peak and ebb, respectively at the beginning and the end of a cycle. Thus, the post-1995 high volatilities on Mondays and Wednesdays could be attributed to beginnings of settlement cycles respectively at the

[5] Wong *et al.* (1999), for the Shanghai Stock Exchange (SSE), have arrived at a similar inference.

BSE and the NSE. Similarly, the post-1995 low volatility on Tuesdays and Fridays could be because of the pressure of closing one's position on those days.

The significantly positive volatility on both reporting and non-reporting Thursdays during Period 2 presents an interesting case and may be explained in terms of *kerb trading* across stock exchanges situated in different cities in India. Earlier, the *kerb market* was occasionally used by the big operators and insiders to manipulate share prices (Krishnan and Narta, 1997, p. 403). Although academic research on this topic is rare, a few newspaper reports and articles have pointed out the existence of a grey market in many stock exchanges in India, especially at the Kolkata (erstwhile Calcutta) stock exchange on Thursdays.[6] It is possible – although difficult to prove – that the significantly high volatility at the Indian capital market on Thursday's during Period 2 was because of this type of activities and the results of this paper could be interpreted as an indirect evidence in this direction. Incidentally, although Choudhry (2000) obtained a significantly positive coefficient pertaining to volatility of returns on Thursdays during the early 1990s, a similar result for Period 1 has not been obtained.

IV. CONCLUSION

In this paper the stability of the day of the week effect has been studied in mean and in conditional variance of returns at the Indian capital market using a GARCH framework. Results based on OLS have also been reported to examine as to what extent the day of the week effect may be inappropriately estimated when volatility aspect of the data is ignored. Strong evidence is found that the significant positive returns at the Indian capital market during the early 1990s on Friday were mostly due to non-reporting Fridays. In fact, the analyses based on the series covering the entire sample period show significant positive effect on non-reporting Friday as also on non-reporting Thursday. OLS-based study on the other hand, has yielded positive effect only on non-reporting Monday. Subperiod wise analyses have revealed that the day-level seasonality is quite different in the two subperiods in the sense that while Monday (non-reporting), Wednesday (reporting) and Friday (non-reporting) have been found to have significant negative, negative and positive effects respectively in Period 1, the same day effects have also been observed in Period 2 but with opposite signs. In Period 1, an additional day effect i.e., significant positive effect on non-reporting Thursday has also been found.

The day of the week effect in volatility of returns have also been found to be different in the two sub-periods. Based on entire sample, significant positive effect were found on non-reporting as well as reporting Mondays and reporting Thursday. While no day-level seasonality has been found in volatility in Period 1, significant positive day effect has been found to be present on both reporting and non-reporting Monday, reporting Tuesday, both reporting and non-reporting Wednesday, both reporting and non-reporting Thursday and reporting Friday.

While testing the hypothesis that day of the week effect could in reality be a day of the fortnight effect these findings along with consideration to 'reporting' and 'non-reporting' days in a fortnight suggest that stock exchange regulations and the nature of interaction between the banking sector with the capital market could possibly throw valuable insights on the origin of the day of the week/fortnight effect in returns. It is possible that the day of the week effect, in reality could be a day of the fortnight effect. Following Wang *et al*. (1997), it is also possible that the periodicity of the seasonality could be even bigger. So far as the seasonality in volatility is concerned, the analysis has revealed that interexchange arbitrage opportunities due to the existence of differences in account period settlement cycles could lead to such seasonality. As research on seasonality in volatility of returns is still at a nascent state, the above finding could possibly be of help in understanding and explaining such seasonality for the capital markets in other economies.

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[6] For example, M. G. Damani, a former president of the Bombay Stock Exchange noted in an article at the Indian Express that 'For years, Kolkata has been getting around this inconvenience by entering into financial deals outside the market'. The same article points out the existence of huge monetary flows between Mumbai and Kolkata market on specific days. In another recent article titled 'BSE brokers default on badla funds, divert to CSE (*Economic Times*, 9 April 2001), Rishi Chopra observed a similar phenomenon.

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