

# **Impact of Derivative Trading on Volatility of the Underlying: Evidence from Indian Stock Market**

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## ***Abstract***

The present paper examines the impact of introduction of derivatives trading on the underlying spot market volatility of seventy two scrips using symmetric and asymmetric GARCH methods. To separate the effect of market pervasive factors influencing volatility, return on NSE nifty is included in the mean equation. Further, in order to capture the impact that introduction of derivatives has had on the volatility of the underlying, a dummy variable which takes up value zero pre introduction of derivatives and one post introduction is included while specifying the volatility dynamics. The results indicate the existence of asymmetric response to new information. Further, the results hint at an increase in the efficiency of processing new information. Overall, there is a strong evidence of a reduction of volatility after the introduction of derivatives trading.

**JEL Classification:** G12, G14.

**Keywords:** Asymmetric response, Derivatives, Volatility

## **Section I: Introduction**

The reforms in the financial sector that took place in the Indian economy during the nineties, resulted in the formation of a vibrant secondary market for stocks. Among other things the reforms created institutional structure to facilitate fair trading to each market participant at a low cost. However, despite the reforms the levels of concentration in trading as well as the level of speculative trades were too high. It was in this backdrop that the L.C. Gupta committee recommended the introduction of derivative instruments so that some of the speculative transactions, which currently take place in the spot market, can be attracted towards the derivatives market. Moreover, introduction of derivative instruments would also enable investors to choose the level of portfolio risk that they are comfortable with. Any risk in excess of this level can be hedged away.

In order to have an efficient derivatives market, it is important to have an efficient spot market. An efficient spot market will be characterized by asset prices that reflect information that is available to the different investors. In fact, both these markets complement each other in terms of their respective efficiencies. On commencement of derivatives trading there arrives a set of active information seekers who, in general, improve market efficiency. These information seekers can be of three types (i) hedgers (ii) arbitrageurs or (ii) manipulators. While hedgers and arbitrageurs facilitate the linking of spot market prices with the futures market price, the manipulators may not facilitate this process. In other words, a derivative market without manipulators, introduces a set of information seekers who improve the efficiency of the spot market by incorporating the information, privy to the derivative market participant, in the spot market asset prices. However, in the presence of manipulators, these information seekers play an ambiguous role. And one can not rule out the possibility of manipulators because of the high level of leverage offered by the derivative instrument. Therefore, it can be said that the effect of additional information, generated by derivatives trading, on the spot market asset prices, depends on the purpose for which the derivative instrument is used. In India most derivative traders describe themselves as hedgers and Indian laws generally require derivatives to be used for hedging purpose only (Sarkar, 2006). However, in practice it is very difficult to differentiate a hedger from a speculator. The aim of the present paper is to analyse the impact of additional information generated due to introduction of individual stock derivative instrument on the volatility of returns on the underlying asset in the Indian stock markets.

Most of the studies, that analyse the impact of derivative trading on the Indian stock market, examine the case of introduction of index futures (Shenbagaraman, 2003; Bandivadekar and Ghosh, 2003; Rao, 2007; Sarangi and Patnaik, 2007). Two studies that analyse the impact of introduction of derivative contracts on individual stocks are by Nath (2003) and Vipul (2006). Nath (2003), among other things, measures volatility by specifying it as a standard Generalised AutoRegressive Conditionally Heteroskedastic (GARCH) (1,1) and Integrated GARCH (1,1) process. However, both these models assume symmetry in response of volatility to information. In the event of asymmetry these models would reveal misleading results. Hence, it is imperative that one checks for asymmetric response before arriving at the GARCH model that is suitable to map the volatility dynamics. Another study that analyses the impact of derivative instruments on individual stock is that of Vipul (2006). The said study also overlooks the issue of asymmetric response. Further, the study analyses a very small sample of six scrips. It is felt that both, the

selection of the scrips to be analysed as well as the selection of the scrips to construct the market portfolio suffer from ‘selection bias’ (elaborated in section 2.3).

In the present study, all companies on which derivative trading has commenced till May, 2005 and have been listed at least two years before commencement of derivatives trading are included. Further, in order to map the general changes in the market, the National Stock Exchange (NSE) Nifty index is used. The study first tests for asymmetric response in the period before introduction of derivative instruments, after introduction of derivative instrument and for the full period. If the asset demonstrates asymmetric response in the full period analysis, an asymmetric GARCH model is specified. In this manner, the present study tries to overcome the problem posed by asymmetric response of volatility as well as covers a large enough sample to overcome any sampling bias. Subsequent part of the study is organized as follows: section 2 presents a brief review of studies that examine the impact of introduction of derivatives in the case of commodities, indexes and individual stocks, section 3 elaborates the empirical design of the paper, section 4 describes the data and discusses the results, the conclusion of the paper is presented in section 5.

## **Section 2: Review of related literature**

Several studies have examined the impact of introduction of derivatives trading on the volatility of the underlying asset, the underlying asset being commodities or stocks. Derivative instruments in commodity markets have been in existence for more than a century, much before they were available on financial instruments. Hence, the early studies examining the impact of derivative trading on the underlying asset have analysed the commodity market. In the review presented below, the studies have been broadly classified as: (i) studies on commodities, (ii) studies on equity indexes and (iii) studies on individual stocks.

### **2.1 Studies on Commodities**

Powers (1970) analyses weekly cash prices for pork bellies and live beef. Firstly, the analysis is carried out on an interval of four years before and after introduction of futures and subsequently on an interval of two years. In the paper, Powers analyses the response of only the error component of price variance. In the case of both the two year as well as the four year interval, the study revealed that the variance has reduced after introduction of futures. However, the study suffers from two major limitations: (i) it doesn’t analyse the response of the systematic component of price variance to the introduction of futures trading and (ii) the findings of the study may not be

particularly relevant if the commodity being analysed is perishable or semi storable and is continuously produced.

Cox (1976) analysed weekly nominal prices of onions, potatoes, pork bellies, hogs, cattle and frozen concentrated orange juice. He first tests the effect of futures trading on market information and subsequently to further check this relationship he forms a trading rule based on the said relation and examines if the rule is profitable or not. The analysis revealed an increase in information flow at the time of futures trading. In other words, the market prices provide more accurate signals for resource allocation when there is futures' trading.

Stein (1987), through a theoretical construct proposes a model that purports to introduce a group of speculators into the spot market on introduction of a derivatives trading. The paper discusses speculation in the context of a perfectly storable commodity in which futures trading has commenced. The model focuses on two aspects of speculative behavior: (i) risk sharing because of introduction of new agents, and (ii) information transmission. While on the one hand presence of speculators provides additional agents to share the risk, on the other hand they also bring new information into the market. This new information may or may not be reflected in the prices. In other words, because of their presence, the prices may become more or even less informative. According to the model it is not necessary that imperfectly informed speculators will always lose money to better informed ones. Thus, to evaluate the overall effect of introduction of derivatives one needs to consider the positive effect of risk sharing as well as the effect (positive or negative) of information externality.

## **2.2 Studies on Indexes**

Derivative contracts on indexes, in the US market, were a result of the transformation from delivery based to cash based settlement. Ever since the introduction of derivative contracts on indexes in the early eighties, there have been a number of studies that examined its impact on the spot prices. Most of these studies found that introduction of futures had led to a reduction in spot market volatility or have no discernible impact. These studies have adopted three alternative models to study the said relationship:

### ***Studies that Follow the Vector Auto Regression (VAR) Approach***

Since the direction of causality between derivatives market activity and spot price volatility is not clearly identified, several studies find the VAR characterization of the volatility-activity relationship more meaningful. These studies analyse the relationship between different measures of volatility and a measure of futures and/or option market activity. Two important studies that adopt this approach are Chatrath *et. al.* (1995) and Kyriacou and Sarno (1999). Both the studies consider four alternative measures of volatility. Three measures common to both the studies are (i) Daily Price Range- given by the difference between the daily high and low price, (ii) Adjusted Daily Price Range - constructed by adjusting the price range if the low price at time 't' exceeds the closing price at time 't-1' then  $(P_t^L - P_{t-1}^c)$  is added to the range or if the high price at 't' is less than the closing at 't-1' then  $(P_{t-1}^c - P_t^H)$  is added to the range. These adjustments are aimed at controlling for the patterns of overnight price jumps that will not be otherwise reflected in the measures of intra day price variability. (iii) Inter day measures of change arrived at by looking at the absolute change in closing price between time t and time t-1  $|P_t^c - P_{t-1}^c|$ . The fourth measure of volatility is different in the two studies mentioned above. In Chatrath *et. al.*, the fourth measure is the rate of change in closing prices measured by the difference between the absolute change in closing price between three days  $|P_t^c - P_{t-1}^c| - |P_{t-1}^c - P_{t-2}^c|$ . Kyriacou and Sarno consider the continuously compounded return  $R_t = \log(P_t^c / P_{t-1}^c)$  as the fourth measure of volatility. In addition, they also consider a GARCH (1,1) measure of volatility. Both the studies define the futures market activity (FTA) and options market activity (OTA) as the ratio of the daily closing volume in the respective markets and their respective open interest. This definition of FTA and OTA is intended at avoiding the need to eliminate the transactions occurring at expiration of the contract. Chatrath *et. al.* (1995) studies the impact of option market activity on the different measures of volatility. The VAR model so specified is estimated using two Stage Least Square (2SLS). The results of the study indicate an increase in the intra day and inter day volatility in the spot market is followed by a decline in cash market variability. In summary, the findings support a decrease in spot market volatility on introduction of derivative instrument.

Kyriacou and Sarno (1999) analysed the impact of both futures and option market activity on different measures of volatility. They follow the Structural Equation Modelling (SEM) technique since VAR methodology does not allow for simultaneity. In other words, the VAR model ignores the contemporaneous interaction between derivative market activity and spot price volatility. The

SEM is estimated using 3SLS. Analysis of descriptive statistics suggested that the first and second moments of FTA were considerable larger than the corresponding moments of OTA which suggests that trading activity in future is on average larger and more volatile than trading activity in the options markets. The results of the study suggest that the activities in the option market and futures market affect spot volatility differently. In case of options market, an increase in activity lead to a decrease in spot volatility while in the case of futures market, an increase in activity lead to an increase in the spot market volatility. The study also revealed that the spot market volatility is time variant and follows a GARCH process.

### ***Studies that follow the GARCH Approach***

These studies argue that in a speculative market, the asset return series is interdependent and hence a GARCH model is more appropriate while analysing the impact of introduction of futures on spot price volatility. Two important studies that follow this approach are Antoniou and Holmes (1995) and Bologna and Cavallo (2002). Antoniou and Holmes analyse daily closing values of FTSE-100 stock index for the period November 1980 to October 1991. Firstly, the paper analyses the whole period by incorporating a dummy variable (in the specification of variance dynamics), which takes a value zero pre introduction of derivatives and one post introduction. The results of the analysis suggest an increase in spot volatility due to the onset of futures trading. Subsequently, the paper estimates a standard GARCH (1,1) model for the two sub-periods (*i.e.* pre and post introduction of futures contracts). The results of this analysis suggest an increase in volatility post introduction of futures contract. Analysis of the GARCH coefficients also reveals that post introduction of futures, there is faster incorporation of new information and as a result there is less persistence. Hence, according to the study, an increase in volatility, post introduction of futures is not necessarily a bad phenomenon; it just indicates an increase in the rate of flow of information.

