“Derivative trading and structural breaks in volatility in India: an ICSS approach”

AUTHORS	Guntur Anjana Raju https://orcid.org/0000-0003-4460-6234 Sanjeeta Shirodkar
ARTICLE INFO	Guntur Anjana Raju and Sanjeeta Shirodkar (2020). Derivative trading and structural breaks in volatility in India: an ICSS approach. *Investment Management and Financial Innovations*, *17*(2), 334-352. doi:10.21511/imfi.17(2).2020.26
DOI	http://dx.doi.org/10.21511/imfi.17(2).2020.26
RELEASED ON	Thursday, 02 July 2020
RECEIVED ON	Tuesday, 28 April 2020
ACCEPTED ON	Friday, 19 June 2020
LICENSE	This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Investment Management and Financial Innovations"
ISSN PRINT	1810-4967
ISSN ONLINE	1812-9358
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
45	1	4

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

Guntur Anjana Raju (India), **Sanjeeta Shirodkar** (India)

DERIVATIVE TRADING AND STRUCTURAL BREAKS IN VOLATILITY IN INDIA: AN ICSS APPROACH

Abstract

Researchers argue that ignoring the structural breaks in the time-series variance can cause significant upward biases in the degree of persistence in estimated GARCH models. Against this backdrop, the present study empirically examines the effect of stock futures on the underlying stock's volatility in India by incorporating the structural breaks with the help of ICSS test and AR (1)-GARCH (1, 1) model for 30 most liquid and actively traded underlying stocks and their associated futures contracts. The study period ranges from the 1st January 2000 or the listing date of the particular stock (whichever is prior) till 31st March 2019. The study contributes to the on-going debate regarding the effect of derivatives on the underlying stock market's volatility in two ways. Firstly, by taking into consideration the breaks in the volatility and, secondly, studying the effect of single stock futures will allow us to evaluate company-specific response to futures trading directly. The study offers a mixed outcome for the stocks under consideration. However, there is evidence of a decline in unconditional volatility for the majority of the stocks. The overall findings indicate that trading in stock futures may not have any detrimental effect on the underlying stock's volatility.

Received on: 28th of April, 2020
Accepted on: 19th of June, 2020
Published on: 2nd of July, 2020

Guntur Anjana Raju, Ph.D., Professor of Commerce, Programme Director for Doctor of Philosophy (Commerce), Goa Business School, Goa University, Goa, India.

Sanjeeta Shirodkar, Junior Research Fellow, Goa Business School, Goa University, Goa, India. (Corresponding author)

Keywords stock futures, volatility, AR (1)-GARCH (1, 1), underlying, cash market, futures market

JEL Classification G11, G14

Conflict of interest statement:
Author(s) reported no conflict of interest

INTRODUCTION

Volatility modeling of the financial asset is one of the critical aspects of economic research as it guides the investors on the risk associated with the investment. In India, derivatives trading started in the year 2000 with the launch of futures contracts on the Nifty Index of NSE and Sensex Index of Bombay Stock Exchange (BSE). Options trading began in the Indian markets in June 2001. Ever since then F&O segment is surging in terms of the number of contracts traded, volume, and offering of new products. The F&O segment of the NSE surpassed the equity market from 2019 to 2020, with an average daily turnover of ₹ 2,37,590,973 Cr, as compared to ₹ 6,81,983 Cr in the cash segment (derivatives updates on NSE website, www.nseindia.com, 2019). NSE outperformed the US-based CME group to claim its No.1 ranking in terms of derivatives trading with more than 6 billion contracts traded volume in 2019 (Das & Sahgal, 2020). Derivatives were introduced to offer a hedging mechanism and enhance the liquidity, thereby increasing the market's overall efficiency. The effect of the listing of derivatives on the underlying market's volatility and, thus, its job in increasing or decreasing the underlying markets' volatility has remained an intense subject of empirical and analytical interest.

Questions about the effect of derivatives trading on underlying market volatility have been empirically addressed in two ways. Firstly, by

http://dx.doi.org/10.21511/imfi.17(2).2020.26

analyzing variation in volatility over the pre- and post-derivatives trading phases and, secondly, by measuring the effect of derivatives trading on the behavior of the underlying markets by comparing the performance with proxies. Moreover, most studies examining the effect of derivatives on the underlying market volatility used some type of GARCH model with dummy variable regressors[1]. However, this approach is based on the underlying presumption that any changes detected during the post-derivatives phase are caused by derivatives trading alone.

An increase in volatility could be the outcome of various other events, such as the initiation of a rolling settlement system, circuit breakers, and changes in regulations, and so on. If the structural breaks in variances of the examined time-series are ignored, the degree of persistence of the GARCH model estimate may be significantly biased. Several studies, such as Diebold (1986), Granger and Hyung (1999), Mikosch and Starica (2000), Diebold and Inoue (2001), have stated that neglecting the structural breaks can lead to spurious GARCH model estimation. The primary reasons for such structural breaks could be the changes in the mechanism of exchange rate systems, global financial markets crisis, or the evolution of the stock markets. The shocks produced by these significant economic or political events may cause a deviation in the financial time-series (Andreou & Ghysels, 2002; Wang & Moore, 2009).

1. LITERATURE REVIEW

The derivatives market and its effect on the underlying market volatility are debated again and again with supporting and countering theories.

1.1. Increased volatility due to futures trading

Wats (2017) examined the effect of the derivatives contracts' expiration on the underlying market's volatility using the GARCH family models. He concluded that spot market volatility has increased during the expiry days and week after the listing of the derivatives. Other studies that find a significant increase in the Index return volatility following the listing of futures include Harris (1989), Brorsen (1991), Lee and Ohk (1992), Antoniou and Holmes (1995), Yao (2016).

