Derivative Trading and Structural Changes in Volatility

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Abstract:

It is believed that the derivatives contribute in efficient price discovery of underlying assets and reduce the volatility in their prices. This hypothesis has been tested by many researchers for Indian stock market and most of them conclude that the volatility of stock prices has come down after the introduction of derivative trading in the market. However, use of a dummy variable as additional regressor with GARCH specification of conditional volatility is not capable to isolate the effect of derivative trading from the impact of other market reforms on the volatility of stock prices. In this paper we identify the dates of structural breaks in volatility of twenty-one stocks using CUSUM estimator and compare these dates with the dates of introduction of derivative trading in respective stocks. We do not find any conclusive evidence suggesting that the introduction of derivative trading has caused a reduction in the volatility of the prices of underlying stocks.

Key Words: Structural Changes, Volatility, CUSUM, Derivative Trading

JEL Classification: C22, G12

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1. Introduction

As the name indicates, derivatives are the imitative financial products, which derive their value from some other assets called 'underlying'. These are believed to be the effective tools of risk-management. Basically derivatives are the tools of risk-transferring, which are used to transfer the risk from a more risk-averse investor to a less risk-averse investor. Therefore, they help in more efficient allocation of risk and more efficient pricing of products in financial and commodity markets. The basic purpose of introducing derivative products in the market was to provide the investors some effective measures to hedge their risk-exposure in different markets. However, apart from being used as hedging tools, these products are also used by risk-taking investors for availing arbitrage and speculative opportunities. Such uses of derivative products are believed to be helpful in building of a strong relationship between the cash and derivative market segments leading to more efficient price-discovery in both the markets. It is also believed that introduction of derivative products increase liquidity in the market. Derivative market segment is dominated by informed institutional investors and therefore, this market segment is expected to be more efficient in price discovery. Many researchers have proposed the hypothesis that derivative markets lead the price movements in cash segment.

Apart from these benefits, certain threats are also associated with derivative trading. This market segment provides good speculative opportunities and excessive speculative trading increases the volatility of the market. There are conflicting claims about the impact of derivative trading on the market volatility. Some researchers argue that derivative trading reduce volatility through better price-discovery. On the other hand, other studies claim that volatility increases after the introduction of derivative trading due to increased speculative activities. Low trading cost and leveraged trading are major attractions for speculators in derivative markets. Recent episode of sub-prime crisis is a good example of how indiscriminate use of derivatives (debt securitisation in this case) can lead to hyper volatility in the market. Since in Indian stock market derivate trading was introduced recently, it provides us a good opportunity to test these hypotheses.

The Security and Exchange Board of India (SEBI) permitted the trading on index futures on May 25, 2000. The trading of BSE Sensex futures commenced at Bombay Stock Exchange (BSE) on June 9, 2000 and on June 12, 2000 trading of Nifty-futures commenced at National Stock Exchange (NSE). In the June 2001 index options and in July 2001 stock options were introduced. Futures on individual stocks were introduced in November 2001. In fact, stock-futures were introduced in India well before their introduction in the USA and many other developed markets. The volume of trading in derivative segment, particularly in stock-futures, took momentum quit rapidly. At NSE trading volume of derivatives has exceeded the volume of cash segment.

This paper studies the impact of derivatives introduction and its impact on the volatility of the underlying securities in India. The study is based on a sample of daily returns of twenty-one stocks on which the derivative products are available for the trading in the market. Although a number of published research studies have already addressed this issue; the present study reinvestigates the issue using a different methodology. Most of the studies examining the impact of derivative trading use some form of GARCH model with dummy variable regressors to study the behaviour of volatility before and after the introduction of derivative trading. This methodology is based on the implicit assumption that whatever changes are observed during the period after the introduction of the derivative trading, are caused by the derivative trading only. But this assumption may be wrong and it may possible that the changes in volatility observed by the GARCH model are due to other reform measures (such as introduction of rolling settlement system, circuit breakers, changes in governance of bourses etc.) and changes in market microstructure. Therefore, in this study we do not assume *priori* that the shift in volatility is due to introduction of derivative trading. First we locate the structural breaks in the volatility of stock prices and then examine the possibility that the breaks cold occur as a result of the introduction of derivative trading. The technique of cumulative-sum-of-squares (CUSUM), incorporating certain recent improvements, has been used for identifying the structural breaks.

2. Review of Literature:

The impact of derivative trading on the volatility of prices of underlying assets is not well understood. There is wide disagreement among researchers at both the conceptual and the empirical front. Danthine (1978) argues that the introduction of futures trading improves market depth and reduces volatility because the cost of responding to mispricing by informed traders is reduced. Antonio and Holms (1995) also suggest that the introduction of derivatives reduces volatility in cash market since speculations are expected to migrate to derivative market. On the other hand, Ross (1989) suggests that derivative trading increases the volatility in the cash market. He argues that derivative trading improve the overall price efficiency of equity market through noise reduction. However, the non-arbitrage condition between spot and derivatives market segments implies that the variance of the price change will be equal to the information flow. The implication of this is that the volatility of asset price increases as the rate of information flow increases. Thus, if futures increase the flow of information, then in absence of arbitrage opportunity, the volatility of spot price must increase.

Similarly, the empirical studies on this issue also come with conflicting conclusions. Some studies (e. g., Stein, 1987; Harris, 1989; Kamara *et al*., 1992; Jagadeesh and Subramanyam, 1993; Narasimhan and Subrahmanyam, 1993; Peat and McCrrory, 1997) show that the volatility of the prices of underlying assets increases after the introduction of derivative trading. This is understood to be the result of speculative activities in derivative market segment; however, as Harris (1989) comments, it is difficult to attribute the observed increase in the volatility solely to derivative trading. Edwards (1988); Herbst and Maberly (1992); Antoniou and Holmes (1995) find that the introduction of the index futures resulted in increased level of volatility in the short run, but no significant impact is found in the long run. On the other hand, many other studies across the countries and asset markets show that the volatility comes down after introduction of derivative trading (for example Basal *et al.*, 1989 and Conrad, 1989 in US; Robinson, 1993; Aitken *et al.*, 1994 in Australia; Kumar *et al.*, 1995 in Japan). Gulen and Mayhew (2000) examine the impact of introduction of futures trading in twenty five countries and obtain mixed results. They found that the volatility in majority of the markets has decreased but it has also increased in some countries including US and

Japan. Lamoureux and Pannikath (1994); Freund *et al.* (1994) and Bollen (1998) find that the direction of the volatility is not consistent over time. Ma and Rao (1988) find that option trading does not have a uniform impact on volatility of underlying stocks. Spyrou (2005) and Alexakis (2007) find that futures trading at Athens Stock Exchange have assisted on incorporation of information into spot prices more quickly but it has not a deterministic impact on the volatility of underlying spot market.