Bologna and Cavallo (2002) studies the impact of introduction of derivatives in Italian stock markets. The paper analyses whether there is a reduction in volatility on introduction of index futures contracts and if there is a reduction, then whether it is because of introduction of futures contracts and not because of any other market pervasive factor. Hence, they also incorporate the DAX index in their mean equation. Unlike Antoniou and Holmes (1995), the results of their study indicate that the spot volatility has reduced post introduction futures. However, the conclusion regarding increase in incorporation of recent news and a reduction in persistence is in congruence with the findings of Antoniou and Holmes.

### ***Studies that follow the GJR specification for asymmetric GARCH effects***

In equity markets, it is commonly observed that bad news tends to have a larger impact on volatility than good news. Black (1976) attributes this effect to the fact that bad news tends to drive down the stock price, thus increasing the leverage of the stock and causing the stock price to be more volatile. Such an asymmetric impact of news on stock price volatility is referred to as 'leverage effect'. The standard GARCH models can't accommodate asymmetric responses of volatility to good/bad news. Variants of GARCH, such as Exponential GARCH (EGARCH) proposed by Nelson (1991), Glosten Jagannathan and Runkle (1993) specification of GARCH (GJR GARCH) and Power GARCH (PGARCH) proposed by Ding *et. al.* (1993), are capable of incorporating asymmetric responses. However, according to Engle and Ng (1993) and Kim and Kon (1994), the GJR specification is better suited to map the asymmetries than the E-GARCH specification. Two important studies that adopt the GJR specification of GARCH model are that of Antoniou *et al* (1998) and Butterworth (2000).

Antoniou *et. al.* (1998) analyses the closing prices on stock market index of six different countries. Following the GJR specification, the paper tests whether futures trading has increased or decreased the level of volatility with the help of a dummy variable that takes value zero pre introduction of futures and one post introduction. Firstly, the model is tested for the whole period. Subsequently, to determine whether existence of futures has led to changes in the asymmetric response of volatility, the said model sans the dummy is estimated for the two sub-periods (pre and post introduction of futures). Finally, in order to assess the extent to which the asymmetric response of volatility in the futures market is different from that in the spot market, the GJR specification of the GARCH model is run on futures market data. The results of the study suggest that although futures trading has had limited impact on the level of stock market volatility, it has had a major impact on the way news impacts volatility. Post introduction of futures trading, the asymmetries in response of volatility have reduced. Overall, the study finds a marked improvement in the way news is transmitted into prices following the onset of futures trading.

Butterworth (2000) analyses the impact of futures trading in FTSE mid 250 index in UK stock markets. The study first estimates a GJR specification of a GARCH model for both the sub - periods (pre and post introduction of futures). On confirming the absence of asymmetric response of volatility, the study adopts the standard GARCH (1,1) model for both sub-periods. The results of the study suggest an increase in the unconditional variance post introduction of futures. The study reasoned this increase to the rise in flow of information following the onset of futures

trading. It was seen that more information is fast reflected in prices and hence the persistence has reduced.

### *Studies in the Indian context*

Ever since the introduction of index futures in the Indian markets, there have been a lot of studies that have analysed the impact of futures trading on the volatility of spot prices. A few important studies are that of Tenmozhi (2002), Nath (2003), Shenbagaraman (2003) and Bandivadekar and Ghosh (2003).

Tenmozhi (2002) analyses the volume of spot market volatility before and after the introduction of stock index futures and also studies the lead-lag relation between the futures and the spot returns. Since, the data analysed is only for two years, the author assumes that heteroskedasticity is not important and hence she measures volatility by computing the standard deviation of daily returns. Further, in order to account for market pervasive factors that influence spot volatility, she uses the nifty junior index. The results of her study indicate a decrease in spot market volatility in the post futures period. The study attributes the fall in spot volatility to the increased trading in cash markets, due to faster dissemination of information. Finally, the study found that futures market tends to lead the spot market by one day and services as the primary market for price discovery.

Nath (2003) studied the behaviour of volatility of twenty stocks and two benchmark indexes in the pre and post derivatives period in India using both static and conditional variance. The conditional variance was modeled following four different methods: (i) GARCH (1,1), (ii) IGARCH with  $\lambda=0.94$ , (iii) One year rolling window of standard deviation and (iv) six month rolling standard deviation. The study revealed that the conditional volatility for most of the stocks and the two benchmark indexes analysed had reduced post introduction of derivatives trading.

Shenbagaraman (2003) and Bandivadekar and Ghosh (2003) adopt the univariate GARCH (1,1) model to examine the impact of introduction of index futures on spot index. In order to incorporate the impact of market pervasive factors, both the studies incorporate a index (nifty junior in case of Shenbagaraman and nifty junior and BSE 200 in the case of Bandivadekar and Ghosh) in their mean equation. The results of the study by Shenbagaraman indicate that there is no significant impact of the introduction of derivatives on spot market volatility. However, she does find a perceptible reduction in persistence. The results of the study by Bandivadekar and Ghosh indicate a decrease in spot volatility on introduction of derivatives. However, while the reduction in the



volatility of NSE nifty was due to introduction of derivatives, the reduction in volatility of BSE Sensex was due to an overall decline in market volatility. They reason this phenomenon to the low turnover in the derivative segment of BSE as compared to its cash segment.

### **2.3 Studies on Individual Stocks**

There are not many studies that analyse the impact of derivatives trading in individual stocks on the volatility of the underlying. However, two such studies are that of Dennis and Sim (1999) and Vipul (2006). Dennis and Sim (1999) investigate changes in volatility of nine stocks on which futures were traded in the Australian stock markets. The volatility is measured using an asymmetric exponential ARCH model. The results of the study indicate that share futures trading has not had any significant effect on the volatility of the underlying share prices for most of the stocks analysed. Even in the case of stocks on which futures trading have had an impact, the results are mixed.

Vipul (2006) analysed the impact of introduction of derivatives trading on six equity shares (selected on the basis of liquidity) and a index (nifty). The sample was arrived at, by first ranking the scrips on which derivative instruments were available on November 15, 2001 and then by again ranking the same scrips on 13 August 2004. Finally, an average of the ranks of these scrips is taken and six scrips with the highest ranking are selected. The study adopts two alternative measures of volatility: (i) the Parkinson's (1980) extreme value measure (ii) the standard GARCH (1,1) measure. In order to proxy the general trend in market volatility a portfolio of ten equity shares, which were not a part of any index and on which derivative instruments were not available, was formed. Two alternative measure of volatility, (i) the extreme value measure and (ii) the GARCH measure of volatility, were adopted. The study reports a reduction in, unconditional volatility and persistence in volatility in the post derivative period. The study reasons this phenomenon to a general stabilization of a post derivative cash market.

To conclude this section, it can be noted that a majority of the studies discussed above conclude that introduction of derivatives trading has led to a reduction in spot market volatility. However, there are very few studies that analyse this relation in the context of individual stocks. Even the two studies that study individual stocks test a very small sample and do not test for asymmetric response. Also the conclusion of both the studies is not congruent.

### Section 3: Empirical Design

In order to investigate the impact of derivatives trading on the underlying spot market volatility, it is necessary to consider volatility both before and after the onset of futures trading. In prior studies, as mentioned earlier, there is a clear disagreement as to whether derivatives have an impact on spot price volatility and subsequently on whether this impact (if any) stabilizes the underlying spot market. However, much of this disagreement emanates from the choice of volatility measure (Board and Sutcliffe, 1991).

Since, the underlying asset being analysed is a stock or an index, the probability of the series being characterized by heteroskedasticity is very high (Mandelbrot, 1963; Fama, 1965, Kamaiah and Amanulla, 1988). Hence, the present study begins by examining the presence of heteroskedasticity in the asset return series. The results indicated presence of heteroskedasticity. Consequently, it is hypothesized that the asset returns series follows a GARCH process. The standard GARCH (p,q) model introduced by Bollerslev (1986) suggests that conditional variance of returns is a linear function of lagged conditional variance and past squared error terms. A model with errors that follow the standard GARCH (1,1) model can be expressed as follows:

$$\left. \begin{aligned} R_t &= c + \varepsilon_t, \text{ where, } \varepsilon_t | \psi_{t-1} \sim N(0, h_t) \\ \text{and } h_t &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} \end{aligned} \right\} \quad (1)$$

where,  $R_t$  is the log returns of the underlying asset,  $\varepsilon_t$  is assumed to be independently and identically distributed (*i.i.d.*) with mean zero,  $h_t$  represents conditional variance in period  $t$ ,  $\alpha_1$  describes the ‘news coefficient’ (impact of one time period old news) and  $\alpha_2$  represents the ‘persistence coefficient’ (impact of news older than one time period). The GARCH coefficients, so generated, can be used to analyse:

- (i) The change in unconditional variance following introduction of derivatives trading: Assuming that the conditional mean (of  $h_t$ ) is constant and equal to zero, and that  $\alpha_1 + \alpha_2 < 1$ , the unconditional variance of the standard GARCH model can be expressed as:

$$h = \frac{\alpha_0}{(1 - \alpha_1 - \alpha_2)} \quad (2)$$

- (ii) The efficiency with which information is impounded into spot prices. In other words, each component of the GARCH (1,1) conditional variance is specified in both the pre as well as post derivatives era.

- (iii) To study the relationship between information and volatility following the onset of derivatives trading, a dummy variable is introduced in the conditional variance equation with the dummy variable  $D$  taking on the value zero pre, and one post introduction of derivatives (Bologna and Cavallo, 2002; Antoniou and Holmes, 1995). Thus, equation (1) becomes:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \gamma D \quad (3)$$

If  $\gamma$ , the coefficient of the dummy variable, is statistically significant, then it can be said that existence of derivative trading has had an impact on spot market volatility. Further, the sign of  $\gamma$  indicates the direction of change in the spot market volatility. If the coefficient is negative, it can be said that the volatility has reduced post introduction of derivatives and *vice versa* if the coefficient is positive.