1.2. Decreased volatility due to futures trading

Others argue that futures' listing potentially reduces the spot market's volatility, thus stabilizing the market. One of the clarifications for the destabilizing theory is that trades in the derivatives market destabilize the underlying market by providing an alternative route for the transmission and reflection of data in the cash market (Cox & Ross, 1976; Ross, 1989). Gulen and Mayhew (2000) studied the effect of index futures on the volatility of the international equity markets by taking the sample of 21 European nations by applying the BEKK model and GJR-GARCH. They found that the volatility of the underlying market has declined for most of the countries under study.

Similarly, Yilgor, Lidvine, and Mebounou (2016), Chiraz (2016), Bhaumik, Karanasos, and Kartsaklas (2016) used different GARCH family models such as Markow-Switching GARCH, ARFI GARCH, EGARCH, and TGARCH. They found the evidence indicating the decline in the underlying market volatility after listing the derivatives trading. Several studies like Pilar and Rafael (2002), Bandivadekar and Ghosh (2003), Thenmozhi (2002), Raju and Karande (2003), Sarangi and Patnaik (2007) have reported a significant decline in the underlying market volatility in India.

1.3. Mixed evidence/no impact of futures trading

Using the GARCH (1, 1) model, Rahman (2001) investigated the effect of trading in index futures on the volatility of Dow Jones Industrial Average (DJIA) component stocks and observed no variation in conditional volatility. Mallikajunappa and Afzal (2008), Thenmozhi (2002), Kavussanos, Visvikis, and Alexakis (2008) argued that improvement in the volatility cycle was not due to the listing

1 See Chan (1991), Reyes (1996), Pericli and Koutmos (1997), Mckenzie, Brailsford, and Faff (2001), Tse (1999), Rahman (2001), Gulen and Mayhew (2000), Bandivadekar and Ghosh (2003), Pok and Poshakwale (2006), and Ryoo and Smith (2006).

of derivatives, but due to many other factors, such as the improved distribution of information and greater transparency.

Due to the increase in the speed of information flow, the stock prices have become more sensitive to the recent innovation in the post-derivative period. Bohl, Salm, and Wilfling (2009), C. Lee, Stevenson, and M. Lee (2014) employed Markow-Switching GARCH, which endogenously identified the distinct volatility regimes, to analyze the effect of derivatives on the volatility and found no influence on the spot market. Mallikajunappa and Afzal (2008), Sarangi and Patnaik (2007) applied the GARCH model with dummy variables and did not find any significant effect of derivatives on the underlying market volatility.

Moreover, the literature is inconclusive about whether the listing of derivatives leads to an increase or decrease in the underlying market's volatility. The vast majority of the studies, which are found in the arena of derivative segments, are concentrated on the effect of index futures on the underlying market. A limited number of studies have been undertaken in the area of single stock futures. Indian studies based on stock futures focus on conceptual clarity or cover only a short period. Research focusing on the index analysis does not consider the stock-specific characteristics, which could also play a significant role in the formation of the volatility.

The present study empirically examines the effect of stock futures on India's underlying stock's volatility by incorporating structural breaks. The study contributes to the on-going debate regarding the effect of derivatives on the underlying stock market's volatility in two ways. Firstly, by reinvestigating the issue by applying a distinct analytical technique, which is based on the methodology used by Aggarwal, Inclan, and Leal (1999), Andreou and Ghysels (2002), Malik and Hassan (2004), Kang, Jung, Park, and Yoon (2007). The study attempts to model the underlying stock's volatility with stock futures by considering the breaks in the volatility. It aims at identifying the structural breaks, if any, in the stock prices by applying the ICSS test of Inclan and Tiao (1994). Secondly, studying the effect of single stock futures will allow us to directly evaluate company-specific responses to futures trading, in contrast to the market-wide effect gained from research with index futures.

2. METHOD

The Individual Stock Futures (ISF) has proved to be a hugely successful financial instrument on Indian bourses, and NSE has continued to account for the majority of total volumes traded in the ISF segment all over the world. The resulting sample for this study comprises 30 most liquid and actively traded underlying stocks on which futures contracts are available. These 30 stock futures contribute to around

Table 1. List of selected stocks and their volume

Source: https://www1.nseindia.com

Stock	Volume			Stock	Volume		
	Contracts				Contracts		
	Futures	Options	Total		Futures	Options	Total
ASHOKLEY	928	1,673	2,601	INFRATEL	3,358	1,383	4,741
AUROPHARMA	1,674	2,003	3,677	INFY	1,759	2,441	4,200
AXISBANK	3,645	3,697	7,342	ITC	1,050	1,287	2,337
BHARTIARTL	11,550	13,551	25,101	JUSTDIAL	1,371	1,179	2,550
CIPLA	1,236	1,025	2,261	KOTAKBANK	1,261	803	2,064
GLENMARK	4,891	5,215	10,106	LT	1,309	1,322	2,631
GRASIM	2,895	1,610	4,505	MARUTI	1,729	3,598	5,327
HDFC	1,469	1,418	2,887	RELIANCE	7,010	15,910	22,920
HDFCBANK	2,234	1,423	3,657	SBIN	3,579	4,940	8,519
HEROMOTOCO	1,865	2,769	4,634	TATAELXSI	1,447	610	2,057
IBULHSGFIN	3,827	1,527	5,354	TATASTEEL	3,581	4,489	8,070
ICICIBANK	3,781	3,536	7,317	TCS	1,451	2,877	4,328
IDEA	4,913	7,224	12,137	VEDL	1,796	1,860	3,656
INDIGO	1,369	853	2,222	YESBANK	10,764	6,420	17,184
INDUSINDBK	1,759	1,049	2,808	ZEEL	2,053	1,602	3,655

http://dx.doi.org/10.21511/imfi.17(2).2020.26

70–80% of the total trading volume of the F&O segment of NSE, excluding the index futures. The majority of them are also part of the S&P Nifty Index, the Benchmark Index of NSE. The data extracted for 30 stocks have been procured from the Bloomberg database. The study period will range from the 1st January 2000 or the listing date of the particular stock (whichever is prior) till 31st March 2019.

