Evidence on the Day-of-the-Week Effect and Asymmetric Behavior in the Bombay Stock Exchange

Ricky Chee-Jiun Chia* and Venus Khim-Sen Liew**

This study examines the existence of day-of-the-week effect and asymmetrical market behavior in the Bombay Stock Exchange (BSE) over the pre-9/11 and post-9/11 sub-periods. This study found the existence of significant positive Monday effect and negative Friday effect during the pre-9/11 sub-period. Further analysis using the EGARCH and EGARCH-M models revealed the asymmetrical market reaction to the positive and negative news in BSE. Moreover, significant day-of-the-week effect is found present in BSE regardless of sub-periods, after controlling for time-varying variance and asymmetrical market behavior.

Introduction

A major concern in the market efficiency literature is the existence of calendar anomalies or seasonality in the stock market returns. Within this burgeoning literature, one of the most well-known calendar anomalies comprises the day-of-the-week effect, in which the mean return on Friday is normally higher compared to other days (Cross, 1973; and Gibbons and Hess, 1981) and the return on Monday is usually negative (Gibbons and Hess, 1981; and Harris, 1986). Empirical studies have found that the day-of-the-week effect appears in the largest stock market of the world (the US), and in other developed markets such as the UK, Germany and Japan (see, for instance, Gibbons and Hess, 1981; Jaffe and Westerfield, 1985; Bowers and Dimson, 1988; Lakonishok and Smidt, 1988; Arsal and Coutts, 1996; Wang et al., 1997; and Apolinario et al., 2006, for empirical studies on developed markets). Apart from developed markets, there have been other studies such as Aggarwal and Rivoli (1989), Woeng et al. (1992), Clare et al. (1998), Brooks and Persand (2001), Kok and Wong (2004) and Hui (2005) which demonstrated that emerging Asian stock markets are not free from such effect.

Among those emerging Asian markets, one of the most appealing markets is the Indian market. The Bombay Stock Exchange (BSE) of India is well-known as one of the oldest stock exchanges in Asia. There are three main indices on the BSE: BSE Sensitive Index (Sensex), Economic Time Ordinary Share Price Index (ET), and BSE National Index (BSEN). BSE Sensex, also called the 'BSE 30', is a value-weighted index composed of 30 companies. These companies have the largest and most actively traded stocks, and are representative of various

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1 Visit http://www.bseindia.com/ for more details.

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sectors on the exchange. They account for around one-fifth of the market capitalization of the BSE. The Sensex is generally regarded as the most popular and precise barometer of the Indian stock markets. In fact, BSE has the greatest number of listed companies in the world, with 4,700 listed in the third quarter of 2007. According to the World Federation of Exchanges 2008, BSE is the world's 10th largest in terms of market capitalization and the largest stock exchange in South Asia.

Due to the significance in the world markets, the day-of-the-week effect in the Indian stock market has attracted considerable attention in the literature. In this respect, previous empirical findings related to this market are worth mentioning. Day-of-the-week effects in the Indian stock market were first reported in Chaudhury (1991). In a separate attempt, Broca (1992) documented the lowest mean return on Wednesday for India, instead of Monday, as exhibited by the developed stock markets. Chaudhry (2000) examined the Asian emerging markets, including India, and reported significant positive Friday returns in the Indian stock market for the period January 1990 to June 1995. The findings of positive Friday returns conformed to the majority of previous empirical findings (Cross, 1973; and Gibbons and Hess, 1981). On the other hand, Bhattacharya et al. (2003) examined the day of the week effect in returns and its volatility in the Indian capital market, covering the period January 1991 to September 2000. This study found significant positive returns on non-reporting Monday by Ordinary Least Squares (OLS) procedure. However, using the more robust Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, this study found evidence of significant positive returns on non-reporting Thursday and Friday. Recently, Sarma (2004) examined the day-of-the-week effects during the post reform era in the Indian stock market. This study investigated the BSE 30, the BSE 100, and the BSE 200 stock indexes to detect the day-of-the-week effect by employing the Kruskal-Wallis test statistics. This study concluded that the Indian stock market exhibited some seasonality in daily returns over the period January 1, 1996 to August 10, 2002.