Coming home, Thenmozhi (2002), in her study on the relationship between CNX Nifty futures and the CNX Nifty index finds that derivative trading has reduced the volatility in the cash segment. Gupta (2002) concludes in his study that the overall volatility of the stock market has declined after the introduction of the index futures. Bandivadekar and Ghosh (2003) conclude that while the 'futures effect' plays a definite role in the reduction of volatility in the case of S&P CNX Nifty, in the case of BSE Sensex, where derivative turnover is considerably low, the effect is rather ambiguous. In a study examining the impact of derivative trading at individual stock level, Nath (2003) observes that the volatility has come down in the post-derivative trading period for most of the stocks. Raju and Karande (2003) also find that the introduction of futures has reduced volatility in the cash market. Many other studies (including Nagraj and Kiran, 2004; Thenmozhi and Sony, 2004; Vipul, 2006; Saktival, 2007, for example) also reach at similar conclusions.

However on the other hand, Shenbagaraman (2003) finds no evidence of any link between trading activity variables on the futures market and spot market volatility. However, he observes that the structure of volatility has changed in post-future period. Samanta and Samanta (2007) also reach at similar conclusion. They find mixed results at the level of individual stocks. Afsal and Mallikarjunappa (2007) find that the derivative trading has no impact on the spot market.

Methodologically, almost all the studies referred here are based on the similar approach. They model the volatility as a GARCH (1, 1) process and include a dummy variable which take the value of 1 for the period after the introduction of derivative trading, and 0 otherwise. A negative coefficient of this dummy variable signifies a reduction in volatility during the post-derivative period. But as we have discussed earlier, a reduced level of market volatility during the recent time period does not imply that the volatility has come down as a result of derivative trading. Many other factors may also be responsible for reduction in market volatility during recent time period. Therefore, in this study we try to identify the structural break, if any, in the volatility of stock prices in proximity of introduction of derivative trading which can logically be attributed as a result of the derivative trading.

3. Research Methodology:

For the purpose of the study of introduction of derivatives and its impact on the volatility of underlying stock returns, we have taken daily returns of twenty-one different companies selected randomly form the fifty companies included presently in S&P CNX Nifty index. The daily stock returns adjusted for dividends, bonus issues and splits, have been collected from PROWESS database of the Centre for Monitoring Indian Economy (CMIE). The Sample Period of the study covers about 12 years beginning from January, 1995 to October, 2007. The possible structural breaks in the volatility of all the individual stocks are detected using a CUSUM-based estimator on the residuals of the AR (1)-GARCH (1, 1) models of returns. The detailed methodology of estimating structural breaks in volatility has been discussed in the following paragraphs.

3.1.Modelling Volatility with Structural Break

It is empirically well-established stylised fact that volatility of stock prices exhibit clustering behaviour. Large price changes tend to be followed by large price changes of either sign; while, small changes are followed by small changes. The standard models of time-varying conditional volatility, such as ARCH and GARCH, often encounter very high level of persistence which may cause the problem of unit-root in the volatility function (French, Schwert and Stambaugh, 1987; Chou, 1988; Schwert and Seguin, 1990; Bollerslev, Chou and Kroner; 1992). Initially, the observed high persistence in volatility was understood to be caused by long-memory in volatility process. Several extensions of GARCH model were designed to take into account this long memory; more popular among them are integrated GARCH or IGARCH model of Bollerslev and Engle (1986), Fractionally Integrated GARCH, or FIGARCH model of Baillie, Bollerslev and Mikkelsen (1996) and Component GARCH model of Engle and Lee (1999).

However, as Diebold (1986) points out, if there is a structural change in the volatility process, the observed high level of persistence may be spurious. Generally an integrated process of order-one and a process with structural break can not be distinguished with the help of statistical procedures (Perron, 1990). It is empirically demonstrated by Lamoureux and Lastrapes (1990) that volatility processes are subject to structural changes and GARCH model produces substantially lower estimates of persistence parameters when such changes are accounted for. It has been confirmed by several recent studies on long-memory in volatility process that if structural breaks are present in the volatility process then the estimate of long-memory turns spurious (for example Granger and Hyung, 1999; Mikosch and Starica, 2000, Diedold and Inoue, 2001).

There are two different approaches used to incorporate structural-shifts in the specification of volatility. In the first approach the volatility is assumed to transit among a predetermined number of volatility-states or regimes - (i.e. high-, moderate- and low-volatility regime) with a specified probability distribution. Mostly, the first-order Markov-switching regime probabilities (as suggested by Hamilton, 1988) are used for this purpose. One model of volatility, known as switching-ARCH or SWARCH, is proposed by Hamilton and Susmel (1994), which combines together the ARCH specification of Engle (1982) and Markov-switching-regime specification of Hamilton (1988). Some attempts have also been made during recent years for combining together the Markov-switching regime specification and GARCH model, (for example, Gray, 1996; Dueker, 1997; Hass, Mittnik and Paolella, 2004; Bauer, 2006). But there are some empirical limitations with these models such as - the numbers of regimes are to be pre-specified and mostly this remains a subjective judgement. In an estimated model these regimes remain hidden and only their probability is known.

The second approach explicitly estimates the structural changes in volatility. In this approach two steps are involved in volatility modelling - in the first step the structural-changes are identified and in the second step an extended GARCH model of volatility is estimated which includes dummy variables representing periods with different volatility levels as identified in the first-stage. Two different types of the tests - the least-square-type tests and the cumulative-sum-of-squares (CUSUM)-type tests are more popularly used for identifying change-points in volatility dynamics.