2.1. Testing for ARCH effect

The ARCH test involves testing the existence of heteroscedasticity in the time-series data. Lagrange multiplier (LM) test by Engle helps in checking for ARCH effect. Let $\varepsilon_t = y_t - u_t$ be the residual series. The squared series ε_t^2 is utilized to implement the LM test for checking conditional heteroscedasticity. The null hypothesis is stated as follows:

$$H_0: \quad \alpha_i = 0,\ i = 1,2,\ldots,q$$

versus

$$H_1: \quad \alpha_i \neq 0,\ \text{for at least one } i.$$

In the linear regression

$$\varepsilon_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_q \varepsilon_{t-q}^2,\ t = q+1,\ldots,N,$$

where q is the length of ARCH lags, and N is the number of observations used in the regression equation.

The test statistic for LM test is defined by:

$$LM = NR^2,$$

where R^2 is the R-squared from the regression of ε_t^2 in the equation and defined by:

$$R^2 = \frac{Regression\ sum\ of\ squares}{Total\ sum\ of\ squares}.$$

2.2. Testing for multiple structural breaks (Iterated Cumulative Sums of Squares (ICSS) algorithm of Inclan and Tiao (1994))

Iterative Cumulative Sums of Squares (ICSS) algorithm proposed by Inclan and Tiao (1994) allows for detecting multiple breakpoints in the variance in a time series. The idea behind the ICSS algorithm of Inclan and Tiao can be outlined in sequential steps. The unconditional variance of financial time-series is stationary until a sudden break is observed. After that, until the occurrence of the next structural break, the unconditional variance is stationary. This process repeats through time, generating multiple numbers of structural breaks in the unconditional variance in n observations:

$$\sigma_t^2 = \begin{cases} \tau_0^2 & 1 < t < i_1 \\ \tau_1^2 & i_1 < t < i_1 \\ \tau_M^2 & i_M < t < i_1 \end{cases}$$

To estimate the number of changes and the point in time of variance shifts, a cumulative sum of squared residuals is used, $C_k = \sum_{t=1}^{k} \varepsilon_t^2$, $k = 1,2\ldots,n$, where $\{\varepsilon_t\}$ is a series of uncorrelated random variables with zero mean and unconditional variance σ_t^2. Inclan and Tiao define the statistic:

$$D_k = \frac{C_k}{C_n} - \frac{tk}{n},\ k = 1,2,\ldots,n,\ D_0 = D_n = 0.$$

If no sudden changes occur during the entire sampling duration in the variance of the sequence, D_k oscillates about zero. If there are one or more sudden shifts in variance, then the D_k statistics will drift either above or below the zero. The ICSS algorithm helps in identifying breaks in variance of the time-series at different points in time.

2.3. Linking the structural breaks in volatility with trading in stock futures

First, the dates for the structural breaks in the stocks will be estimated. Later, these structural breaks were matched with the dates of the listing of stock futures on the individual stocks. If a structural break is found within six months of the listing of stock futures, it has been attributed as likely to derivative trading.

AR (1)-GARCH (1, 1) is a GARCH family model, in which the mean is determined by a first-order auto-regressive AR (1), with a GARCH (1, 1) error:

$$x_t = u_t + \sigma_t \varepsilon_t,\ \mathrm{E}\left[\varepsilon_t\right] = 0,\ \mathrm{E}\left[\varepsilon_t^2\right] = 1,\ \varepsilon_t \text{ i.i.d.},$$

$$\mu_t = \lambda X_{t-1},$$

$$\sigma_t^2 = a_0 + a\left(X_{t-1} - \mu_{t-1}\right)^2 + b\sigma_{t-1}^2.$$

Once all the structural breakpoints are identified, dummy variables are created for each detected break. Each dummy variable is denoted with value one onwards from the identified location until the end of the data series and 0 elsewhere.

3. RESULTS

Table 2 displays the result of the ADF unit root test. All the variables are non-stationary at the level as the *p*-value is more than 0.05%. Therefore, the Unit Root Test is conducted in the first difference for all the variables. All the series are stationary at the first difference at 1% level of significance. The results of the ADF test indicate that all variables are integrated of the same order.

Table 3 depicts the ARCH test results for all 30 stocks traded at the cash segment of NSE. The standard diagnostic test of the Residuals from the model confirms the presence of ARCH effect. There is a presence of the ARCH effect in the closing return series of all the variables.

After detecting the structural breaks in the return series of selected highly traded 30 stocks, an attempt has been made to associate these structural

Table 2. Unit root test (augmented Dickey-Fuller test)