It is worth pointing out that among the limited studies on the Indian stock market, Choudhry (2000) and Bhattacharya et al. (2003) employed the symmetric GARCH model to take into account the time varying volatility of the stock returns. Nonetheless, none of the existing studies on this market has considered the asymmetrical stock market behavior. In the light of the above observations, this study aims to re-examine the existence of day-of-the-week effect in the Indian stock market, by taking into consideration the stock market asymmetric behavior.

Data

The data of this study consists of the daily closing values of the BSE Sensex over the period January 1998 to November 2008. This time span is divided into two sub-periods: (1) from

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1 Gibbons and Hess (1981), Jaffe and Westerfield (1985), Bowers and Dimson (1988), and Lakonishok and Smidt (1988) were among those early studies that documented the lowest returns on Monday and the highest returns on Friday for developed countries.

2 Engle and Ng (1993), for instance, pointed out that the market reaction to bad and good news tends to be asymmetric in nature.
January 1998 to September 2001, and (2) from October 2001 to November 2008, to account for the September 11 (9/11) incident and its extraordinary impact on India's economic and growth performance. Following the literature, daily returns are calculated as a continuously compounded daily percentage change in the composite index in order to avoid the influence of extreme index values (Boldea and Jindal, 2006), as follows:

\[ R_t = 100 \times (\ln I_t - \ln I_{t-1}) \]

where \( \ln I_t \) and \( \ln I_{t-1} \) are the logarithms of the stock index for periods \( t \) and \( t - 1 \), respectively. In the case of a day following a non-trading day, the return is calculated using the closing price indices of the latest trading day.

Table 1 presents the descriptive statistics for the daily returns series for the pre-9/11 and post-9/11 sub-periods. Descriptive statistics gives the mean, standard deviation (Std. Dev.) and Jarque-Bera normality test statistics, together with its corresponding p-value. The descriptive statistics is to review the nature of the volatility of the returns and the distribution of the returns. Overall, Table 1 depicts that on an average, the daily returns for the pre-9/11 sub-period is negative, but the returns turned positive after the 9/11 incident. In the pre-9/11 sub-period itself, the highest daily returns were obtained on Mondays, while the lowest returns were achieved on Fridays. This observation is inconsistent with the most previous studies for the day-of-the-week effect. This stylised fact is reversed after the 9/11 incidents, with the lowest returns occurring on Mondays and the highest returns happening on Fridays. Hence, the patterns of day-of-the-week effect is consistent with those findings from the developed market following the 9/11 incident. The null hypothesis of normally distributed daily returns is rejected by the Jarque-Bera normality test results, implying that in line with

<table>
<thead>
<tr>
<th></th>
<th>Pre-9/11</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>-0.0270</td>
<td>0.2087</td>
<td>0.0204</td>
<td>0.1002</td>
<td>-0.0358</td>
<td>-0.4263</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>1.8858</td>
<td>2.3190</td>
<td>1.6728</td>
<td>1.7595</td>
<td>1.7565</td>
<td>1.8073</td>
</tr>
<tr>
<td><strong>Jarque-Bera</strong></td>
<td>134.7410</td>
<td>18.0657</td>
<td>134.8610</td>
<td>15.4642</td>
<td>1.6434</td>
<td>37.6096</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0004</td>
<td>0.4397</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post-9/11</strong></td>
<td>0.0628</td>
<td>0.0105</td>
<td>0.0520</td>
<td>0.0821</td>
<td>0.0186</td>
<td>0.1506</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>1.6139</td>
<td>1.7854</td>
<td>1.5153</td>
<td>1.4667</td>
<td>1.4672</td>
<td>1.8065</td>
</tr>
<tr>
<td><strong>Jarque-Bera</strong></td>
<td>273.6480</td>
<td>833.5648</td>
<td>322.8560</td>
<td>109.8885</td>
<td>174.7322</td>
<td>767.2843</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

It is worth noting that the terrorist acts might create uncertainty, which might impact the overall economic activity in various industries, within the US and the other countries like India. Therefore, it might indirectly influence the international investors' behavior in managing and designing the investment portfolio.

The probability of the Jarque-Bera test statistic is less than 0.0001, except for Monday (0.0001), Wednesday (0.0004) and Thursday (0.4397) for the pre-9/11 sub-period.