CUSUM-type tests are basically designed to locate a single structural-break in the series (see Brown, Durbin and Evans, 1975). However, Inclan and Tiao (1994) suggest an iterative procedure based on CUSUM statistics for detecting multiple breaks in volatility, which is known as the iterated cumulative-sum-of-squares (ICSS) algorithm. In one of the widely-known study based on ICSS-algorithm, Aggarwal, Inclan and Leal (1999) analyse the volatility of stock prices in emerging markets and report that the volatility in these markets is subject to frequent structural changes. However, studies based on Monte Carlo experiments show that ICSS-test for structural break suffers from size distortions (Andreou and Ghysels, 2002; Pooter and Dijk, 2004).The simplistic and unrealistic assumptions about volatility dynamics is the most serious weakness of this test. With more realistic assumptions some improved CUSUM-type tests have been suggested more recently in the literature to detect structural break in volatility (see for example; Kim, Cho and Lee, 2000; Kokoszka and Leipus, 2000; Lee and Park, 2001; Sanso, Arago and Carrion, 2004). An overview of different versions of CUSUM-type tests can be summarized as follows:

3.2.CUSUM-Type Tests for Change in Volatility

3.2.1. Testing for a Single Structural Break-

Let y_t (t=1……..T) is a mean-adjusted time series in which T being the available sample size. The null-hypothesis of the test is that the unconditional variance of y_t is constant, that is H0: $\sigma_t^2 = \sigma^2$ for all t=1………T; and the alternative hypothesis is - there is a single structural break in the volatility, that is-

$$H_a: \quad \sigma_t^2 = \begin{cases} \sigma_1^2 & for \quad t = 1........................k^* \\ \sigma_2^2 & for \quad t = k^* + 1................T. \end{cases} \qquad ……….. (1)$$

Where the k^* is an unknown change point.

The cumulative-sum-of-squares process, C_k for this series is defined as:

$$C_k = \sum_{t=1}^{k} y_t^2 \qquad k = 1......T \qquad ……… (2)$$

and the mean-adjusted and normalized CUSUM process (D_κ) is than defined as;

$$D_k = \frac{1}{\sqrt{T}} \sum_{t=1}^{k} y_t^2 - \frac{k}{T\sqrt{T}} \sum_{t=1}^{T} y_t^2 \qquad \text{……… (3)}$$

The terminal values of this process are always zero, that is, $D_1 = D_T = 0$.

If the series y_t contains no change in variance than the D_k statistics oscillates around zero and if plotted against 'k' will look like a horizontal line. However, if the series contains the change in variance, than it will plot as a drift from zero either in positive or in negative direction. Theoretically, the absolute value of D_k will reach at its maximum value at the change point k^* (i.e. $k=k^*$), after which it will return towards zero. The null-hypothesis of constant variance is rejected if the maximum absolute value of D_k, $\max_{1 \le k \le T} |D_k|$, is larger than some predetermined critical value. Under mild regulatory conditions the D_k statistics weakly converse to a Brownian bridge, such that;

$$U_k = \frac{1}{\Theta} |D_k| \Rightarrow \sup_{0 \le r \le 1} |B(r)| \qquad \text{……. (4)}$$

Where, Θ^2 is the long-run variance of the squired series (i.e. y^2_t), such that

$$\Theta^2 = \sum_{i=-\infty}^{\infty} \rho_i \qquad \text{…….. (5)}$$

Where, ρ_i is i^{th} order autocovariance of y^2_t.

Various CUSUM-type tests proposed in the literature, differ in their assumptions about the distribution properties of time-series y_t,, which determine the long-run variance, Θ^2. It is assumed by Inclan and Tiao (1994) that y_t is a sequence of independent and identically distributed (*iid*) normal random variable. Therefore, all the autocovariances of y^2_t are zero and its long-run variance, Θ^2 is equal to its sample variance, i. e. $E[\{y_t^2 - E(y_t^2)\}^2]$, which, due to normality assumption, further reduces to '$\sigma^2\sqrt{2}$', where σ^2 is the sample variance of y_t. Putting these values in (3) and (4), and after some simple algebraic manipulations, we get the following Inclan and Tiao (IT) estimator of change point in volatility:

$$U_k(IT) = \sqrt{\frac{T}{2}} \max_{1 \le k \le T} \left| \frac{C_k}{C_T} - \frac{k}{T} \right| \qquad \text{……… (6)}$$

In view of the well documented stylised fact that return variances show conditional heteroskedasticity, the assumption of normality and *iid* of y_t is far from being realistic. Monte Carlo simulation based studies show that Inclan and Tiao estimator suffers from size distortion and ICSS algorithm based on it tends to overstate the number of structural breaks in variance under the presence of conditional heteroskedasticity (Bacmann and Dubois, 2002; Sanso; Arago and Carrion, 2004).

Recently, many modified CUSUM-type estimators of change point in variance have been suggested in the literature, which are based on different sets of assumptions about distributional properties of y_t. Lee and Park (2001) assume that y_t follows an infinitive-order moving average process while Kokoszka and Leipus (2000) assumes that it follows an infinitive-order ARCH process. Kim, Cho and Lee (2000) proposed a test based on the assumption that y_t follows a GARCH (1, 1) process. Models also differ in respect to the approaches adopted for computation of long-run variance (Θ). One possibility is to use a parametric estimation of variance based on specific assumptions regarding y_t^2 and its autocorrelations, ρ_i (as suggested by Kim, Cho and Lee, 2000). An alternative and more robust approach is to use nonparametric or data based estimators as advocates by Kokoszka and Leipus (2000). Andreou and Ghysels (2002), for example, use autoregression heteroskedasticity and autocorrelation consistent (ARHAC) estimator of den Haan and Levin (1997); on the other hand, Sanso, Arago and Carrion (2004) and Pooter and Dijk (2004) use Bartlett kernel estimator for this purpose.