However, the standard GARCH models assume symmetry in the response of volatility to information. In other words, the models assume that the response of volatility, to ‘bad’ news as well as ‘good’ news, is similar. If the response is asymmetric, then the standard GARCH models will end up mis specifying the relationship and further inferences based on this model may be misleading. However, the standard GARCH model can be easily extended to include asymmetric effects (Glosten, Jagannathan and Runkle, 1993). In the model, the asymmetric response of conditional volatility to information is captured by including, along with the standard GARCH variables, squared values of  $\varepsilon_{t-1}$  when  $\varepsilon_{t-1}$  is negative. In other words, the model allows for asymmetries by augmenting the standard GARCH model with a squared error term following ‘bad’ news. In doing so, it allows the negative return shocks to generate greater volatility than positive return shocks. Hence, equation (1) is extended as follows:

$$\left. \begin{aligned} h_t &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \gamma_1 s_{t-1}^- \varepsilon_{t-1}^2 \\ \text{where, } s_{t-1}^- &= 1 \text{ if } \varepsilon_{t-1} < 0, s_{t-1}^- = 0 \text{ o.w.} \end{aligned} \right\} \quad (4)$$

In the present study, firstly, the existence of asymmetric response is tested individually for each asset, for all three time periods, *i.e.*: (i) pre introduction of derivatives, (ii) post introduction and (iii) full period. Test of asymmetry in the period pre and post introduction of derivatives, reveals the impact that introduction of derivatives trading has had on the response of volatility to new information generated. The test of asymmetric response for the full period helps in identifying the GARCH model to be specified while analyzing the impact of derivatives trading on spot market volatility. For this purpose, a dummy variable is added while specifying the volatility dynamics

with the dummy taking a value 0 before introduction of derivatives trading and one for the period after introduction. For all the scrips that demonstrate asymmetric response, for the full period of analysis, the GJR model along with a dummy is specified as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \gamma_1 s_{t-1}^- \varepsilon_{t-1}^2 + \gamma_2 D \quad (5)$$

In the case of scrips that do not demonstrate asymmetry, the standard GARCH (1,1) along with the dummy variable is specified as:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \gamma D \quad (6)$$

As stated earlier, the significance and sign of the coefficient of the dummy variable helps in understanding the impact that introduction of derivatives has had on the volatility in the spot market. For e.g., a significant and negative coefficient (of the dummy variable) implies that there is a reduction in variance due to introduction of derivatives trading and *vice versa* if the coefficient is significant and positive. However, the reduction in volatility may be simply because of the impact of market pervasive factors. Hence, it is necessary to separate the volatility arising from market wide factors. In the present study the said objective is achieved by incorporating log returns on nifty in the mean equation (depicted in equation 1), *i.e.*:

$$R_t = c + \beta * R_{nifty} + \varepsilon_t, \text{ where, } \varepsilon_t | \psi_{t-1} \sim N(0, h_t) \quad (7)$$

where  $h_t$  follows a ARMA(1,1) process.

## **Section 4: Data and Empirical Results**

### **4.1 Data**

The study attempts to analyse return on all those stocks, on which derivative trading has commenced by May 2005. Only those companies with a minimum of two years of data prior to introduction of derivatives trading on the underlying have been included in the analysis. The study analyses daily closing prices of each stock for the period January 1997 to August 2007. The data would start from 1<sup>st</sup> January 1997 or the day, on which the company is listed on a stock exchange, whichever is later. Based on the above criteria, finally seventy two companies were identified and analysed (List of companies given in Appendix-I). In order to map the effect of market pervasive factors that affect the volatility of stock returns, returns on nifty was used for the time frame for

which the scrip is being analysed. The data on closing stock prices on the scrips as well as nifty was obtained from CMIE Prowess database.

The log return on an asset is calculated as:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (8)$$

Log returns are preferred above percentage returns because in case of the later the return on the negative side can not be below hundred, while on the positive side, there is no limit. As a result the returns will be positively skewed and will violate normality. Hence, in the present study, returns are specified in logarithmic terms (Varma, 1998).

## 4.2 Results

Tables 1.A, 1.B and 1.C report the summary statistic for each scrip for the three time periods analysed. To conserve on space only skewness and kurtosis statistic have been reported. Further the table reports the Jarque-Bera (JB) test statistic which examines the normality of the data. The said test is based on the result that a normally distributed random variable should have a skewness equal to zero and kurtosis equal to three. The test statistic follows a chi-square distribution. Additionally, the table reports the results of Lagrange Multiplier (LM) test examining the presence of autocorrelation in squared residuals (Engle, 1982). The test is conducted up to a lag of 12 and the test statistic follows a chi-square distribution.

The results indicate that, in almost all the scrips analysed and for all the three time periods, the skewness is non-zero and the kurtosis is in excess of three. Further, the JB test indicates that the assumption of normality is violated by log return series of all the scrips analysed. Finally, the LM statistic suggests that in almost all the cases the squared residuals are autocorrelated, thus confirming the presence of ARCH effects in the time series analysed. Consequently, in order to study the impact of information on volatility of stock returns, a Generalised ARCH measure of volatility was deemed fit. However, as discussed earlier, the standard GARCH models assume symmetry in the response of volatility to information, which may not be the case always. Hence, the study first tests for existence of asymmetric response in each of the three time periods by specifying the GJR GARCH (1,1) specification of volatility dynamics. The result of the asymmetric response analysis for all the scrips, for the three time periods is reported in Tables 2.A, 2.B and 2.C. The outcome suggests a mixed response. About a third of the companies analysed displayed asymmetric response in all the three time periods analysed. In the case of another fourth of the companies analysed, asymmetric response (which was absent in the pre

derivatives period) was witnessed in the post derivatives period. Only in the case of one sixth of the companies analysed was it seen that asymmetry in response has been remedied in the post derivative period. Overall, it can be said that introduction of derivatives trading has had a negligible impact in resolving the asymmetric response of volatility to information in the market.

Further, each component, of the GJR GARCH measure of variance, is analysed. Firstly, the change in  $\alpha_1$  and  $\alpha_2$  due to introduction of derivatives trading is analysed. The results revealed that in about two thirds of the companies the relative importance of  $\alpha_1$ , as compared to  $\alpha_2$  in determining the volatility dynamics has increased. In other words, due to introduction of derivatives, the relative impact of the ‘news coefficient’ in determining return volatility has increased as compared to the ‘persistence coefficient’. Secondly, the long run (unconditional) variance is analysed. Assuming that: (a)  $\alpha_1 + \alpha_2 < 1$  and (b) the conditional mean is constant and equal to zero, it can be said that the unconditional variance of the process exists. In the case of scrips which demonstrated asymmetric response, the GJR GARCH model was specified and the unconditional variance was calculated following Andersen *et. al.* (2005) as:

$$\sigma^2 = \frac{\alpha_0}{(1 - \alpha_1 - \alpha_2 - 0.5\gamma)} \quad (9)$$

For scrips that did not demonstrate asymmetry in response, the unconditional variance was calculated following equation (2).

The results, as reported in tables 2.A. and 2.B., indicate that in the case of three fourth of the companies analysed, the unconditional volatility has increased after derivative trading was allowed on these companies. This is consistent with the interpretation that there has been an increase in the quantity of information flowing into the spot market in the period following the onset of derivatives trading.

Finally, the impact of introduction of derivatives on the conditional volatility is analysed. In order to incorporate the effect of market pervasive factors on asset returns, the returns on nifty were incorporated in the mean equation. The results of the analysis as reported in Table 3 indicate that in each case nifty significantly and positively affected scrip returns, which is in conformity with standard asset pricing theories. As mentioned earlier, in order to analyse the overall impact of introduction of derivatives on the conditional volatility of the spot market, a dummy was incorporated while specifying the volatility dynamics. The dummy would take a value zero in the

pre introduction period and one post. The results indicate that in the case of about eighty per cent of the scrips analysed, the coefficient of the dummy variable is significant and negative. Thus, it can be said that introduction of derivatives trading has resulted in reduction in spot market volatility.

### **Section 5: Conclusion**

The present paper examines the impact of introduction of derivative trading on the volatility dynamics of the underlying stock using both symmetric and asymmetric GARCH techniques. In the process, the study first tests for existence of asymmetry and then, for the assets that demonstrated asymmetry, the GJR extension of the standard GARCH model is used. The results of the study do confirm presence of asymmetric response in the case of most of the scrips analysed. Further, it was seen that subsequent to the introduction of derivatives trading, the relative importance of the 'news coefficient' in determining asset return volatility has increased. This result assumes greater importance when seen in light of the fact that post introduction of derivatives, the unconditional volatility has increased, thus indicating an increase in the quantity of information flowing into the spot market. In other words, the 'news coefficient' has increased despite an increase in the overall quantum of information. On the whole, it is seen that introduction of derivative trading has resulted in a reduction in the spot market volatility of the underlying stock.

The findings of the present study conform to the findings of Nath (2003) and Vipul (2006). However, the present study additionally tests for asymmetric effects and also works on a larger sample for a larger time period.

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**Table 1.A: Summary Statistics for the Pre Introduction Period**

Name	Pre Introduction of Derivatives			
	Skewness	Kurtosis	JB	LM
ABB Ltd.	-0.22	6.68	1184.53***	155.19***
Alok Industries Ltd	1.28	40.92	126535.7***	324.92***
Amtek Auto Ltd.	0.51	5.74	747.018***	246.89***
Arvind Mills Ltd.	0.84	6.14	885.64***	56.63***
Ashok Leyland Ltd	0.29	4.42	203.61***	167.58***
Associated Cement Co. Ltd	0.09	4.58	127.93***	85.93***
Aditya Birla Nuvo Ltd.	-6.38	165.50	229.62***	1.4
Aurobindo Pharma Ltd	-1.38	25.85	46183.93***	9.81
Bajaj Auto Ltd	0.19	5.04	217.39***	62.66***
Ballarpur Industries Ltd	0.54	5.65	715.36***	131.40***
Bharat Forge Co. Ltd	0.12	4.74	265.24***	162.02***
Bharat Petroleum Corp	0.60	4.31	86.88***	166.31***
Bongaigaon Refinery Ltd	0.69	7.78	2154.99***	273.70***
Century Textiles Ltd	0.29	4.41	200.04***	143.47***
Cesc Ltd	0.69	5.49	708.31***	64.87***
Chambal Fertilizers Ltd	0.63	16.04	14954.23***	88.9043***
Colgate Palmolive (I) Ltd	0.47	6.43	1092.75***	169.94***
Dabur India Ltd	0.12	5.58	579.93***	172.09***
Escorts India Ltd	0.24	5.52	449.75***	152.04***
Essar Oil Ltd	1.00	11.74	7009.73***	140.52***
Federal Bank Ltd	0.25	6.29	964.07***	350.27***
Glaxosmithkline Pharma Ltd.	0.24	5.72	661.73***	155.59***
Great Eastern Shipping Co. Ltd.	0.39	5.95	80.38***	94.82***
Gujarat Ambuja Cement Ltd	0.12	4.25	80.64***	88.81***
Gujarat Narmada Fert. Co. Ltd.	0.39	6.21	950.28***	159.36***
HDFC Bank Ltd	0.19	27.87	25703.01***	331.1***
Hero Honda Motors Ltd	0.36	5.13	319.65***	107.29***
Hindalco Industries Ltd	0.28	4.84	186.22***	77.45***
Hindustan Lever Ltd	0.33	5.48	330.09***	90.12***
Hindustan Petroleum Corp	0.16	4.29	88.97***	212.77***
IDBI Bank Limited	0.38	8.41	2577.79***	290.19***
IFCI Ltd	1.06	9.14	3693.50***	114.13***
India Cements Ltd	0.16	4.94	339.08***	216.67***
Indian Hotels Co. Ltd	-0.12	6.66	1164.12***	94.27***
Indian Oil Corp. Ltd.	0.37	7.10	1215.43***	273.1***
Indian Petrochemicals Corp. Ltd.	-0.70	12.47	5792.2***	35.70***
Infosys Technologies Ltd	-0.10	4.28	84.84***	173.86***
Ispat Industries Ltd	0.35	10.87	5436.95***	135.52***
ITC Ltd	-0.05	4.60	129.27***	113.58***
Larsen & Toubro Ltd	-0.12	4.39	99.7***	82.36***
LIC Housing Finance Ltd	0.24	6.10	852.64***	228.55***