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a majority of the previous findings, these daily returns are not normally distributed, with the exception of Thursday returns for the pre-9/11 sub-period.

Figure 1 shows that the daily returns (especially on Monday and Friday) differ substantially for the pre-9/11 and post-9/11 sub-periods. Hence, it would be more appropriate to analyze the day-of-the-week effects according to pre-9/11 and post-9/11 sub-periods.

Figure 1: Daily Returns According to Pre-9/11 and Post-9/11 Sub-Periods

Empirical Method

The daily seasonality in stock market adjusted returns is analyzed by the following OLS model with dummy variables:

\[ R_t = \alpha_0 + \sum_{i=1}^{4} \alpha_i \delta_i + \alpha_5 R_{t-1} + \epsilon_t \]  \hspace{1cm} ... (2)

where \( R_t \) is the logarithmic return of the market index as compounded in Equation (1); \( \delta_1, \delta_2, \delta_3, \) and \( \delta_4 \) are dummy variables which take on the value 1 if the corresponding day is Tuesday, Wednesday, Thursday and Friday respectively, and 0 otherwise; \( \epsilon_t \) is the error term. Meanwhile, \( \alpha_0, \alpha_1, \ldots, \alpha_4 \) are parameters to be estimated. Among them, \( \alpha_0 \) measures the mean return (in percentage) on Monday; whereas \( \alpha_1, \ldots, \alpha_4 \) represent the difference of average return of the stock index for Tuesday, Wednesday, Thursday and Friday respectively, as compared to Monday's mean return.
In this model, two hypotheses are of interest. First, this model is to examine whether the corresponding return on a specific day-of-the-week is significantly different from zero. For Monday, the usual t-test of individual significance may be applied to the estimator of $\alpha_1$. For other days, it is necessary to perform a Wald test of restriction on the coefficient. In particular, the null hypothesis of insignificant return on day $i$, $H_0: \alpha_0 + \alpha_1 = 0$, may be tested against the alternative of significant return on the day $i$, $H_a: \alpha_0 + \alpha_1 \neq 0$. The rejection of the null hypothesis implies that one may obtain non-zero return on day $i$.

Second, this model is to test if the daily returns are indifferent for all days over the week. The null hypothesis of this test is: $H_0: \alpha_0 = \alpha_1 = \alpha_2 = \alpha_3$ (same average daily return for the week). If the result is significant, then it could be concluded that the market index is characterized by statistically different average daily returns. Therefore, the rejection of the null hypothesis would imply that day-of-the-week effect is indeed present.

A lagged value of the return variable ($R_{t-1}$) is introduced in Equation (2) to avoid serial correlation error terms in the model, which may yield misleading inferences. Besides, Monday dummy variable was excluded from the equation to avoid the dummy variable trap.

While the above models are used to characterize the mean return, there is no reason to pre-suppose that the residual variance of $\epsilon_t$ in Equation (2) will not vary over the sample period. In this respect, GARCH model is able to capture the time-varying variability in the variance of the residuals. This approach has the advantage that the conditional variance can be expressed as a function of past errors. These models assume that the variance of the residual term is not constant through time. Thus, joint estimates, not only in the mean but also in the conditional variance of the day-of-the-week effect, are performed in this study.

It is noteworthy that the GARCH model assumes that upward and downward movements in the market will cause the same magnitude of volatilities, implying symmetrical behavior of market reactions towards positive and negative news. However, it is commonly observed that the negative returns are followed by a higher volatility than the positive returns. Besides, Engle and Ng (1993) also point out that the market reaction to bad and good news tends to be asymmetric in nature. To incorporate the possible asymmetry effect of the stock market behavior, the Exponential GARCH or EGARCH (due to Nelson, 1991) model is employed. In addition, considering the fact that past conditional variance may affect the future variance in the stock markets, the following EGARCH-Mean specification of the conditional volatility is finally utilized in this study:

$$R_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \delta_h + \sum_{i=1}^{q} \alpha_{i+1} R_{t-i} + \alpha_{i+1} \sigma_i^2 + \epsilon_i$$  \hspace{1cm} ...(3)

$$\log \sigma_i^2 = \beta_0 + \sum_{j=1}^{q} \gamma_j \log \sigma_j^2 + \sum_{i=1}^{q} \left( \beta_i \frac{\epsilon_{i-t}}{\sigma_{i-t}} - \sqrt{\frac{2}{\pi}} + \psi_i \frac{\epsilon_{i-t}}{\sigma_{i-t}} \right) + \sum_{i=1}^{q} \alpha_i \delta_h$$  \hspace{1cm} ...(4)

The ARCH-LM and Ljung-Box Q-test results depicted in Table 2 show that the OLS is not efficient and hence strengthen the use of EGARCH method in this study.