One more pragmatic approach to construct a CUSUM-type estimator of change-point in variance is to filter the series first in order to remove the conditional heteroskedasticity. Bacmann and Dubois (2002) and Lee, Tokutsu and Maekawa (2003) suggest to use CUSUM statistics on standardized residuals from GARCH (1, 1) model. Pooter and Dijk (2004) examine this suggestion with extensive Monte Carlo simulation experiments and find that it performs better in comparison to other alternative models. One obvious benefit of using filtered series is that it is likely to follow *iid*. If we further assume that it is normally distributed, we may use Inclan and Tiao estimator on this filtered series. Even, if we relax the assumption of normal distribution, the long-run variance of the squired series is likely to be equal to its estimated sample variance in view of the *iid* property of the series. Keeping in view these benefits, this study uses filtered series for computation of CUSUM statistics. We use AR (1) GARCH (1, 1) model for this purpose.

3.2.2. The Asymptotic and Finite Sample Critical Values:

Under mild regulatory conditions the CUSUM statistics weakly converse to a Brownian bridge and under the null-hypothesis of no-structural break follow a Kolmogorov-Smirnov type asymptotic distribution. The 90%, 95% and 99% percentile (two-tailed test) critical values of this distribution are respectively; 1.22, 1.36 and 1.63. However, as pointed out by Pooter and Dijk (2004) and Sanso, Argo and Carrion (2004) among others, the use of these asymptotic critical values may distort the performance of the test particularly when we use it iteratively with the sub-samples of different sizes to find out multiple breaks. These researchers have attempted to fit response surface with extensive Monte Carlo simulation experiments to obtain the finite sample critical values of different CUSUM-type tests. In this study we use the response surface estimated by Sanso, Argo and Carrion (2002). For an Inclan and Tiao-type test (assuming a normally distributed *iid* series), they estimated the following response-surface for 5% quartile (α=0.05):

$$q_T^{\alpha=0..5} = 1.359167 - 0.737020T^{-0.5} - 0.06915556T^{-1} \quad \text{……….} \quad (7)$$

where 'T' is the sample size.

If the series is assumed to be *iid*, but not normally distributed, its estimated response-surface for 5% quartile is:

$$q_T^{\alpha=0..5} = 1.363934 - 0.942936T^{-0.5} + 0.500405T^{-1} \quad \text{…………} \quad (8)$$

3.2.3. Testing for Multiple Structural Breaks:

The CUSUM-type tests are basically designed to test a single-structural break. However, as suggested by Inclan and Tiao (1994) in their ICSS algorithm, these tests can be applied in a sequential manner to identify multiple structural breaks in volatility. First the entire sample is tested for the presence of a single break in the volatility using CUSUM statistics. If a significant break is present, the sample is split into two sub-samples using the date of structural-break as the split-point. Next, each sub-sample is examined for presence of structural breaks using the CUSUM test (while implementing CUSUM-test on residuals from GARCH model, we estimate the GARCH model afresh for each sub-sample). If such break is found in any sub- sample, it is further split into two segments. This procedure is continued until no more structural breaks are detected in any of the sub-sample.

3.2.4. The Minimum Limit for Sub-Sample:

In this study we have imposed a minimum limit for a sub-sample while deducting the multiple breaks. This limit is decided to be 500 observations. If after breaking a sample period into sub-samples the size of a sub-sample goes below the minimum limit, no further attempt is made to detect a structural break in that sub-sample.

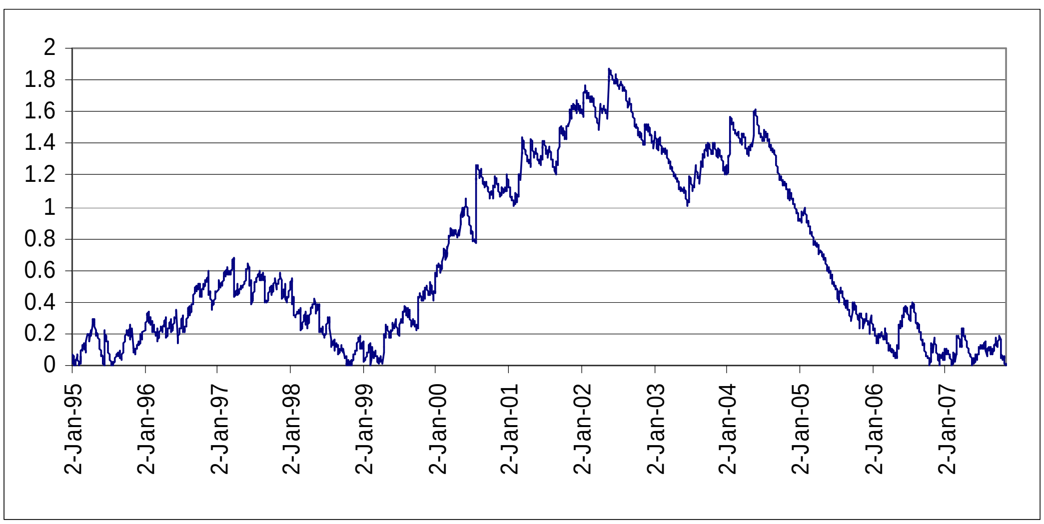
3.2.5. An Example:

We try to explain the methodology used in this study with the help of an example of a stock (M&M) included in the study.

First, taking the entire sample period of daily returns (From January 1, 1995 to October 31, 2007, total 3170 observations) an AR (1)-GARCH (1, 1) model is estimated and centralised standard residual from this model are obtained. Using these residuals, the D_k statistic is calculated using equation (3) and U_k statistic is obtained using equation (4) assuming that the long-run variance and sample variance of the squared standardised residuals are equal (i.e. these residuals follow *iid* process). Figure: 1 show the time series plot of U_k statistics.

Figure: 1

M&M: U_k Statistics for the Entire Sample



The highest value of U_k statistics reaches on May 24, 2002 and this value is higher than its critical value (which 1.347 based on equation: 8). Therefore, this date has been taken as the date of first structural break for M&M. To detect further structural breaks in the volatility of M&M stock, the entire sample period is divided into two sub-samples using date of break as splitting point. - First sub-sample from January 1, 1995 to May 24, 2002 and second, from May 25, 2002 to October 31, 2007. The AR (1)-GARCH (1, 1) model is estimated afresh and then U_k statistics is estimated separately for each of the sub-samples. The results are displayed in Figure: 2 from first sub-sample and in Figure: 3 for the second sub-sample.