**Table 1.A: Summary Statistics for the Pre Introduction Period (Contd...)**

Name	Pre Introduction of Derivatives			
	Skewness	Kurtosis	JB	LM
Mahanagar Telephone Nigam Ltd	0.06	4.02	52.82***	70.75***
Maharashtra Seamless Ltd	0.63	8.58	2852.52***	215.81***
Mahindra & Mahindra Ltd	-0.11	4.33	91.38***	100.04***
Mastek Ltd	-0.10	3.50	18.49***	243.28***
Mphasis BFL Limited	0.07	4.96	337.34***	335.30***
MRPL	1.18	9.93	4631.49***	160.93***
Nagarjuna Fertilizers Ltd	1.03	9.01	3532.23***	164.36***
National Aluminium Co. Ltd	0.54	7.42	1310.11***	40.07***
Nicolas Piramal India Ltd	0.19	5.58	585.50***	214.69***
NIIT Ltd	-0.98	5.56	448.70***	256.07***
Oil And Natural Gas Corp.	11.15	280.20	4886862***	0.1931
Orchid Chemicals Ltd	0.39	4.74	316.63***	192.17***
Oriental Bank Of Commerce	-0.73	14.75	5823.2***	222.72***
Punjab Tractors Ltd	0.26	7.19	1550.13***	160.94***
Ranbaxy Labs Ltd	0.10	4.84	172.02***	146.44***
Reliance Capital Ltd	0.00	4.77	272.03***	306.11***
Reliance Energy Ltd	0.17	4.32	93.34***	141.05***
Reliance Industries Ltd	0.25	4.82	179.45***	118.79***
Satyam Computer Services	-0.04	3.60	18.10***	159.97***
Shipping Corp Of India Ltd.	6.39	132.90	1076674***	0.2145
Siemens Ltd	0.04	5.49	5355.48***	181.86***
SRF Ltd	0.40	7.13	1552.58***	227.51***
Tata Chemicals Ltd	-0.02	6.00	7778741***	179.47***
Tata Motor Co. Ltd.	-0.08	3.69	23.69***	79.12***
Tata Iron And Steel Co. Ltd.	0.00	4.58	125.19***	91.00***
Tata Power Ltd	0.22	5.89	430.56***	249.46***
Tata Tea Ltd	0.27	4.28	96.1664***	90.8759***
Titan Industries Ltd	0.54	5.23	535.71***	83.76***
Videocon International Ltd	0.36	4.37	209.15***	220.04***
Videsh Sanchar Nigam Ltd	-1.15	18.81	22077.16***	17.92
Wipro Ltd	5.47	115.50	807907.4***	0.03574

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% levels respectively.

**Notes:** (i) The Kurtosis reported in the table is in excess of three. (ii) The Jarque-Bera test statistic is calculated as:

$$JB = \frac{T}{6} \left( \hat{s}^2 + \frac{(\hat{k} - 3)^2}{4} \right) \sim \chi^2(2),$$

where, T is the total number of observations,  $\hat{s}$  is the sample skewness and  $\hat{k}$  is the sample kurtosis.

(iii) LM is the Lagrange Multiplier test for ARCH effects (Engle, 1982), up to a lag of 12. The test statistic is again distributed as  $\chi^2(12)$ . (iv) Only the p-values are reported.

**Table 1.B: Summary Statistics for the Post Introduction Period**

Name	Post Introduction of Derivatives			
	Skewness	Kurtosis	JB	LM
ABB Ltd.	-0.12	5.849	198.63***	68.97***
Alok Industries Ltd	0.13	5.438	138.91***	53.20***
Amtek Auto Ltd.	0.77	9.636	1093.85***	1093.853***
Arvind Mills Ltd.	-0.22	5.53	268.4***	84.60***
Ashok Leyland Ltd	-0.22	5.449	1503144***	55.02***
Associated Cement Co. Ltd	-0.13	5.353	338.07***	119.81***
Aditya Birla Nuvo Ltd.	0.11	7.877	578.97***	44.09***
Aurobindo Pharma Ltd	0.67	6.543	337.91***	67.14***
Bajaj Auto Ltd	-0.98	11.13	4217.73***	398.67***
Ballarpur Industries Ltd	-0.53	8.642	777.39***	90.31***
Bharat Forge Co. Ltd	0.19	7.656	530.19***	77.77***
Bharat Petroleum Corp	-0.25	9.239	2364.50***	19.97*
Bongaigaon Refinery Ltd	-0.42	9.25	679.28***	123.18***
Century Textiles Ltd	-0.38	6.627	333.79***	108.97***
Cesc Ltd	-0.60	9.244	953.49***	108.91***
Chambal Fertilizers Ltd	-0.52	7.109	423.75***	37.34***
Colgate Palmolive (I) Ltd	1.20	12.15	2174.4***	3.2
Dabur India Ltd	-0.06	7.224	433.68***	61.83***
Escorts India Ltd	0.18	5.309	123.344***	51.18***
Essar Oil Ltd	0.91	8.17	707.78***	86.90***
Federal Bank Ltd	-0.25	7.659	517.92***	90.99***
Glaxosmithkline Pharma Ltd.	-0.05	5.978	215.65***	122.63***
Great Eastern Shipping Co. Ltd.	-4.42	66.13	98698.86***	0.3791
Gujarat Ambuja Cement Ltd	-0.07	5.362	338.48***	76.91***
Gujarat Narmada Fert. Co. Ltd.	0.01	7.531	484.15***	36.83***
HDFC Bank Ltd	0.32	5.192	360.92***	184.49***
Hero Honda Motors Ltd	-0.05	4.41	94.4***	72.92***
Hindalco Industries Ltd	-0.63	7.832	1504.66***	160.34***
Hindustan Lever Ltd	-0.12	7.463	1205.89***	53.50***
Hindustan Petroleum Corp	-0.55	17.75	13207.51***	6.74
IDBI Bank Limited	-0.12	5.802	191.96***	57.72***
IFCI Ltd	0.55	6.836	368.76***	49.43***
India Cements Ltd	0.11	6.01	210.65***	81.71***
Indian Hotels Co. Ltd	-0.35	9.517	1043.85***	208.77***
Indian Oil Corp. Ltd.	-0.24	9.45	1702.68***	201.08***

**Table 1.B: Summary Statistics for the Post Introduction Period (Contd..)**

Name	Post Introduction of Derivatives			
	Skewness	Kurtosis	JB	LM
Indian Petrochemicals Corp. Ltd.	13.85	355	5927647***	0.2107
Infosys Technologies Ltd	-1.51	25.83	32025.85***	58.08***
Ispat Industries Ltd	9.74	175	706311.8***	0.1059
ITC Ltd	0.26	6	560.76***	108.27***
Larsen & Toubro Ltd	0.75	6.18	747.79***	799.37***
LIC Housing Finance Ltd	-0.28	5.91	214.05***	29.97***
Mahanagar Telephone Nigam Ltd	0.10	6.17	607.97***	152.24***
Maharashtra Seamless Ltd	0.03	5.74	177.48***	64.72***
Mahindra & Mahindra Ltd	-0.05	5.22	297.66***	90.1***
Mastek Ltd	-6.19	111.8	569719.9***	0.4801
Mphasis BFL Limited	0.44	7.433	481.29***	91.36***
MRPL			506.61***	105.3***
Nagarjuna Fertilizers Ltd	-0.22	6.2	241.17***	45.23***
National Aluminium Co. Ltd	13.76	352.9	5857320***	0.0275
Nicolas Piramal India Ltd	0.13	6.495	298.44***	93.39***
NIIT Ltd	12.32	297.2	4144892***	0.1803
Oil And Natural Gas Corp.	-0.48	7.696	1092.32***	143.81***
Orchid Chemicals Ltd	-0.79	8.0058	650.15***	124.08***
Oriental Bank Of Commerce	0.27	5.928	613.78***	107.08***
Punjab Tractors Ltd	-0.42	9.253	938.58***	73.54***
Ranbaxy Labs Ltd	0.19	6.179	619.46***	60.45***
Reliance Capital Ltd	0.14	9.828	1134.24***	45.86***
Reliance Energy Ltd	-0.92	28.05	38058.75***	193.36***
Reliance Industries Ltd	-2.06	34.66	61550.56***	8.31
Satyam Computer Services	0.05	4.992	240.09***	167.37***
Shipping Corp Of India Ltd.	-0.12	13.74	5486.39***	160.94***
Siemens Ltd	0.08	7.232	435.65***	74.36***
SRF Ltd	0.33	8.218	639.87***	75.91***
Tata Chemicals Ltd	0.10	6.537	304.84***	76.96***
Tata Motor Co. Ltd.	-0.49	7.745	1416.59***	237.06***
Tata Iron And Steel Co. Ltd.	-0.79	11.54	4551.19***	231.74***
Tata Power Co. Ltd	-0.09	4.377	116.59***	135.29***
Tata Tea Ltd	-0.21	5.094	275.82***	238.28***
Titan Industries Ltd	0.67	8.861	852.79***	14.63
Videocon International Ltd	19.98	446	4574516***	0.0283
Videsh Sanchar Nigam Ltd	-0.03	7.216	431.84***	46.42***
Wipro Ltd	-0.38	16.02	8092.52***	163.28***

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% levels respectively.