Stock	Spot		Futures		Stock	Spot		Futures	
	ADF at level	ADF at first difference	ADF at level	ADF at first difference		ADF at level	ADF at first difference	ADF at level	ADF at first difference
ASHOKLEY	–2.669	–77.9823	–1.8401	–25.085	INFRATEL	–1.903	–252.625	–1.840	–251.084
	(–0.079)	(–0.00)	(–0.361)	(–0.00)		(–0.330)	(–0.000)	(–0.361)	(–0.000)
AUROPHARMA	–3.075	–14.3857	–3.067	–14.026	INFY	–2.8434	–264.133	–2.696	–264.045
	(–0.112)	(–0.000)	(–0.114)	(–0.000)		(–0.052)	(–0.000)	(–0.074)	(–0.000)
AXISBANK	–2.407	–216.989	–2.473	–218.720	ITC	–1.793	–435.009	–1.887	–297.513
	(–0.139)	(–0.000)	(–0.121)	(–0.000)		(–0.389)	(–0.000)	(–0.333)	(–0.000)
BHARTIARTL	–2.496	(–240.736)	–420.76	–420.769	JUSTDIAL	–1.436	–169.532	–1.450	–218.429
	(0.116)	(–0.000)	(–0.000)	(0.000)		(–0.565)	(–0.000)	(–0.558)	(–0.000)
CIPLA	–1.471	–305.751	–1.505	–189.269	KOTAKBANK	–2.743	–254.133	–2.596	–254.045
	(–0.548)	(–0.000)	(–0.531)	(–0.000)		(–0.072)	(–0.000)	(–0.064)	(–0.000)
GLENMARK	–1.476	–296.195	–1.189	–186.673	LT	–2.496	–240.736	–420.769	–420.769
	(–0.546)	(–0.000)	(–0.681)	(–0.000)		(0.116)	(–0.000)	(–0.000)	(0.000)
GRASIM	–1.903	–252.625	–1.840	–251.084	MARUTI	–1.683	–435.009	–1.797	–298.513
	(–0.330)	(–0.000)	(–0.361)	(–0.000)		(–0.389)	(–0.000)	(–0.333)	(–0.000)
HDFC	–2.843	–264.133	–2.696	–264.045	RELIANCE	–1.803	–242.625	–1.740	–241.084
	(–0.052)	(–0.000)	(–0.074)	(–0.000)		(–0.320)	(–0.000)	(–0.351)	(–0.000)
HDFCBANK	–2.283	–174.557	–2.256	–169.916	SBIN	–2.496	–240.736	–420.769	–420.769
	(–0.177)	(–0.000)	(–0.186)	(–0.000)		(0.116)	(–0.000)	(–0.000)	(0.000)
HEROMOTOCO	–1.219	–116.178	–1.098	–128.5	TATAELXSI	–1.471	–305.751	–1.505	–189.269
	(–0.668)	(–0.000)	(–0.718)	–0.0001		(–0.548)	(–0.000)	(–0.531)	(–0.000)
IBULHSGFIN	–0.992	–161.898	–0.692	–162.498	TATASTEEL	–1.476	–296.195	–1.189	–186.673
	(–0.758)	(–0.000)	(–0.846)	(–0.000)		(–0.546)	(–0.000)	(–0.681)	(–0.000)
ICICIBANK	–1.783	–425.009	–1.897	–298.513	TCS	–1.903	–252.625	–1.840	–251.084
	(–0.389)	(–0.000)	(–0.333)	(–0.000)		(–0.330)	(–0.000)	(–0.361)	(–0.000)
IDEA	–2.843	–264.133	–2.696	–264.045	VEDL	–2.283	–174.557	–2.256	–169.916
	(–0.052)	(–0.000)	(–0.074)	(–0.000)		(–0.177)	(–0.000)	(–0.186)	(–0.000)
INDIGO	0.895	–195.973	0.538	–277.977	YESBANK	–1.211	–116.178	–1.098	–128.5
	(–0.995)	(–0.000)	(–0.988)	(–0.000)		(–0.668)	(–0.000)	(–0.718)	(–0.000)
INDUSINDBK	–1.360	–216.679	–1.370	–216.604	ZEEL	–0.992	–161.898	–0.692	–162.498
	(–0.603)	(–0.000)	(–0.598)	(–0.000)		(–0.758)	(–0.000)	(–0.846)	(–0.000)

Note: ( ) denote *p*-value.

http://dx.doi.org/10.21511/imfi.17(2).2020.26

Table 3. Results of ARCH test

Variables	*p*-value	Inference	Variables	*p*-value	Inference
ASHOKLEY	0.000	Present	INFRATEL	0.000	Present
AUROPHARMA	0.000	Present	INFY	0.000	Present
AXISBANK	0.000	Present	ITC	0.000	Present
BHARTIARTL	0.000	Present	JUSTDIAL	0.000	Present
CIPLA	0.000	Present	KOTAKBANK	0.000	Present
GLENMARK	0.000	Present	LT	0.000	Present
GRASIM	0.000	Present	MARUTI	0.000	Present
HDFC	0.000	Present	RELIANCE	0.000	Present
HDFCBANK	0.000	Present	SBIN	0.000	Present
HEROMOTOCO	0.000	Present	TATAELXSI	0.000	Present
IBULHSGFIN	0.000	Present	TATASTEEL	0.000	Present
ICICIBANK	0.000	Present	TCS	0.000	Present
IDEA	0.000	Present	VEDL	0.000	Present
INDIGO	0.000	Present	YESBANK	0.000	Present
INDUSINDBK	0.000	Present	ZEEL	0.000	Present

breaks with the listing dates of stock futures on individual stocks. The stocks, which have displayed similar patterns in terms of changes in persistence in volatility, unconditional volatility, and rate of adjustment to new information (measured by α), have been grouped. The detailed analysis after incorporating detected structural breaks into the AR (1)-GARCH (1, 1) Model is presented in Appendix. Stocks were divided into seven categories, viz. Panel A, Panel B, Panel C, Panel D, Panel E, Panel F, and Panel G. This classification is based on the influence of stock futures on the underlying volatility.

If a structural break is observed six months after listing the stock futures, it is associated with trading in futures. After this structural break date, the change in persistence of volatility, unconditional volatility, and rate of adjustment to new information (denoted by α) is observed and reported in Table 4. In the case of AUROPHARMA, ICICIBANK, and JUSTDIAL, the total persistence increases, while α and unconditional volatility declined for the period after this break (Panel A). On the contrary, ASHOKLEY, AXISBANK, HDFCBANK, INDUSINDBK, INFRATEL, RELIANCE, and TCS have shown a downfall in

Table 4. Impact of stock futures on the volatility of underlying stocks

Stock	Impact on the volatility			
	If structural break associated with stock futures trading	Direction of impact		
		Persistence	α	Unconditional Volatility
Panel A				
AUROPHARMA	Yes	↓	↑	↑
ICICIBANK	Yes	↓	↑	↑
JUSTDIAL	Yes	↓	↑	↑
Panel B				
ASHOKLEY	Yes	↓	↓	↓
AXISBANK	Yes	↓	↓	↓
HDFCBANK	Yes	↓	↓	↓
INDUSINDBK	Yes	↓	↓	↓
INFRATEL	Yes	↓	↓	↓
RELIANCE	Yes	↓	↓	↓
TCS	Yes	↓	↓	↓
Panel C				
BHARTIARTL	Yes	↑	↑	↓
INFY	Yes	↑	↑	↓
MARUTI	Yes	↑	↑	↓