Figure: 2

M&M: U_k Statistics for the period of January 1, 1995 to May 24, 2002

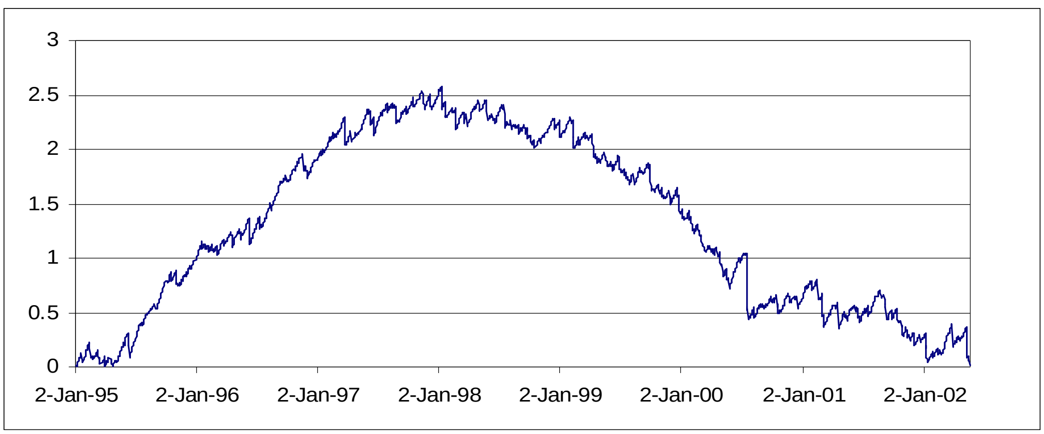
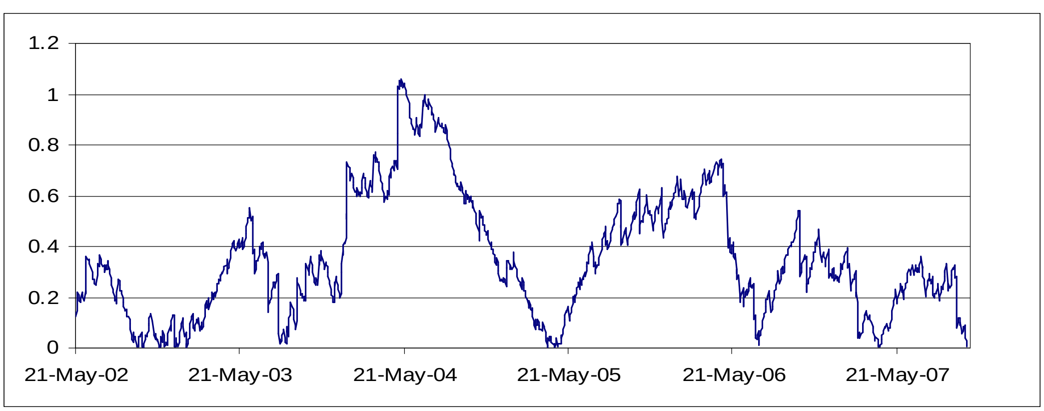


Figure: 3

M&M: U_k Statistics for the period of May 25, 2002 to October 31, 2007



No further structural break is found in second sub-sample; but in first sub-sample one more break is detected on January 14, 1998 when the U_k statistics shows the highest values for this sub-sample which is also higher than its critical value obtained using equation (8). Now we further divide the first sub-sample into two more sub-samples – third sub-sample from January 1, 1995 to January 14, 1998 and forth sub-sample from January 15, 1998 to May 24, 2002.

Now, AR (1)-GARCH (1, 1) models are estimated and U_k statistic is computed with their residuals for third and forth sub-samples respectively. This statistic does not exceed its critical values in both the sub-samples. Therefore, no further structural break is detected in volatility.

Thus, we have detected two structural breaks in the volatility dynamics of M&M – first on January 14, 1998 and second on May 24, 2002. Using these breaks we may identify three volatility periods for this company as follows:

i. From January 1, 1995 to January 14, 1998
ii. From January 15, 1998 to May 24, 2002
iii. From May 25, 2002 to October 31, 2007.

Figure: 4

M&M: U_k Statistics for the period of January 01, 1995 to January14, 1998

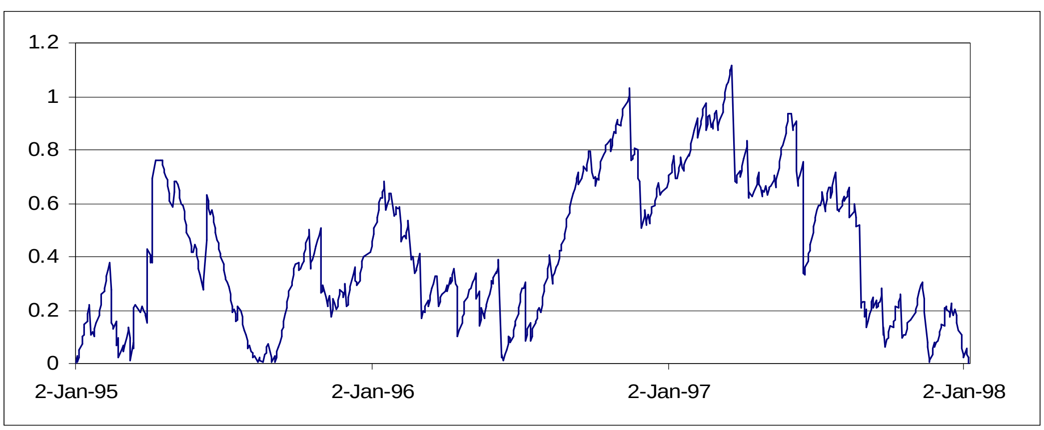
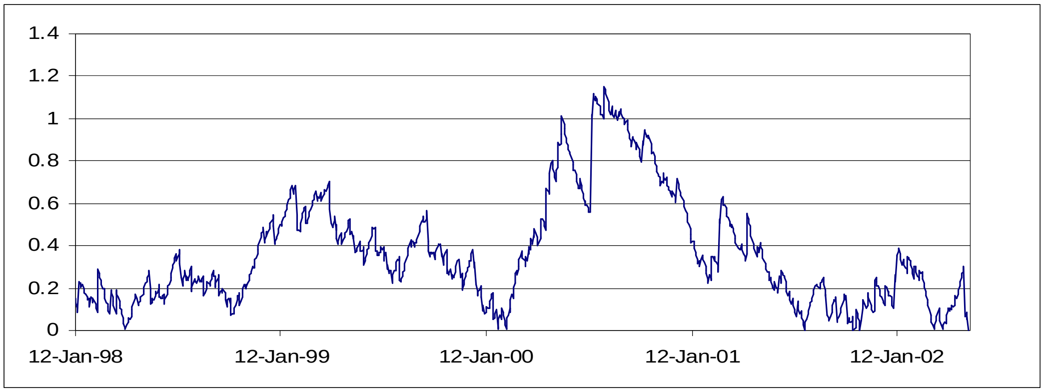