**Notes:** See notes to Table 1.A.

**Table 1.C: Summary Statistics for the Full Period**

Name	Full-Period			
	Skewness	Kurtosis	JB	LM
ABB Ltd.	-0.22	6.67	1510.8***	207.35***
Alok Industries Ltd	1.29	44.19	188542.9***	412.72***
Amtek Auto Ltd.	0.55	6.28	1329.84***	302.44***
Arvind Mills Ltd.	0.60	6.23	1310.03***	112.35***
Ashok Leyland Ltd	0.25	4.75	366.26***	237.94***
Associated Cement Co. Ltd	0.02	5.71	810.34***	253.80***
Aditya Birla Nuvo Ltd.	-6.16	171.80	317.30***	2.351
Aurobindo Pharma Ltd	-1.30	77.19	65548.39***	15.99
Bajaj Auto Ltd	-0.06	7.35	2101.29***	277.15***
Ballarpur Industries Ltd	0.48	6.22	1247.84***	199.45***
Bharat Forge Co. Ltd	0.14	5.22	554.54***	238.73***
Bharat Petroleum Corp	-0.05	6.12	1076.38***	202.22***
Bongaigaon Refinery Ltd	0.71	8.85	4012.87***	373.98***
Century Textiles Ltd	0.17	0.48	359.96***	228.91***
Cesc Ltd	0.57	6.00	1138.47***	101.35***
Chambal Fertilizers Ltd	0.43	14.68	15182.1***	109.54***
Colgate Palmolive (I) Ltd	1.20	8.12	3102.5***	93.83***
Dabur India Ltd	-0.06	7.22	433.68***	221.97***
Escorts India Ltd	0.02	5.31	572.26***	195.15***
Essar Oil Ltd	0.89	11.42	8203.4***	192.23***
Federal Bank Ltd	-0.25	7.66	517.92***	90.99***
Glaxosmithkline Pharma Ltd.	-0.05	5.83	904.35***	216.16***
Great Eastern Shipping Co. Ltd.	-0.69	19.51	30400.05***	8.71
Gujarat Ambuja Cement Ltd	0.04	5.00	444.34***	209.63***
Gujarat Narmada Fert. Co. Ltd.	0.34	6.48	1391.28***	192.5***
HDFC Bank Ltd	0.29	10.13	5670.72***	474.33***
Hero Honda Motors Ltd	0.26	5.23	582.26***	193.42***
Hindalco Industries Ltd	-0.10	6.11	1073.03***	191.35***
Hindustan Lever Ltd	16.00	6.43	1315.38***	158.33***
Hindustan Petroleum Corp	-0.14	9.54	4737.94***	78.57***
IDBI Bank Limited	0.29	8.01	2813.21***	343.63***
IFCI Ltd	0.94	8.54	3786.23***	142.29***
India Cements Ltd	0.15	5.14	515.43***	273.84***
Indian Hotels Co. Ltd	-0.17	7.31	2069.70***	269.05***
Indian Oil Corp. Ltd.	0.19	7.84	2604.15***	430.14***
Indian Petrochemicals Corp. Ltd.	7.51	225.30	5495537***	0.5436
Infosys Technologies Ltd	-0.41	9.15	4264.19***	245.15***

**Table 1.C: Summary Statistics for the Full Period (Contd..)**

Name	Full-Period			
	Skewness	Kurtosis	JB	LM
Ispat Industries Ltd	1.44	26.54	62289.4***	30.13***
ITC Ltd	0.01	5.80	869.17***	298.63***
Larsen & Toubro Ltd	0.15	5.31	602.31***	673.68***
LIC Housing Finance Ltd	0.20	6.37	1274.25***	288.54***
Mahanagar Telephone Nigam Ltd	0.07	4.96	427.74***	215.35***
Maharashtra Seamless Ltd	0.54	8.36	3315.53***	264.72***
Mahindra & Mahindra Ltd	-0.15	5.11	503.95***	251.37***
Mastek Ltd	-1.39	22.30	42093.41***	16.36
Mphasis BFL Limited	0.10	5.43	658.19***	443.06***
MRPL	1.09	10.29	6408.38***	221.44***
Nagarjuna Fertilizers Ltd	0.72	8.26	3291.03***	198.17***
National Aluminium Co. Ltd	7.26	193.80	4054595***	0.01312
Nicolas Piramal India Ltd	0.18	5.79	876.07***	259.83***
NIIT Ltd	5.77	153.30	2517162***	0.7892
Oil And Natural Gas Corp.	10.64	324.40	11488891***	0.3751
Orchid Chemicals Ltd	0.23	5.21	565.63***	286.94***
Oriental Bank Of Commerce	-0.22	10.75	6670.45***	423.95***
Punjab Tractors Ltd	0.34	7.45	2241.93***	206.29***
Ranbaxy Labs Ltd	0.14	5.82	890.59***	316.09***
Reliance Capital Ltd	0.03	5.74	829.78***	286.07***
Reliance Energy Ltd	-0.23	12.03	9047.1***	332.96***
Reliance Industries Ltd	-0.52	13.61	12572.62***	59.14***
Satyam Computer Services	0.01	4.72	327.80***	456.01***
Shipping Corp Of India Ltd.	5.83	143.90	2213263***	0.5103
Siemens Ltd	0.04	5.80	866.02***	224.25***
SRF Ltd	0.39	7.35	2157.73***	266.28***
Tata Chemicals Ltd	-0.03	6.40	1281.85***	242.97***
Tata Motor Co. Ltd.	-0.08	4.34	200.69***	258.07***
Tata Iron And Steel Co. Ltd.	-0.11	4.94	420.47***	293.69***
Tata Power Co. Ltd	-0.14	8009.00	2785.29***	488.49***
Tata Tea Ltd	0.23	5.65	801.02***	247.62***
Titan Industries Ltd	0.56	5.78	994.25***	85.86***
Videocon International Ltd	16.98	600.70	39672612	0.215
Videsh Sanchar Nigam Ltd	-0.99	17.59	24019.75***	26.54***
Wipro Ltd	5.52	142.10	2156399***	0.2209

\*\*\*,\*\* and \* indicate significance at 1%,5% and 10% levels respectively.

**Notes:** See notes to Table 1.A.

**Table 2.A: Results of the GJR-GARCH (1,1) Model for the Pre Introduction Period**  
Pre Introduction of Derivatives

	$\alpha_0 * 10^{-4}$	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSR	LBTSSR	Unconditional Variance*10 <sup>-4</sup>
ABB Ltd.	0.89	0.23	0.64	0.01000	34.63***	8.19	7.12
Aditya Birla Nuvo Ltd.	0.17	0.16	0.87	-0.07000	38.4***	2	34.00
Alok Industries Ltd	0.4	0.07	0.89	0.03000	14.63	108.2***	16.00
Amtek Auto Ltd.	0.02	0.09	0.91	0.00200	18.07	19.48*	0.00
Arvind Mills Ltd.	13	0.15	0.78	-0.04100	33.93***	16.86	143.65
Ashok Leyland Ltd	5	0.1	0.85	0.02500	27.62***	7.49	100.00
Associated Cement Co. Ltd	1	0.1	0.78	0.08400	22.59*	14.35	12.82
Aurobindo Pharma Ltd	0.5	0.19	0.77	0.07000	63.79***	2.256	100.00
Bajaj Auto Ltd	0.6	0.09	0.78	0.06000	1081	7.357	6.00
Ballarpur Industries Ltd	0.4	0.12	0.84	0.02000	29.81***	7.95	10.00
Bharat Forge Co. Ltd	0.07	0.05	0.95	-0.02000	20.95*	28.53***	7.00
Bharat Petroleum Corp	0.13	0.07	0.91	0.03100	15.91	44.03***	28.89
Bongaigaon Refinery Ltd	3	0.21	0.69	-0.07000	14.94	8.34	22.22
Century Textiles Ltd	0.8	0.12	0.83	-0.00800	61.27***	6.698	16.00
CESC Ltd	4	0.018	0.52	-0.04000	2005*	5.899	8.66
Chambal Fertilizers Ltd	0.4	0.14	0.85	-0.10000	12.35	3.12	6.67
Colgate Palmolive (I) Ltd	0.05	0.08	0.93	-0.05000	17.46	19.2*	3.33
Dabur India Ltd	0.14	0.09	0.89	-0.02000	37.53***	20.95*	4.67
Escorts India Ltd	0.44	0.11	0.87	-0.02000	48.34***	9.25	14.67
Essar Oil Ltd	1.1	0.12	0.83	-0.02000	18.84*	25.34**	18.33
Federal Bank Ltd	15	0.15	0.75	0.01000	49.83***	19.73*	157.89
Glaxosmithkline Pharma Ltd.	0.4	0.1	0.81	0.33000	20.28*	8.46	-5.33
Grasim Industries Ltd	0.06	0.06	0.94	0.00600	26.26***	20.92*	NA
Great Eastern Shipping Co. Ltd.	0.6	0.11	0.8	0.04000	16.47	6.67	8.57
Gujarat Ambuja Cement Ltd	1	0.1	0.74	0.08000	14.16	11.56	8.33
Gujarat Narmada Fert. Co. Ltd.	0.55	0.11	0.84	-0.00080	25.42**	2.66	11.00
HDFC Bank Ltd	2	0.17	0.3	0.23000	16.26	7.94	4.82
Hero Honda Motors Ltd	1.5	0.14	0.67	0.00000	12.67	11.48	7.89
Hindalco Industries Ltd	1.2	0.19	0.64	-0.04000	23.75**	5.41	7.06
Hindustan Lever Ltd	0.4	0.07	0.82	0.11000	32.9***	15.6	7.27
Hindustan Petroleum Corp	0.2	0.08	0.89	0.02000	24.58**	26.7***	10.00
IDBI Bank Limited	1.2	0.17	0.74	-0.04000	22.48**	10.32	10.91
IFCI Ltd	0.8	0.13	0.84	-0.03000	119.83*	5.46	17.78
India Cements Ltd	7	0.16	0.8	0.00600	25.39**	12.38	175.00
Indian Hotels Co. Ltd	0.54	0.1	0.79	0.02000	25.01**	4.17	4.91
Indian Oil Corporation Ltd.	0.6	0.21	0.73	-0.03000	13.82	12.6	8.00



**Table 2.A: Results of the GJR-GARCH (1,1) Model for the Pre Introduction Period (Contd..)**  
Pre Introduction of Derivatives