Table 4 (cont.). Impact of stock futures on the volatility of underlying stocks

Stock	Impact on the volatility			
	If structural break associated with stock futures trading	Direction of impact		
		Persistence	α	Unconditional Volatility
Panel D				
CIPLA	Yes	↓	↑	↓
HDFC	Yes	↓	↑	↓
INDIGO	Yes	↓	↑	↓
LT	Yes	↓	↑	↓
Panel E				
GRASIM	Yes	↑	↓	↓
HEROMOTOCO	Yes	↑	↓	↓
ITC	Yes	↑	↓	↓
SBIN	Yes	↑	↓	↓
TATASTEEL	Yes	↑	↓	↓
ZEEL	Yes	↑	↓	↓
Panel F				
IDEA	Yes	↑	↑	↑
Panel G				
GLENMARK	No	–	–	–
IBULHSGFIN	No	–	–	–
KOTAKBANK	No	–	–	–
TATAELXSI	No	–	–	–
VEDL	No	–	–	–
YESBANK	No	–	–	–
Total = 30	Yes = 24	Increased = 10	Increased = 11	Increased = 4
	No = 6	Decreased = 14	Decreased = 13	Decreased = 20

the total persistence, unconditional volatility, and ***α*** (Panel B).

Panel C comprises of BHARTIARTL, INFY, and MARUTI. There is a decline in the unconditional volatility, but its persistence, as well as ***α***, has increased after the occurrence of the structural break. Panel D consists of CIPLA, HDFC, INDIGO, and LT for which the total persistence and unconditional volatility have declined, but ***α*** has increased during the observed structural break in volatility. There is observed an increase in ***α***, and reduction in the total persistence and the unconditional volatility of GRASIM, HEROMOTOCO, ITC, SBIN, TATASTEEL, and ZEEL for the period after the listing of stock futures (Panel E). However, no structural break is observed within six months after the listing of stock futures for GLENMARK, IBULHSGFIN, KOTAKBANK, TATAELXSI, and VEDL, and YESBANK (Panel G).

No structural break was observed within six months after listing the stock futures for six out of thirteen stocks. Unconditional volatility has declined for twenty out of twenty-four stocks for which structural breaks were observed within six months after the listing of stock futures. It is noted that the unconditional volatility has declined for the majority of the stocks after the listing of futures contracts. Total persistence has risen for ten stocks while declined for fourteen stocks. On the other hand, ***α*** has increased for eleven stocks, while it has decreased for thirteen stocks.

4. DISCUSSION

Through this study, an attempt has been made to model the underlying stock's volatility with stock futures by taking into consideration the breaks in the volatility. Several studies, such as Diebold (1986), Granger and Hyung (1999), Mikosch and Starica (2000), Diebold and Inoue (2001), have stated that neglecting the structural breaks can lead to spurious GARCH model estimation. Therefore, Iterated Cumulative Sums of Squares (ICSS) algo-

http://dx.doi.org/10.21511/imfi.17(2).2020.26

rithm of Inclan and Tiao (1994) was applied for detecting the multiple structural breaks for 30 highly traded and liquid stocks.

If a break is observed within six months after the listing of stock futures, then unconditional volatility, the nature of changes in total persistence, and α have been examined. Reduction in the unconditional volatility was observed for twenty out of thirty stocks after incorporating detected structural breaks into the AR(1)-GARCH(1,1) model. It is noted that the unconditional volatility has declined for the majority of the stocks after the listing of futures contracts. Total persistence has risen for ten stocks while declined for fourteen stocks. On the other hand, α has increased for eleven stocks, while it has decreased for thirteen stocks.

CONCLUSION

Through this analysis, any consistent patterns were not found in terms of changes in total persistence, unconditional volatility, and α for the underlying stocks for the period after the relevant breaks. The mixed outcome could be due to stock-specific characteristics, which could also play a significant role in the formation of the volatility. Consequently, the listing of stock futures may not have any clear effect on the underlying stock's volatility. The findings of the study reveal that the unconditional volatility has declined for the majority of the stocks after the listing of futures contracts. The analysis findings suggest that trading in stock futures may not have any detrimental effect on the underlying stock's volatility. These findings are in line with conclusions drawn by Badhani, Harish, and Chauhan (2008), Malik and Shah (2016).

AUTHOR CONTRIBUTIONS

Conceptualization: Sanjeeta Shirodkar.
Data curation: Sanjeeta Shirodkar.
Formal analysis: Sanjeeta Shirodkar.
Investigation: Guntur Anjana Raju, Sanjeeta Shirodkar.
Methodology: Guntur Anjana Raju, Sanjeeta Shirodkar
Project administration: Sanjeeta Shirodkar.
Resources: Guntur Anjana Raju.
Software: Guntur Anjana Raju, Sanjeeta Shirodkar.
Supervision: Guntur Anjana Raju.
Validation: Guntur Anjana Raju.
Visualization: Sanjeeta Shirodkar.
Writing – original draft: Sanjeeta Shirodkar.
Writing – review & editing: Guntur Anjana Raju.