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where $\alpha_{k+1}$ measures the reward to risk ratio, and $\xi$ is an error term with zero mean and conditional variance $\sigma^2$. Meanwhile, $p$ is the order of GARCH terms and $q$ is the order of ARCH terms, with the values $p \geq 0$ and $q \geq 0$ (Choudhry, 1995; and Hentschel, 1995). There are several ways to determine the selection of $p$ and $q$, such as Mean Squared Error (MSE), Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). However, SIC is the most suitable to use in determining the appropriate orders of $p$ and $q$. That is because, SIC is consistent and it penalizes most heavily for degrees of freedom, as compared to MSE and AIC. Apart from that, SIC is more consistent than AIC, which also tends to select the models that are too large (Lutkepohl, 1991).

Note that on the left-hand side of Equation (4) is the logarithm of the conditional variance. This implies that the leverage effect is exponential rather than quadratic, and that forecasts of the conditional variance are guaranteed to be non-negative. In this case, the presence of leverage effects can be tested by the hypothesis that $\gamma_i > 0$, whereas the impact is asymmetric if $\gamma_i \neq 0$.

**Empirical Results and Discussions**

Table 2 presents the OLS results for the day-of-the-week effect in this study. The results show that the coefficient of intercept term that represented the benchmark day of Monday is significantly different from zero in BSE during pre-9/11 sub-period, but is insignificant during

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-9/11</th>
<th>Post-9/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant, $\alpha_0$</td>
<td>0.2303 (0.0887)***</td>
<td>0.0029 (0.9726)</td>
</tr>
<tr>
<td>Tuesday, $\alpha_2$</td>
<td>-0.2200 (0.2502)</td>
<td>0.0485 (0.6814)</td>
</tr>
<tr>
<td>Wednesday, $\alpha_3$</td>
<td>-0.1311 (0.1491)</td>
<td>0.0760 (0.5196)</td>
</tr>
<tr>
<td>Thursday, $\alpha_4$</td>
<td>-0.2761 (0.1484)</td>
<td>0.0106 (0.9279)</td>
</tr>
<tr>
<td>Friday, $\alpha_5$</td>
<td>-0.6548 (0.0006)*</td>
<td>0.1465 (0.2146)</td>
</tr>
<tr>
<td>Return (-1), $\alpha_6$</td>
<td>0.0485 (0.1316)</td>
<td>0.0619 (0.0075)*</td>
</tr>
</tbody>
</table>

**Diagnostic Checking**

<table>
<thead>
<tr>
<th>ARCH-LM Statistic (p-value)</th>
<th>Pre-9/11</th>
<th>Post-9/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Lags</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>10 Lags</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>15 Lags</td>
<td>0.0000</td>
<td>0.0000</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Ljung-Box Q Statistic (p-value)</th>
<th>Pre-9/11</th>
<th>Post-9/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Lags</td>
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<tr>
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<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>15 Lags</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
post-9/11 sub-period. The coefficients of the dummy variables for the day of Tuesday, Wednesday, Thursday and Friday in the pre-9/11 sub-period are negative. However, only the negative Friday returns are statistically significant at 1% level, implying that only Friday returns are significantly different from Monday returns. The Wald test result indicates that the null hypothesis of equal returns on all days is rejected at 1% significance level. Thus, day-of-the-week effect is found present in the pre-9/11 sub-period. As for the post-9/11 sub-period, there is no evidence of day-of-the-week effect by the Wald test.

The daily returns that are estimated based on OLS model for both sub-samples are plotted in Figure 2. Another Wald test is applied to examine if these returns are significantly different from zero, and the results are summarized in Table 3. It is evident from Table 3 that the null hypothesis of zero return can be rejected for Monday and Friday in the

![Figure 2: Daily Returns Based on OLS Model](image)

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