	$\alpha_0 * 10^{-4}$	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSR	LBTSSR	Unconditional Variance*10 <sup>-4</sup>
Indian Petrochemicals Corp. Ltd.	1	0.18	0.72	-0.00500	35.96***	14.09	10.00
Infosys Technologies Ltd	1.5	0.18	0.7	0.03000	33.25***	13.43	12.50
Ispat Industries Ltd	0.2	0.05	0.94	0.01000	22.12**	17.54	40.00
ITC Ltd	0.3	0.07	0.89	0.01000	7.148	13.03	7.50
Larsen & Toubro Ltd	0.7	0.09	0.08	0.03000	19.45*	11.36	0.86
LIC Housing Finance Ltd	5	0.14	0.82	-0.04000	36.4***	9.31	83.33
Mahanagar Telephone Nigam Ltd	0.4	0.06	0.89	0.03000	19.19*	10.27	11.43
Maharashtra Seamless Ltd	0.2	0.24	0.8	-0.05000	19.8*	6.26	-13.33
Mahindra & Mahindra Ltd	2	0.14	0.68	0.05000	36.64***	4.35	11.11
Mastek Ltd	3	0.2	0.67	0.04000	64.3***	16.32	23.08
Mphasis BFL Limited	0.5	0.13	0.83	0.02000	55.27***	28.63***	12.50
MRPL	1	0.11	0.79	0.03200	38.61***	7.43	11.90
Nagarjuna Fertilizers Ltd	0.5	0.31	0.74	-0.13000	23.77**	16.82	33.33
National Aluminium Co. Ltd	0.5	0.09	0.9	-0.03000	19.07*	8.18	20.00
Nicolas Piramal India Ltd	0.3	0.12	0.85	-0.02000	24.65**	7.20	10.00
NIIT Ltd	1	0.16	0.73	0.09000	27.16***	11.1	15.38
Oil And Natural Gas Corp.	0.1	0.19	0.91	-0.17000	19.2*	0.143	-6.67
Orchid Chemicals Ltd	1	0.16	0.73	-0.02000	40.3***	8.69	9.09
Oriental Bank Of Commerce	0.3	0.09	0.85	0.04000	27.74***	10.54	7.50
Punjab Tractors Ltd	2	0.32	0.36	0.16000	28.23***	28.22***	8.33
Reliance Capital Ltd	6	0.12	0.82	0.02000	54.61***	14.59	100.00
Reliance Energy Ltd	1	0.16	0.74	-0.03000	17.47	9.61	10.00
Reliance Industries Ltd	0.9	0.12	0.72	0.11000	21.84**	14.16	8.57
Satyam Computer Services	1	0.1	0.8	0.07000	24.51**	10.07	15.38
Shipping Corp Of India Ltd.	1	0.03	0.91	0.03000	4.38	0.17	22.22
Siemens Ltd	0.2	0.12	0.85	0.02000	39.53***	22.18**	10.00
SRF Ltd	0.2	0.09	0.92	-0.05000	9.79	11.87	13.33
Tata Chemicals Ltd	0.4	0.13	0.84	-0.01000	44.34***	4.92	13.33
Tata Iron And Steel Co. Ltd.	0.2	0.12	0.68	0.07000	22.65**	3.83	1.21
Tata Power Co. Ltd	0.7	0.11	0.82	-0.02000	18.36	5.15	10.00
Tata Tea Ltd	1	0.07	0.74	0.12000	31.99***	3.99	7.69
Tata Motor Ltd	0.5	0.06	0.88	0.08000	19.27*	11.27	25.00
Titan Industries Ltd	1	0.11	0.79	-0.00100	23.32*	17.04	10.00

**Table 2.A: Results of the GJR-GARCH (1,1) Model for the Pre Introduction Period (Contd..)**

	Pre Introduction of Derivatives						
	$\alpha_0 * 10^{-4}$	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSR	LBTSSR	Unconditional Variance* $10^{-4}$
Videocon International Ltd	2	0.14	0.69	0.00900	66.06***	3.43	11.76
Videsh Sanchar Nigam Ltd	1	0.09	0.8	0.01500	13.14	0.63	9.09
Wipro Ltd	4	-0.001	0.77	0.11000	30.34***	0.14	22.73

\*\*\*,\*\* and \* indicate significance at 1%,5% and 10% levels respectively.

**Note:** (i) LBTSR and LBTSSR stand for Ljung-Box Test of Standardized Residuals and Squared Standardised Residuals respectively. They test for existence of autocorrelation in Standardized and Squared Standardised Residuals up to 12 lags. Test statistic is distributed as  $\chi^2(12)$  and tests the null hypothesis of absence of autocorrelation. (ii) The unconditional variance is calculated following equation (9), if  $\gamma_1$  is significant or else following equation (2).

**Table 2.B: Results of the GJR-GARCH (1,1) Model for the Post Introduction Period**

Name	Post Introduction of Derivatives						Unconditional Variance*10 <sup>-4</sup>
	$\alpha_0 * 10^{-4}$	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSSR	LBTSSR	
ABB Ltd.	0.79***	0.17***	0.62***	0.08	12.95	5.12	3.76
Aditya Birla Nuvo Ltd.	0.5***	0.03*	0.8***	0.10***	8.513	4.283	4.17
Alok Industries Ltd	0.79***	0.04*	0.78***	0.11**	10.49	6.027	6.32
Amtek Auto Ltd.	2***	0.37***	0.34***	0.05	11.38	32.69***	6.90
Arvind Mills Ltd.	0.7***	0.11***	0.78***	0.05**	16.13	8.845	8.24
Ashok Leyland Ltd	0.8***	0.04**	0.75***	0.14***	16.79	12.89	5.71
Associated Cement Co. Ltd	0.15***	0.11***	0.86***	0.003	20.33*	13.31	5.00
Aurobindo Pharma Ltd	1***	0.15***	0.54***	0.05	8.97	6.979	3.23
Bajaj Auto Ltd	0.16***	0.02	0.77***	0.20***	24.63**	8.435	1.45
Ballarpur Industries Ltd	1***	0.05	0.49***	0.43***	14.67	1.221	4.08
Bharat Forge Co. Ltd	0.4***	-0.01	0.85***	0.16***	12.79	4.05	5.00
Bharat Petroleum Corp	0.6***	0.08***	0.80***	0.05***	17.43	4.079	6.32
Bongaigaon Refinery Ltd	0.8***	0.13***	0.74***	0.2***	137.4***	4.404	26.67
Century Textiles Ltd	0.9***	0.08***	0.74***	0.19***	6.425	7.071	10.59
CESC Ltd	1***	0.11***	0.64***	0.16***	12.4	11.41	5.88
Chambal Fertilizers Ltd	1.4***	-0.03*	0.64***	0.18***	14.47	6.21	4.67
Colgate Palmolive (I) Ltd	0.3*	-0.0004	0.93***	0.04**	7.197	2.301	5.95
Dabur India Ltd	0.24***	0.07***	0.9***	-0.02	23.53	14.72	8.00
Escorts India Ltd	16***	0.11***	0.69***	0.18***	15.56	6.565	145.45
Essar Oil Ltd	1.5***	0.20***	0.38***	0.69	4.977	3.923	3.57
Federal Bank Ltd	2***	0.79*	0.46***	0.24***	30.97***	5.694	-5.41
Glaxosmithkline Pharma Ltd.	0.5***	0.13***	0.67***	0.16**	7.374	9.711	4.17
Grasim Industries Ltd	3***	0.14***	0.79***	0.03	26.55***	9.58	42.86
Great Eastern Shipping Co. Ltd.	2***	-0.06***	0.78***	0.11***	11.31	0.2373	8.89
Gujarat Ambuja Cement Ltd	0.13***	0.06***	0.89***	0.03**	21.29**	7.435	3.71
Gujarat Narmada Fert. Co. Ltd.	1.4***	0.15***	0.62***	0.05	16.45	5.625	6.09
HDFC Bank Ltd	0.4***	0.15***	0.78***	0.05**	18.44	16.51	8.89
Hero Honda Motors Ltd	0.6***	0.11***	0.76***	0.03	14.99	17.07	4.62

**Table 2.B: Results of the GJR-GARCH (1,1) Model for the Post Introduction Period (Contd..)**

Name	Post Introduction of Derivatives						Unconditional Variance*10 <sup>-4</sup>
	$\alpha_0$ *10 <sup>-4</sup>	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSR	LBTSSR	
Hindalco Industries Ltd	0.13***	0.11***	0.88***	-0.029*	18.34	16.56	5.31
Hindustan Lever Ltd	0.6***	0.06***	0.75***	0.069**	13.33	1.205	3.75
Hindustan Petroleum Corp	0.4***	0.07***	0.85***	0.06***	10.66	1.61	8.00
IDBI Bank Limited	2***	0.03	0.60***	0.25***	16.68	6.833	8.16
IFCI Ltd	5.7***	0.19***	0.43***	0.16**	12.22	1.425	19.00
India Cements Ltd	3***	0.09**	0.48***	0.50***	12.94	10.78	16.67
Indian Hotels Co. Ltd	0.285***	0.08***	0.8***	0.13***	5.253	19.02*	5.09
Indian Oil Corporation Ltd.	0.09***	0.05***	0.9***	0.08***	29.86***	15.13	9.00
Indian Petrochemicals Corp. Ltd.	0.1***	0.20***	0.84***	0.02	17.99	0.8532	-2.50
Infosys Technologies Ltd	0.18***	0.06***	0.86***	0.11***	16.78	2.866	7.20
Ispat Industries Ltd	12***	0.75*	0.71	0.12	9.727	0.69	-26.09
ITC Ltd	0.5***	0.08***	0.73***	0.91***	9.792	6.761	-1.89
Larsen & Toubro Ltd	0.4***	0.14***	0.75***	0.02	22.28**	8.56	3.64
LIC Housing Finance Ltd	0.6***	0.08***	0.73***	0.07*	16.16	9.93	3.87
Mahanagar Telephone Nigam Ltd	0.7***	0.14***	0.76***	-0.004	24.24**	12.39	7.00
Maharashtra Seamless Ltd	0.3***	0.01	0.87***	0.104***	16.57	12.84	4.41
Mahindra & Mahindra Ltd	0.3***	0.08***	0.84***	0.06***	27.44***	12.98	6.00
Mastek Ltd	0.3***	0.19***	0.91***	-0.186***	5.69	0.1482	-42.86
Mphasis BFL Limited	1***	0.09**	0.67***	0.260***	3.8	15.05	9.09
MRPL	1***	0.10***	0.65***	0.092**	11.46	8.52	4.88
Nagarjuna Fertilizers Ltd	0.8***	0.14***	0.8***	-0.006	10.03	3.714	13.33
National Aluminium Co. Ltd	7***	-0.0007	0.09*	0.46***	4.07	0.028	10.28
Nicolas Piramal India Ltd	0.7***	-0.04**	0.84***	0.18***	18.08	24.03**	6.36
NIIT Ltd	2***	0.99***	0.41***	-0.58***	7.962	1.06	-18.18
Oil And Natural Gas Corp.	0.1***	0.13***	0.88***	-0.053***	17.26	14.37	3.77
Orchid Chemicals Ltd	1***	0.07**	0.69***	0.17***	13.63	25.1**	6.45
Oriental Bank Of Commerce	0.2***	0.15***	0.86***	-0.06***	20.44*	13.11	10.00

**Table 2(B): Results of the GJR-GARCH (1,1) Model for the Post Introduction Period (Contd..)**

Name	Post Introduction of Derivatives						Unconditional Variance*10 <sup>-4</sup>
	$\alpha_0$ *10 <sup>-4</sup>	$\alpha_1$	$\alpha_2$	$\gamma_1$	LBTSR	LBTSSR	
Reliance Capital Ltd	2***	0.14***	0.52***	0.325***	9.428	10.44	11.11
Reliance Energy Ltd	0.5***	0.11***	0.74***	0.088***	24.01**	15.09	4.72
Reliance Industries Ltd	1***	0.35***	0.34***	-0.06**	3.599	8.969	2.94
Satyam Computer Services	0.3***	0.07***	0.86***	0.07***	10.2	8.886	8.57
Shipping Corp Of India Ltd.	0.4***	0.10***	0.84***	0.006	9.64	8.32	6.67
Siemens Ltd	0.7***	0.17***	0.71***	0.043	12.97	8.302	5.83
SRF Ltd	5***	0.44***	0.25***	0.081	20.44*	4.72	16.13
Tata Chemicals Ltd	0.9***	0.03	0.6***	0.24***	11.13	7.68	3.60
Tata Iron And Steel Co. Ltd.	0.3***	0.07***	0.83***	0.9***	21.86**	10.79	-0.86
Tata Power Co. Ltd	0.4***	0.09***	0.82***	0.030	14.75	20.26*	4.44
Tata Tea Ltd	0.3***	0.10***	0.84***	0.011	12.59	8.585	5.00
Tata Motor Ltd	0.1***	0.07***	0.89***	0.015	14.12	16.47	2.50
Titan Industries Ltd	2***	0.05***	0.65***	0.21***	23.72**	6.34	10.26
Videocon International Ltd	6*	-	0.83***	-0.166***	2.581	0.025	23.44
Videsh Sanchar Nigam Ltd	0.4***	0.08***	0.86***	0.017	15.99	7.85	6.67
Wipro Ltd	0.8***	0.08***	0.66***	0.287***	8.732	5.73	6.87

\*\*\*,\*\* and \* indicate significance at 1%,5% and 10% levels respectively.