REFERENCES

1. Aggarwal, R., Inclan, C., & Leal, R. (1999). Volatility in Emerging Stock Markets. *Journal of Financial and Quantitative Analysis, 34*(1), 33-55. Retrieved from https://ideas.repec.org/a/cup/jfinqa/v34y1999i01p33-55_00.html
2. Andreou, E., & Ghysels, E. (2002). Detecting Multiple Breaks in Financial Market. *Journal of Applied Econometrics, 17,* 579-600. https://doi.org/10.1002/jae.684
3. Antoniou, A., & Holmes, P. (1995). Futures trading, information and spot price volatility: evidence for the FTSE-100 stock index futures contract using GARCH. *Journal of Banking and Finance, 19*(1), 117-129. https://doi.org/10.1016/0378-4266(94)00059-C
4. Awan, A., & Shah, S. M. A. (2014). The Price and Volume Effect of Single-Stock Futures Trading on the Pakistani stock market. *The Lahore Journal of Business, 2,* 1-32. Retrieved from https://pdfs.semanticscholar.org/c795/151143e32056fbed6f88d26059f93c170b24.pdf
5. Badhani, K. N., Harish, B., & Chauhan, A. K. (2008). *Derivative Trading and Structural Changes in*

Volatility Derivative Trading and Structural Changes in Volatility. Paper presented at IDIGR Conference (pp. 1-29). Retrieved from http://www.igidr.ac.in/conf/money/mfc_10/Harish%20Bisht_A%20Chauhan_K%20N%20Badhani.pdf

6. Bae, S. C., Kwon, T. H., & Park, J. W. (2004). Futures trading, spot market volatility, and market efficiency: The case of the Korean index futures markets. *The Journal of Futures Markets, 24*(12), 1195-1228. https://www.sciencedirect.com/science/article/abs/pii/037842669400059C?via%3Dihub

7. Bandivadekar, S., & Ghosh, S. (2003). Derivatives and Volatility on Indian Stock Markets. In *Reserve Bank of India Occasional Papers* (Vol. 24). Retrieved from https://www.rbi.org.in/upload/Publications/PDFs/60616.pdf

8. Bhaumik, S., Karanasos, M., & Kartsaklas, A. (2016). The informative role of trading volume in an expanding spot and futures market. *Journal of Multinational Financial Management, 35,* 24-40. https://doi.org/10.1016/j.mulfin.2016.03.002

9. Bohl, M. T., Salm, C. A., & Wilfling, B. (2009). Do Individual Index Futures Investors Destabilize the Underlying Spot Market ? *The Journal of Futures Markets, 31*(1), 81-101. https://doi.org/10.1002/fut.20460

10. Brorsen, B. W. (1991). Futures trading, transaction costs, and stock market volatility. *Journal of Futures Markets, 11*(2), 153-163. https://doi.org/10.1002/fut.3990110203

11. Chan, K. (1991). A Further Analysis of the Lead-Lagg Relationship Between the Cash Market and Stock Index Futures Market. *The Review of Financial Studies, 4*(4), 657-684. Retrieved from https://ideas.repec.org/a/oup/rfinst/v5y1992i1p123-52.html

12. Chiraz, A. (2016). Does the Index Futures Destabilize the Underlying Spot Market? Some Evidence from Frensh Stock Exchange. *Business and Economics Journal, 7*(3). Retrieved from https://www.hilarispublisher.com/open-access/does-the-index-futures-destabilize-the-underlying-spot-market-someevidence-from-frensh-stock-exchange-2151-6219-1000244.pdf

13. Cox, J. C., & Ross, S. A. (1976). A Survey of Some New Results in Financial Option Pricing Theory. *The Journal of Finance, 31*(2), 383-402. https://doi.org/10.1111/j.1540-6261.1976.tb01893.x

14. Das, S., & Sahgal, R. (2020). NSE turns world's largest exchange in derivatives trading. *The Economic Times*. Retrieved April 1, 2020, from Economic Times website: https://economictimes.indiatimes.com/markets/stocks/news/nse-turns-worlds-largest-exchange-in-derivatives-trading/articleshow/73359798.cms

15. Diebold, F.X. (1986). Modeling the Persistence of Conditional Variances: A Comment. *Econometric Reviews, 5*(1), 51-56. https://doi.org/10.1080/07474938608800096

16. Diebold, F. X., & Inoue, A. (2001). Long memory and regime switching. *Journal of Econometrics, 105*(1), 131-159. https://doi.org/10.1016/S0304-4076(01)00073-2

17. Granger, C. W. J., & Hyung, N. (1999). Occasional Structural Breaks and Long Memory. *Marine Ecology Progress Series, 11*(3), 399-421. https://doi.org/10.1016/j.jempfin.2003.03.001

18. Gulen, H., & Mayhew, S. (2000). Stock Index Futures Trading and Volatility in International Equity Markets. *The Journal of Futures Markets, 20*(7), 661-685. Retrieved from https://www.krannert.purdue.edu/faculty/hgulen/futures.pdf

19. Harris, L. (1989). S & P 500 Cash Stock Price Volatilities. *The Journal of Finance, 44*(5), 1155-1175. Retrieved from https://www.jstor.org/stable/2328637?seq=1

20. Jithendranathan, T. (2010). Effect of Single Stock Futures on the Volatility of Underlying Russian Stocks. *Global Business & Finance Review, 15*(2). Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2488069

21. Kang, S. H., Jung, J., Park, K., & Yoon, S. (2007). Sudden Changes in Variance and Volatility Persistence in Asian Foreign Exchange Markets. *The Journal of the Korean Economy, 11*(1), 129-143. Retrieved from http://www.akes.or.kr/eng/papers(2009)/sang_hoon_kang.pdf

22. Kavussanos, M. G., Visvikis, I. D., & Alexakis, P. D. (2008). The Lead-Lag Relationship Between Cash and Stock Index Futures in a New Market. *European Financial Management, 14*(5), 1007-1025. https://doi.org/10.1111/j.1468-036X.2007.00412.x

23. Khan, S. U., & Rizwan, F. (2008). Trading Volume and Stock Returns: Evidence from Pakistan's Stock Market. *International Review of Business Research Papers, 4*(2), 151-162. Retrieved from https://pdfs.semanticscholar.org/ac5a/eeefb21d2efa4011ec73d2664b7240841c9f.pdf