Figure: 5

M&M: U_k Statistics for the period of January 15, 1998 to May 24, 2002



3.3.Estimating Volatility in Different Sub-Periods:

After detecting the possible structural breaks, the volatility parameters are estimated for different sub-periods using the dates of possible breaks as splitting points using AR(1) GARCH(1,1) model. The volatility persistence and unconditional volatility for different sub-period are calculated with the help of these estimated parameters as follows:

Persistence = $\alpha+\beta$ ……….. (9)

Unconditional volatility = $\omega/(1-\alpha-\beta)$ ……….. (10)

The results are presented in the Annexure.

3.4. Associating the Volatility Breaks with Derivative Trading:

Having estimated the date of structural breaks, we attempt to match these dates with the dates of introduction of derivative trading on respective stocks. Derivative trading on individual stocks started at NSE on July 2, 2001 with introduction of individual stock options. However, stock options could not gain popularity. Trading on stock futures stared on November 9, 2001, which soon became very popular. Therefore, for the stocks on which derivative trading was initially introduced, November 9, 2007 has been as the effective date of introduction of derivative trading. For other stock the date of inclusion in derivative trading is assumed to be the date on which the first price quotation of the derivative trading is available in the website of NSE.

The date of introduction of derivative trading is compared with the dates of structural breaks in the volatility of the underlying stock. If there is a break within the period between three months before and six month after the introduction of the derivative trading, it has been attributed as possibly caused by derivative trading. The change in volatility persistence, unconditional volatility and rate of adjustment in volatility to new information (measured by α) after this break date is observed and reported in Table: 1.

Table: 1
Impact of Derivatives Trading on Volatility of Underlying Stock

Name of the Company	Impact on the Volatility			
	structural break caused by derivative trading	Direction of impact		
		Persistence	α	Unconditional Volatility
ACC	Yes	Increased	Decreased	Decreased
Ambuja	No			
Bajaj Auto	Yes	Decreased	Increased	Decreased
BHEL	Yes	Increased	Increased	Decreased
BPCL	Yes	Decreased	Increased	Decreased
Cipla	Yes	Decreased	Increased	Decreased
Dr. Reddy	No			
Glaxo	No			
Grasim	Yes	Increased	Decreased	Increased
HPCL	No			
HUL	Yes	Increased	Decreased	Decreased
ITC	Yes	Decreased	Increased	Decreased
L&T	Yes	Increased	Decreased	Increased
M&M	No			
MTNL	No			
Reliance Energy	Yes	Increased	Decreased	Increased
RIL	Yes	Decreased	Increased	Decreased
SAIL	No			
SBIN	Yes	Decreased	Increased	Increased
Tata Power	Yes	Increased	Increased	Decreased
Tata Moters	No			
Total	Yes= 13 No= 8	Increased= 7 Decreased=6	Increased= 8 Decreased=5	Increased= 4 Decreased= 9

4. Results and Discussion:

The stock-options on ACC stock were introduced on July 02, 2001 but the trading of stock-futures started on November 9, 2001, which has been used as the effective date of introduction of derivative trading on this stock. A volatility break on this stock is observed on March 5, 2002, which is within six months' period from the date of introduction of stock futures on ACC. Data presented in Panel: 1 of the Annexure show that during the period following this break the volatility persistence has increased, while the unconditional volatility and the rate of adjustment to news (α) have decreased.

In Case of Ambuja Cement, no volatility break is detected around the date of introduction of derivative trading.

A structural break is found in volatility of Bajaj Auto on August 13, 2001, which is within the stipulated time period in proximity of the introduction of derivative trading on this stock. The results presented in Panel: 3 of the Annexure show that the rate of adjustment in volatility has increased while the volatility persistence and the measure of unconditional volatility have decreased during the period following this break. However, these changes in the volatility dynamics are not of permanent nature as another break in volatility takes place after a period of about four years and the situation inverts. The similar phenomenon is observed in other stocks also.

The trading of stock-futures started in BHEL stock on November 9, 2001 and we detect a structural break in volatility of returns on this stock on March 07, 2002. The result shows that the unconditional volatility has decreased but its persistence as well as the rate of adjustment towards new information has increased after this structural break.

In BPCL a structural break in volatility is observed on the April 19, 2001. During the period subsequent to this break the volatility persistence and unconditional volatility come down but the rate of adjustment increases (Panel: 5). Similar results are obtained for Cipla (Panel: 6). However, no structural break is fond in proximity of the introduction of derivatives trading on Dr. Reddy's Lab (Pane: 7), Glexo (Panel: 8) and HPCL (Panel: 10).

Panel: 9 presents the results of the analysis of volatility breaks in Grasim. The trading of futures started on this stock on November 9, 2001 and a structural break is detected in volatility of the stock price on December 31, 2001. The results show that the rate of adjustment towards new information has decreased and unconditional volatility and the total persistence have increased after the introduction of derivative trading. These results are just opposite of the observations that we had made in case of BPCL and Bajaj Auto.

In case of HUL (previously, HLL), we observe that a structural break in volatility takes place on October, 2001 (Panel: 11). During the period subsequent to this break the persistence of the volatility increases; while, the adjustment coefficient and unconditional volatility decrease. On the other hand we observe just opposite impact of derivative trading on the volatility of L&T stock (Panel: 12), where the persistence of the volatility decreases; while, the adjustment coefficient and unconditional volatility increases during the period subsequent to the introduction of derivative trading.