**Note:** See notes to Table 2.A

**Table 2.C: Results of the GJR-GARCH (1,1) Model for the Full Period**

Name	Full period				LBTSR	LBTSSR
	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\gamma_1$		
ABB Ltd.	0.83***	0.22***	0.64***	0.026	43.06***	6.086
Aditya Birla Nuvo Ltd.	0.19***	0.13***	0.87***	-0.039***	47.88***	2.336
Alok Industries Ltd	0.26***	0.07***	0.90***	0.026***	14.56	109.2***
Amtek Auto Ltd.	0.02***	0.09***	0.9***	-0.006	15.41	14.52
Arvind Mills Ltd.	0.7***	0.13***	0.81***	-0.004	39.72***	18.19
Ashok Leyland Ltd	0.3***	0.09***	0.87***	0.034**	35.68***	13.01
Associated Cement Co. Ltd	0.15***	0.10***	0.86***	0.04***	29.4***	18.71*
Aurobindo Pharma Ltd	0.5***	0.17***	0.79***	0.055***	64.1***	2.897
Bajaj Auto Ltd	0.04***	0.07***	0.88***	0.08***	20.41*	14.64
Ballarpur Industries Ltd	0.3***	0.11***	0.86***	0.0399***	26.65***	111.79
Bharat Forge Co. Ltd	0.1***	0.06***	0.93***	-0.004	26.12***	26.2***
Bharat Petroleum Corp	0.2***	0.07***	0.88***	0.04***	15.14	18.6*
Bongaigaon Refinery Ltd	0.7***	0.15***	0.84***	-0.023**	18.08	9.13
Century Textiles Ltd	0.8***	0.12***	0.81***	0.02*	47.09***	7.69
CESC Ltd	2***	0.14***	0.68***	0.007	21.79**	3.109
Chambal Fertilizers Ltd	0.3***	0.13***	0.86***	-0.078***	14.19	3.916
Colgate Palmolive (I) Ltd	0.06***	0.07***	0.93***	-0.036***	16.93	8.891
Dabur India Ltd	0.13	0.08	0.91	-0.023**	30.51	22.42**
Escorts India Ltd	0.6***	0.12***	0.83***	-0.0045	43.78***	9.661
Essar Oil Ltd	0.6***	0.10***	0.86***	0.001	13.97	33.17***
Federal Bank Ltd	1***	0.15***	0.696***	0.0637***	56.35***	21.56**
Glaxosmithkline Pharma Ltd.	0.4***	0.1***	0.807***	4.4***	12.3	6.235
Grasim Industries Ltd	0.12***	0.095***	0.88***	0.02**	43.2***	25.2**
Great Eastern Shipping Co. Ltd.	1.3***	0.09***	0.732***	45.5**	16.67	0.4217
Gujarat Ambuja Cement Ltd	0.2***	0.08***	0.874***	0.04***	25.13**	12.54
Gujarat Narmada Fert. Co. Ltd.	0.6***	0.11***	0.8318***	-0.005	20.18*	2.82
HDFC Bank Ltd	0.5***	0.15***	0.7492***	0.08***	21.9**	14.91
Hero Honda Motors Ltd	0.8***	0.13***	0.7612***	0.01	15.39	113.9
Hindalco Industries Ltd	0.3***	0.12***	0.8422***	-0.026**	32.14***	9.854
Hindustan Lever Ltd	0.4***	0.06***	0.812***	0.079***	23.01**	7.768

**Table 2.C: Results of the GJR-GARCH (1,1) Model for the Full Period (Contd..)**

Name	Full period				LBTSR	LBTSSR
	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\gamma_1$		
Hindustan Petroleum Corp. Ltd.	0.28***	0.08***	0.8732***	0.05***	22.15**	3.033
IDBI Bank Limited	1.3***	0.15***	0.7344***	0.004	26.58***	9.61
IFCI Ltd	1.1***	0.13***	0.817***	-0.018	14.97	7.79
India Cements Ltd	0.93***	0.14***	0.7722***	0.04**	25.08**	11.66
Indian Hotels Co. Ltd	0.4***	0.08***	0.809***	0.05***	27.59*	5.5786
Indian Oil Corporation Ltd.	0.3***	0.14***	0.807***	0.020*	37.09***	24.15**
Indian Petrochemicals Corp. Ltd.	0.2***	0.21***	0.835***	-0.024*	42.15***	1.917
Infosys Technologies Ltd	0.3***	0.15***	0.803***	0.057***	31.23***	5.61
Ispat Industries Ltd	3***	0.10***	0.79***	0.017	21.58**	0.2573
ITC Ltd	0.2***	0.07***	0.8768***	0.037***	6.174	9.051
Larsen & Toubro Ltd	0.2***	0.1***	0.864***	0.023**	42.47***	19.26*
LIC Housing Finance Ltd	0.5***	0.13***	0.806***	-0.02*	47.67***	8.96
Mahanagar Telephone Nigam Ltd	0.4***	0.09***	0.857***	0.02**	36.92***	10.69
Maharashtra Seamless Ltd	0.3***	0.17***	0.809***	-0.01	9.934	9.208
Mahindra & Mahindra Ltd	0.2***	0.06***	0.904***	0.04***	61.66***	22.98**
Mastek Ltd	1***	0.15***	0.831***	-0.03**	46.32***	0.4181
Mphasis BFL Limited	0.5***	0.13***	0.811***	0.06***	46.56***	32.17***
MRPL	0.9***	0.1***	0.816***	0.48***	42.74***	9.15
Nagarjuna Fertilizers Ltd	0.5***	0.26***	0.765***	-0.10***	23.99**	18.02
National Aluminium Co. Ltd	5***	0.10***	0.483***	0.02	14.37	0.05
Nicolas Piramal India Ltd	0.4***	0.11***	0.82***	0.20	35.25***	11.31
NIIT Ltd	1***	0.37***	0.637***	-0.07***	25.9**	2.362
Oil And Natural Gas Corp.	0.04***	0.16***	0.919***	-0.12***	22.53**	0.184
Orchid Chemicals Ltd	0.9***	0.14***	0.77***	0.01	48.82***	10.71
Oriental Bank Of Commerce	0.2***	0.14***	0.849***	-0.02**	29.43***	24.3**
Punjab Tractors Ltd	1***	0.29***	0.369***	0.15***	30.14***	15.33
Reliance Capital Ltd	1***	0.14***	0.746***	0.4***	50.51***	5.759
Reliance Energy Ltd	0.4***	0.12***	0.807***	0.029***	24.84**	26.37***
Reliance Industries Ltd	0.9***	0.24***	0.5733***	0.63***	19.71*	12.37

**Table 2.C: Results of the GJR-GARCH (1,1) Model for the Full Period (Contd..)**

Name	Full period				LBTSR	LBTSSR
	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\gamma_1$		
Satyam Computer Services	0.2***	0.09***	0.877***	0.04**	16.77	14.26
Shipping Corp Of India Ltd.	0.1***	0.06***	0.926***	0.03***	4.09	0.338
Siemens Ltd	0.4***	0.14***	0.804***	0.03**	41.27***	19.22*
SRF Ltd	0.9***	0.14***	0.817***	-0.04***	9.55	9.73
Tata Chemicals Ltd	0.3***	0.12***	0.833***	-0.002	37.48***	5.63
Tata Iron And Steel Co. Ltd.	0.4***	0.09***	0.837***	0.04***	28.66***	4.39
Tata Power Co. Ltd	0.2***	0.09***	0.873***	0.02**	28.68***	13.7
Tata Tea Ltd	0.2***	0.07***	0.874***	0.06***	44.45***	5.09
Tata Motor Ltd	0.2***	0.06***	0.897***	0.03***	25.06**	12.47
Titan Industries Ltd	2***	0.10***	0.787***	0.02*	29.08***	14.86
Videocon International Ltd	10***	0.1***	0.269***	0.09**	15.19	0.024
Videsh Sanchar Nigam Ltd	0.9***	0.08***	0.823***	0.03**	16.34	0.6895
Wipro Ltd	3***	0.08***	0.669***	0.10***	28.71***	0.05

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% levels respectively.

**Notes:** See notes to Table 2.A, unconditional variance is calculated only for the period before and after introduction of derivatives since in order to compare if there is a change due to introduction of derivatives. Hence, for the full period analysis the unconditional variance has not been computed.