24. Lee, C. L., Stevenson, S., & Lee, M. L. (2014). Futures trading, Spot Price Volatility and Market Efficiency: Evidence from European Real Estate Securities Futures. *Journal of Real Estate Finance and Economics, 48,* 299-322. Retrieved from https://ideas.repec.org/a/kap/jrefec/v48y2014i2p299-322.html

25. Lee, S. B., & Ohk, K. Y. (1992). Stock index futures listing and structural change in time-varying volatility. *Journal of Futures Markets, 12*(5), 493-509. https://doi.org/10.1002/fut.3990120502

26. Malik, F., & Hassan, S. A. (2004). Modeling volatility in sector index returns with GARCH models using an iterated algorithm. *Journal of Economics and Finance, 28*(2), 211-225. https://doi.org/10.1007/BF02761612

27. Malik, I. R., & Shah, A. (2016). The Impact of Single Stock Futures on Market Efficiency and Volatility: A Dynamic CAPM Approach. *Emerging Markets Finance and Trade, 53*(2), 339-356. https://doi.org/10.1080/1540496X.2016.1210507

http://dx.doi.org/10.21511/imfi.17(2).2020.26

28. Mallikarjunappa, T., and Afzal (2008). The Impact of Derivatives on Stock Market Volatility: A Study of the Nifty Index. *Asian Academy of Management Journal of Accounting and Finance, 4*(2), 43-65.

29. Mckenzie, M. D., Brailsford, T. J., & Faff, R. W. (2001). New Insights into the Impact of the Introduction of Futures Trading on Stock Price Volatility. *The Journal of Futures Markets, 21*(3), 237-255. https://doi.org/10.1002/1096-9934(200103)21:3%3C237::AID-FUT3%3E3.0.CO;2-0

30. Mikosch, T., & Starica, C. (2000). Limit Theory for the Sample Autocorrelations and Extremes of a GARCH (1, 1) Process. *The Annals of Statistics, 28*(5), 1427-1451. Retrieved from https://www.jstor.org/stable/2674101?seq=1

31. Pericli, A., & Koutmos, G. (1997). Index futures and options and stock market volatility. *Journal of Futures Markets, 17*(8), 957-974. https://doi.org/10.1002/(SICI)1096-9934(199712)17:8%3C957::AID-FUT6%3E3.0.CO;2-K

32. Pilar, C., & Rafael, S. (2002). Does derivatives trading destabilize the underlying assets? Evidence from the Spanish stock market. *Applied Economics Letters, 9*(2), 107-110. https://www.tandfonline.com/doi/abs/10.1080/13504850110049441

33. Pok, W. C., & Poshakwale, S. (2006). The impact of the introduction of futures contracts on the spot market volatility : the case of Kuala Lumpur Stock Exchange. *Applied Financial Economics, 14*(2), 37-41. https://doi.org/10.1080/09603100420000176416

34. Rahman, S. (2001). The introduction of derivatives on the dow jones industrial average and their impact on the volatility of component stocks. *Journal of Futures Markets, 21*(7), 633-653. https://doi.org/10.1002/fut.1702

35. Raju, M. T., & Karande, K. (2003). *Price Discovery and Volatility on NSE Futures Market*. Retrieved from https://www.sebi.gov.in/sebi_data/attachdocs/1293096997650.pdf

36. Reyes, M. G. (1996). Index Futures Trading and Stock Price Volatility: Evidence from Denmark and France. *Journal of Economics and Finance, 20*(3), 81-88. Retrieved from https://link.springer.com/article/10.1007/BF02920609

37. Ross, G. J. (1989). Modeling Financial Volatility in the Presence of Abrupt Changes. *The Journal of Finance, XLIV*(1), 1-17. Retrieved from https://arxiv.org/abs/1212.6016

38. Ryoo, H., & Smith, G. (2006). The impact of stock index futures on the Korean stock market The impact of stock index futures on the Korean stock market. *Applied Financial Economics, 14*(4), 37-41. https://doi.org/10.1080/09603100420002001183

39. Sarangi, S. P., & Patnaik, K. U. S. (2011). Impact of Futures and Options on the Underlying Market Volatility: An Empirical Study on S&P CNX Nifty Index. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.962036

40. Thenmozhi, M. (2002). *Do the S&P CNX Nifty Index And Nifty Futures Really Lead/Lag? Error Correction Model: A Co-integration Approach*. Retrieved from https://www1.nseindia.com/research/content/research_initiative.htm

41. Tse, Y. (1999). Price Discovery and Volatility Spillovers in the DJIA Index and Futures Markets. Journal of future markets, *19*(8), 911-930. https://doi.org/10.1002/(SICI)1096-9934(199912)19:8%3C911::AID-FUT4%3E3.0.CO;2-Q

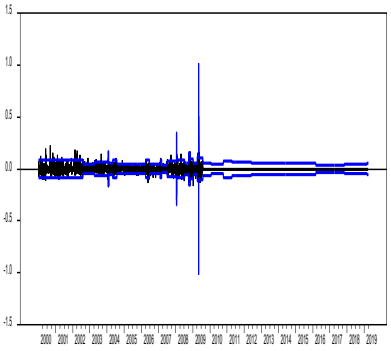
42. Wang, P., & Moore, T. (2009). Sudden changes in volatility: The case of five central European stock markets. *Journal of International Financial Markets, Institutions and Money, 19*(1), 33-46. Retrieved from https://ideas.repec.org/a/eee/intfin/v19y2009i1p33-46.html

43. Wats, S. (2017). Expiration Day Impact on the Indian Spot Market Volatility. *NMIMS Management Review, XXXIII,* 88-97. Retrieved from https://management-review.nmims.edu/wp-content/uploads/2017/01/expiration-day-impact-on-the-indian-spot-market-volatility-sangeeta-wats.pdf