The results of analysis of the volatility breaks in ITC stock are also similar to the results of BPCL and Bajaj Auto. We observe an increased value of adjustment coefficient, α, and reduction in the volatility persistence and the unconditional volatility of this stock for the period subsequent to introduction of derivative trading (Panel: 12). On the other hand, the stocks of L&T and Reliance Energy show just opposite results (Panel: 13 and 16). The stocks of M&M (Panel: 14) and SAIL (Panel: 18) do not show any structural break in proximity of the date of introduction of derivative trading. The stocks of MTNL (Panel: 15) and Tata Motors (Table: 20) do not show any structural break in volatility at all during the period covered in this study. Stock of RIL, alike to ITC, shows a decreased level of volatility persistence and unconditional volatility but an increased level of adjustment coefficient after the introduction of derivative trading (Panel: 17). In case of State Bank of India (SBI) the adjustment coefficient of the volatility and unconditional volatility increase and persistence of volatility decreases after the introduction of the derivative trading (Panel: 19); while in case of Tata Power (Panel: 21) the unconditional volatility decreases and the volatility persistence as well as the speed of adjustment of volatility to new information increases.

The results obtained in this study show a mixed picture. Out of the 21 stocks, in eight stocks no structural break was found within the stipulated time period. Out of remaining thirteen stocks, which show structural break during the period in proximity of introduction of derivative trading, the unconditional volatility has decreased in nine stocks while in four stocks it has increased. The volatility persistence has increased in seven stocks and decreased in six stocks. The rate of adjustment of volatility to new information has increased in eight stocks, while it has decreased in five stocks. Therefore, no generalisation can be made about the impact of derivative trading on volatility.

5. Conclusion:

In this paper we have made an attempt to identify the structural breaks in the volatility dynamics of twenty-one stocks using the cumulative-sum-of-squares (CUSUM) procedure. These dates are compared with the date of introduction of derivative trading in respective stocks to examine if any structural break is induced by the derivative trading. If a break is observed in proximity of introduction of derivative trading, the nature of changes in volatility persistence, rate of adjustment in volatility to news and unconditional volatility have been analysed. We do not observe any consistent pattern in the reaction of volatility dynamics towards introduction of derivative trading. Therefore, it can be concluded on the basis of the results of this study that the introduction of derivative trading has no definite implication for the volatility of underlying stocks.

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Annexure

1. Volatility Breaks in ACC

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 17-10-1996	2.6722	0.0798	0.7895	0.8692	20.4342
18-10-1996 to 05-03-2002	5.1401	0.1271	0.7897	0.9168	61.8024
06-03-2002 to 18-05-2004	2.1123	0.0779	0.8602	0.9381	34.1131
19-05-2004 to 27-02-2006	0.8276	0.0801	0.8768	0.9569	19.2074
28-02-2006 to 31-10-2007	3.0037	0.2937	0.5482	0.8419	18.9966

2. Volatility Breaks in Ambuja Cement

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 20-04-2005					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 08-01-1998	1.3858	0.1022	0.8510	0.9621	36.5634
09-01-1998 to 07-05-2001	6.4163	0.1493	0.6133	0.7626	27.0273
08-05-2001 to 31-10-2007	1.4357	0.0964	0.8558	0.9522	30.0299

3. Volatility Breaks in Bajaj Auto

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 01-10-1996	0.7331	0.1097	0.8375	0.9472	13.8962
02-10-1996 to13-08-2001	3.2286	0.1169	0.7752	0.8921	29.9107
14-08-2001 to 18-05-2004	2.6000	0.1957	0.4679	0.6636	7.7286
19-05-2004 to13-02-2006	1.7387	0.0471	0.8566	0.9037	18.0476
14-02-2006 to 31-10-2007	3.0684	0.1653	0.5588	0.7241	11.1223

4. Volatility Breaks in BHEL

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading: 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 28-05-1998	3.5799	0.2556	0.5843	0.8399	22.3659
29-05-1998 to 07-03-2002	9.1327	0.1149	0.6721	0.7871	42.8864
08-03-2002 to 31-10-2007	2.0388	0.1575	0.7414	0.8989	20.1737

5. Volatility Breaks in BPCL

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading: 02-07-2001					
Period	ω	α	β	Total Persistence (α+β)	Unconditional Volatility: ω/(1-α-β)
02-01-1995 to 02-04-1998	3.2272	0.1593	0.4942	0.6535	9.3142
03-04-1998 to 19-04-2001	7.0561	0.1146	0.7911	0.9057	74.8180
20-04-2001 to 02-12-2004	5.0257	0.2000	0.5346	0.7346	18.9364
03-12-2004 to 31-10-2007	2.5205	0.0902	0.7976	0.8878	22.4667

6. Volatility Breaks in Cipla

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading: 02-07-2001					
Period	ω	α	β	Total Persistence (α+β)	Unconditional Volatility: ω/(1-α-β)
02-01-1995 to 27-02-1996	5.1531	0.2368	0.50063	0.7375	19.6272
28-02-1996 to 18-12-1998	3.2377	0.2148	0.51033	0.7251	11.7773
19-12-1998 to 22-10-2001	3.7717	0.0726	0.89078	0.9634	103.0241
23-10-2001 to 25-04-2003	1.5358	0.1024	0.50407	0.6065	3.9029
26-04-2003 to 31-10-2007	3.0240	0.1547	0.55661	0.7113	10.4736

7. Volatility Breaks in Dr. Reddy

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading: 02-07-2001					
Period	ω	α	β	Total Persistence (α+β)	Unconditional Volatility: ω/(1-α-β)
02-01-1995 to 17-03-1998	2.1294	0.2210	0.6338	0.8548	14.6646
18-03-1998 to 21-06-2000	6.5563	0.1287	0.7772	0.9059	69.6517
22-06-2000 to 31-05-2004	5.1207	0.2005	0.0682	0.2687	7.0019
01-06-2004 to 31-10-2007	0.8829	0.0318	0.9574	0.9892	81.4470