**Table 3: Estimates of Effect of Derivatives Trading on Spot Market Volatility**

Name	$R_{Nifty}$	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\gamma_1$	$\gamma_2 \times 10^{-4}$	LBTSR	LBTSSR
ABB Ltd.	0.63***	1.3***	0.23***	0.51***		-0.5***	22.01**	4.75
Alok Industries Ltd	0.90***	0.31***	0.07***	0.90***	0.028***	-0.16***	10.89	113***
Amtek Auto Ltd.	0.37***	0.04***	0.11***	0.9***		0.07***	16.39	13.01
Arvind Mills Ltd.	1.07***	0.9***	0.15***	0.78***	-0.033**	-0.4***	30.81***	6.133
Ashok Leyland Ltd	0.95***	0.2***	0.06***	0.92***	-0.005	-0.13***	13.05	14.59
Associated Cement Co. Ltd	0.38***	0.67***	0.09***	0.81***	0.076***	-0.4***	55.64***	10.57
Aditya	0.68***	0.2***	0.12***	0.89***	-0.07***	-0.03***	35.54***	1.60
Aurobindo Pharma Ltd	0.80***	0.5***	0.16***	0.79***	0.039**	0.17***	34.7***	1.572
Bajaj Auto Ltd	1***	0.5***	0.24***	0.67***	-1.13	-0.5***	55.99***	14.28
Ballarpur Industries Ltd	0.90***	1.25***	0.18***	0.68***	0.027**	-0.66***	6.459	5.045
Bharat Forge Co. Ltd	0.81***	0.08***	0.05***	0.94***		-0.03***	10.17	28.41
Bharat Petroleum Corp	0.73***	0.3***	0.11***	0.85***	0.002	-0.06**	16.88	9.75
Bongaigaon Refinery Ltd	0.95***	3***	0.21***	0.65***	-0.083***	-2***	3.732	8.62
Century Textiles Ltd	0.01***	0.8***	0.1***	0.82***	0.001	-0.4***	18.72*	8.15
CESC Ltd	0.88***	2.8***	0.14***	0.62***		-1.6***	13.64	7.41
Chambal Fertilizers Ltd	0.53***	0.322***	0.11***	0.88***	-0.103***	-0.046***	14.73	2.826
Colgate Palmolive (I) Ltd	0.60***	0.2***	0.13***	0.84***	-0.085***	0.15***	18.3	8.17
Dabur India Ltd	0.71***	0.12***	0.07***	0.93***	-0.041***	-0.006	20.16*	14.2
Escorts India Ltd	1.1***	0.3***	0.09***	0.88***	-0.02*	0.046*	28.17***	15.6
Essar Oil Ltd	0.98***	1.18***	0.12***	0.81***		-0.48***	8.42	31.18***
Federal Bank Ltd	1.05***	1.2***	0.15***	0.72***	-0.022	-0.47***	33.43***	23.48**
Glaxosmithkline Pharma Ltd.	0.62***	0.8***	0.16***	0.66***	0.03	-0.3***	12.22	11.51
Grasim Industries Ltd	0.80***	0.09***	0.05***	0.94***	-0.009	-0.05***	16.91	14.91
Great Eastern Shipping Co.	0.83***	0.6***	0.07***	0.85***	-0.020*	0.2***	9.1	0.547
Gujarat Ambuja Cement Ltd	0.36***	0.23***	0.08***	0.86***	0.057***	0.012	38.22***	11.47
Gujarat Narmada Fert. Co.	0.93***	0.2***	0.05***	0.92***		0.05***	16.82	2.88
HDFC Bank	0.81***	0.6***	0.15***	0.74***	-0.005	-0.2***	27.3***	13.94
Hero Honda Motors Ltd	0.34***	2***	0.18***	0.58***		-0.6***	10.82	20.69*
Hindalco Industries Ltd	0.72***	0.5***	0.11***	0.81***	-0.038***	-0.2***	18.65*	5.78
Hindustan Lever Ltd	0.78***	0.2***	0.06***	0.87***	0.027**	-0.04***	17.55	7.52
Hindustan Petroleum Corp	0.78***	0.2***	0.09***	0.86***	0.054***	0.04*	22.35**	3.06
IDBI Bank Limited	0.94***	2***	0.17***	0.65***		-0.3***	16.51	12.65
IFCI Ltd	1.03***	0.98***	0.17***	0.77***		0.4***	14.21	5.31
India Cements Ltd	1.13***	0.98***	0.13***	0.77***	0.03*	-0.25***	11.01	12.45
Indian Hotels Co. Ltd	0.65***	0.5***	0.09***	0.77***	0.056***	-0.2***	21.43**	6.7
Indian Oil Corporation Ltd.	0.6***	0.4***	0.16***	0.79***		-0.09***	22.14**	23.44**
Indian Petrochemicals Corp. Ltd.	1.18***	0.9***	0.14***	0.72***	0.044**	-0.5***	15.16	10.49
Infosys Technologies Ltd	1***	0.5***	0.12***	0.82***	0.032*	-0.3***	36.21***	1.18***
Ispat Industries Ltd	0.84***	0.66***	0.08***	0.89***		0.95***	19.35*	0.503
ITC Ltd	0.85***	0.6***	0.13***	0.77***	-0.029*	-0.3***	12.13	6.09
Larsen & Toubro Ltd	1.08***	0.32***	0.16***	0.8***	-0.039**	-0.098***	13.39	16.07
LIC Housing Finance Ltd	0.75***	0.4***	0.13***	0.84***	-0.07***	-1.5***	35.94***	9.61
Mahanagar Telephone Nigam Ltd	1.05***	0.4***	0.10***	0.84***	-0.026**	-0.064**	24.08**	5.44
Maharashtra Seamless Ltd	0.40***	0.4***	0.14***	0.81***		-0.0129	9.533	7.82
Mahindra & Mahindra Ltd	1.03***	0.6***	0.1***	0.84***	-0.019*	-0.35***	22.46**	14.46

**Table 3: Estimates of Effect of Derivatives Trading on Spot Market Volatility (Contd..)**

Name	$R_{Nifty}$	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\gamma_1$	$\gamma_2 \times 10^{-4}$	LBTSR	LBTSSR
Mastek Ltd	0.43***	1***	0.15***	0.81***	0.006	0.4***	29.42***	0.442
Mphasis BFL Limited	0.88***	0.5***	0.12***	0.83***	0.393**	-0.19***	28.05***	23.68**
MRPL	0.96***	0.9***	0.09***	0.81***	0.062***	-0.4***	20.45*	9.07
Nagarjuna Fertilizers Ltd	0.69***	0.4***	0.17***	0.83***	-0.111***	0.21***	12.44	13.83
National Aluminium Co. Ltd	0.32***	4***	0.11***	0.57***		0.5***	11.51	0.06***
Nicolas Piramal India Ltd	0.62***	0.3***	0.10***	0.83***		0.07**	26.04***	17.23
NIIT Ltd	0.32***	1***	0.38***	0.64***	-0.1***	-0.2**	16.29	3.46
Oil And Natural Gas Corp.	0.23***	0.2***	0.18***	0.91***	-0.149***	-0.2***	16.75	0.15
Orchid Chemicals Ltd	1***	0.77***	0.13***	0.78***		-0.38***	31.42***	12.55
Oriental Bank Of Commerce	0.84***	30***	0.14***	0.8***		0.04*	16.78	11.29
Punjab Tractors Ltd	0.31***	1.5***	0.27***	0.43***	0.126***	-0.3***	19.48*	18.04
Ranbaxy Labs Ltd	0.59***	0.3***	0.10***	0.83***	0.022*	-0.05**	28.52***	10.6
Reliance Capital Ltd	1.37***	0.1***	0.10***	0.85***	0.20**	0.08***	29.33***	10.04
Reliance Energy Ltd	0.58***	1***	0.20***	0.65***	-0.016	-0.18***	16.68	11.06
Reliance Industries Ltd	1.07***	1.1***	0.30***	0.44***	-0.103***	-0.59***	12.25	48.16***
Satyam Computer Services	1.35***	1***	0.10***	0.79***	0.0491***	-0.77***	12.18	14.95
Shipping Corp Of India Ltd.	0.11***	0.9***	0.05***	0.9***	0.023***	-0.7***	3.84	0.300
Siemens Ltd	0.78***	0.4***	0.09***	0.84***	0.006	-0.05**	19.36*	8.31
SRF Ltd	0.87***	0.3***	0.06***	0.92***	-0.0002	-0.003	8.232	22.66**
Tata Chemicals Ltd	0.85***	0.4***	0.1***	0.82***		-0.2***	24.05**	4.19
Tata Motor Co. Ltd.	1.16***	0.17***	0.05***	0.92***	0.003	-0.09***	9.73	11.32
Tata Iron And Steel Co. Ltd.	1.13***	0.5***	0.12***	0.79***	0.013	-0.17***	11.75	8.66
Tata Power Co. Ltd	0.92***	0.3***	0.1***	0.86***	-0.004	-0.14***	22.07**	6.48
Tata Tea Ltd	0.91***	0.44***	0.09***	0.81***	0.075***	-0.23***	25.29**	8.22
Titan Industries Ltd	0.98***	1.4***	0.11***	0.76***	0.019	-0.4***	10.13	15.08
Videocon International Ltd	1.17***	2***	0.14***	0.66***	0.012	4***	14.03	0.045
Videsh Sanchar Nigam Ltd	0.83***	1***	0.1***	0.82***	-0.042***	-0.5***	10.71	0.76
Wipro Ltd	0.54***	5***	0.06***	0.61***	0.194***	-4***	12.37	0.11

\*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% levels respectively.

**Notes:** (i)  $R_{nifty}$  stands for log returns on NSE nifty, (ii)  $\gamma_1$ , if significant, indicates asymmetric response. Again  $\gamma_1$  to be strictly positive to justify the 'leverage story' (Black, 1976). (iii)  $\gamma_2$  is the coefficient of the dummy variable representing the introduction of derivative trading. A negative  $\gamma_2$  indicates a reduction in variance post introduction of derivatives and a positive  $\gamma_2$  indicates vice versa. (iv) LBTSR and LBTSSR stand for Ljung-Box Test of Standardized Residuals and Squared Standardised Residuals respectively. They test for existence of autocorrelation in Standardized and Squared Standardised Residuals up to 12 lags. Test statistic is distributed as  $\chi^2(12)$  and tests the null hypothesis of absence of autocorrelation.

## Appendix I: List of Companies Analysed

ABB Ltd.
Alok Industries Ltd
Amtek Auto Ltd.
Arvind Mills Ltd.
Ashok Leyland Ltd
Associated Cement Co. Ltd
Aditya Birla Nuvo Ltd.
Aurobindo Pharma Ltd
Bajaj Auto Ltd
Ballarpur Industries Ltd
Bharat Forge Co. Ltd
Bharat Petroleum Corp
Bongaigaon Refinery Ltd
Century Textiles Ltd
Cesc Ltd
Chambal Fertilizers Ltd
Colgate Palmolive (I) Ltd
Dabur India Ltd
Escorts India Ltd
Essar Oil Ltd
Federal Bank Ltd
Glaxosmithkline Pharma Ltd.
Great Eastern Shipping Co. Ltd.
Gujarat Ambuja Cement Ltd
Gujarat Narmada Fert. Co. Ltd.
HDFC Bank Ltd
Hero Honda Motors Ltd
Hindalco Industries Ltd
Hindustan Lever Ltd
Hindustan Petroleum Corp
IDBI Bank Limited
IFCI Ltd
India Cements Ltd
Indian Hotels Co. Ltd
Indian Oil Corp. Ltd.

Indian Petrochemicals Corp. Ltd.
Infosys Technologies Ltd
Ispat Industries Ltd
ITC Ltd
Larsen & Toubro Ltd
LIC Housing Finance Ltd
Mahanagar Telephone Nigam Ltd
Maharashtra Seamless Ltd
Mahindra & Mahindra Ltd
Mastek Ltd
Mphasis BFL Limited
MRPL
Nagarjuna Fertilizers Ltd
National Aluminium Co. Ltd
Nicolas Piramal India Ltd
NIIT Ltd
Oil And Natural Gas Corp.
Orchid Chemicals Ltd
Oriental Bank Of Commerce
Punjab Tractors Ltd
Ranbaxy Labs Ltd
Reliance Capital Ltd
Reliance Energy Ltd
Reliance Industries Ltd
Satyam Computer Services
Shipping Corp Of India Ltd.
Siemens Ltd
SRF Ltd
Tata Chemicals Ltd
Tata Motor Co. Ltd.
Tata Iron And Steel Co. Ltd.
Tata Power Ltd
Tata Tea Ltd
Titan Industries Ltd
Videocon International Ltd
Videsh Sanchar Nigam Ltd
Wipro Ltd