8. Volatility Breaks in Glaxo

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading: : 01-07-2005					
Period	ω	α	β	Total Persistence (α+β)	Unconditional Volatility: ω/(1-α-β)
02-01-1995 to 11-11-1997	2.8904	0.1777	0.1367	0.3143	4.2155
12-11-1997 to 17-12-1999	6.0813	0.2566	0.1054	0.3621	9.5326
17-12-1999 to 05-06-2000	12.0360	0.1773	0.2942	0.4715	22.7718
06-06-2000 to 21-05-2002	3.6969	0.2771	0.3878	0.6649	11.0314
22-05-2002 to 31-10-2007	1.5725	0.1276	0.7649	0.8925	14.6324

9. Volatility Breaks in Grasim

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 03-02-1998	2.0851	0.1144	0.3234	0.4378	3.7087
04-02-1998 to 26-05-2000	6.4494	0.0864	0.8591	0.9455	118.2294
27-05-2000 to 31-12-2001	5.9509	0.3074	0.2615	0.5690	13.8062
01-01-2002 to 31-10-2007	1.1593	0.1685	0.7733	0.9419	19.9402

10. Volatility Breaks in HPCL

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 10-05-1995	6.1886	0.0111	0.8245	0.8356	37.6436
11-05-1995 to 29-05-1998	1.8622	0.1950	0.4607	0.6557	5.4090
30-05-1998 to12-01-2001	9.4250	0.3387	0.1072	0.4459	17.0096
13-01-2001 to 06-08-2002	1.9543	0.0891	0.8883	0.9774	86.5139
07-08-2002 to 31-10-2007	2.3208	0.1089	0.8484	0.9573	54.3013

11. Volatility Breaks in HUL

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 25-04-1997	0.9545	0.1520	0.6730	0.8250	5.4526
26-04-1997 to 10-10-2001	2.1280	0.1027	0.8372	0.9399	35.3897
11-10-2001 to 02-07-2003	0.9774	0.0991	0.8447	0.9437	17.3662
03-07-2003 to 31-10-2007	2.6968	0.1359	0.6235	0.7594	11.2087

12. Volatility Breaks in ITC

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 02-11-2001	3.4298	0.0689	0.8795	0.9484	66.4181
03-11-2001 to 02-09-2005	1.6997	0.1810	0.6055	0.7865	7.9617
03-09-2005 to 31-10-2007	2.2541	0.0878	0.8126	0.9003	22.6129

13. Volatility Breaks in L&T

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 30-04-1998	2.4064	0.1320	0.7277	0.8597	17.1545
01-05-1998 to 25-07-2000	7.3246	0.0824	0.8334	0.9159	87.0525
26-07-2000 to 09-11-2001	5.9836	0.1232	0.6126	0.7358	22.6480
10-11-2001 to 23-05-2003	0.7583	0.0186	0.9670	0.9856	52.6592
24-05-2003 to 31-10-2007	1.8871	0.1601	0.7634	0.9235	24.6802

14. Volatility Breaks in M&M

Date of inclusion in Nifty : Before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 14-01-1998	3.5084	0.1041	0.6018	0.7059	11.9287
15-01-1998 to 24-05-2002	6.0605	0.1324	0.7527	0.8851	52.7363
25-05-2002 to 31-10-2007	1.6448	0.0871	0.8717	0.9588	39.9231

15. Volatility Breaks in MTNL

Date of inclusion in Nifty : Before 2002
Date of commencement of derivative trading : 02-07-2001
No structural break in volatility is detected

16. Volatility Breaks in Reliance Energy

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 12-03-2004					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 01-04-1999	4.6660	0.1367	0.6092	0.7459	18.3608
02-04-1999 to 30-05-2001	6.3253	0.1646	0.6722	0.8368	38.7649
31-05-2001 to 06-06-2003	2.0174	0.1347	0.6117	0.7464	7.9547
07-06-2003 to 18-05-2004	5.9502	0.5140	0.0655	0.4485	10.7900
19-05-2004 to 31-10-2007	2.1141	0.2109	0.6901	0.9010	21.3477

17. Volatility Breaks in RIL

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 29-11-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 20-11-2001	3.6022	0.2186	0.6355	0.8541	24.6896
21-11-2001 to 31-10-2007	2.1473	0.2527	0.4844	0.7371	8.1664

18. Volatility Breaks in SAIL

Date of inclusion in Nifty : 04-08-2003					
Date of commencement of derivative trading: 15-09-2006					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 24-11-1997	4.2023	0.2113	0.6260	0.8374	5.0186
25-11-1997 to 05-04-2000	20.2690	0.4358	0.0237	0.4595	35.5005
06-04-2000 to 09-07-2004	3.2230	0.2363	0.7418	0.9780	3.2955
10-07-2004 to 31-10-2007	3.1393	0.1815	0.7367	0.9182	3.4191

19. Volatility Breaks in SBI

Date of inclusion in Nifty: Before 2002					
Date of commencement of derivative trading: 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 28-02-2002	0.8837	0.0667	0.8999	0.9666	26.4251
01-03-2002 to 19-12-2003	2.9875	0.1090	0.8261	0.9351	45.9970
20-12-2003 to 19-05-2004	6.0329	0.3889	0.2063	0.5952	14.9020
20-05-2004 to 31-10-2007	1.8995	0.0495	0.9143	0.9637	52.3412

20. Volatility Breaks in Tata Moters

Date of inclusion in Nifty : before 2002
Date of commencement of derivative trading : 26-12-2003
No structural break in volatility is detected

21. Volatility Breaks in Tata Power

Date of inclusion in Nifty : before 2002					
Date of commencement of derivative trading : 02-07-2001					
Period	**ω**	**α**	**β**	**Total Persistence (α+β)**	**Unconditional Volatility: ω/(1-α-β)**
02-01-1995 to 26-03-1999	4.1018	0.2074	0.1945	0.4019	6.8579
27-03-1999 to 04-03-20002	6.9024	0.1175	0.7107	0.8282	40.1769
05-03-2002 to 31-10-2007	1.4513	0.1572	0.7841	0.9413	24.7026