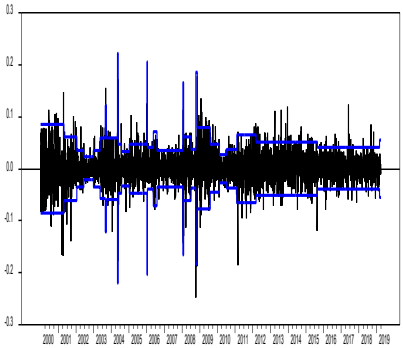
44. Yilgor, A. G., Lidvine, C., & Mebounou, C. (2016). The Effect of Futures Contracts on the Stock Market Volatility : An Application on Istanbul Stock Exchange. *Journal of Business, Economics and Finance, 5*(3), 307-317. Retrieved from https://www.researchgate.net/publication/338396003_The_effect_of_futures_contracts_on_the_stock_market_volatility

45. Yao, Y. (2016). The Impact of Stock Index Futures on Spot Market Volatility. *International Conference on Education, Sports, Arts and Management Engineering (ICESAME 2016)*, 1244-1247. Retrieved from https://www.atlantis-press.com/proceedings/icesame-16/25851103

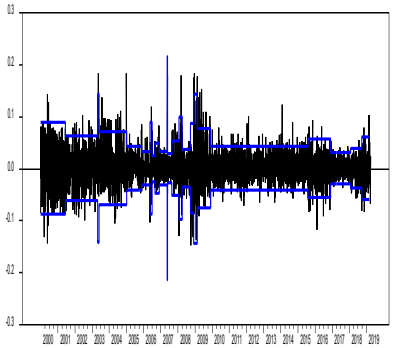
APPENDIX



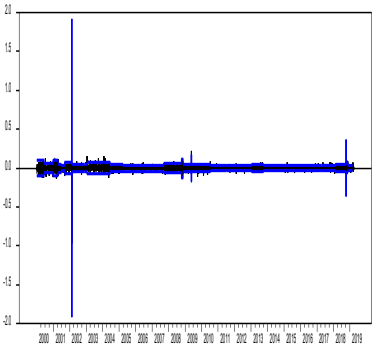
ASHOKLEY



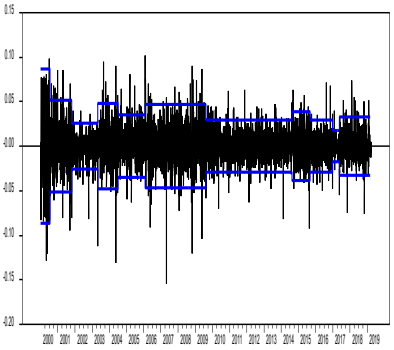
AUROPHARMA



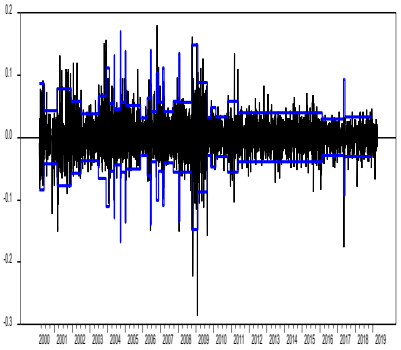
AXISBANK



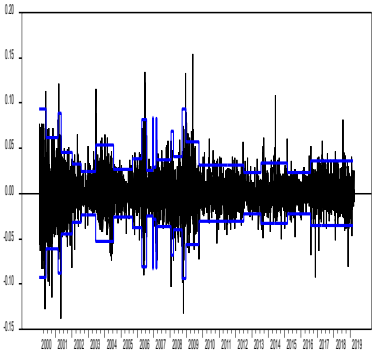
BHARTIARTL



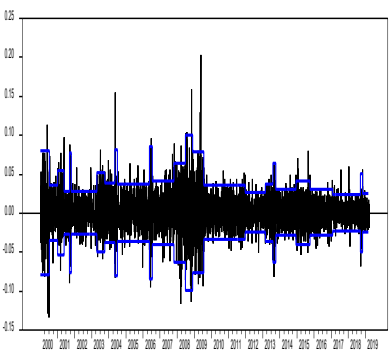
CIPLA



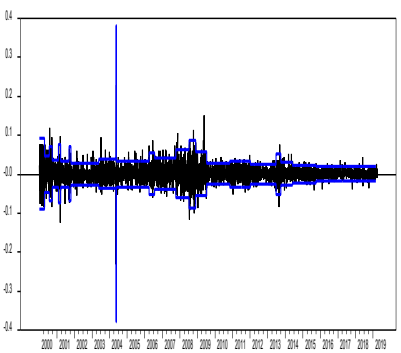
GLENMARK



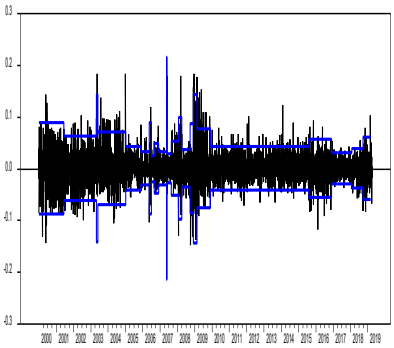
GRASIM



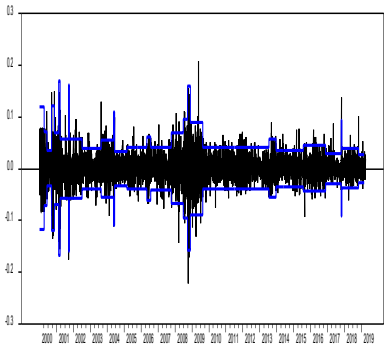
HDFCBANK



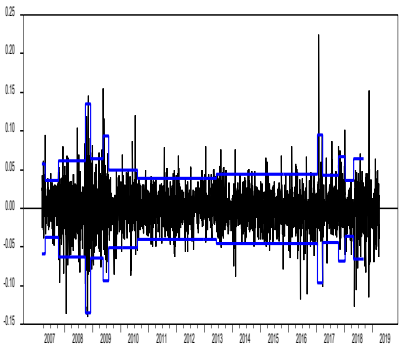
HDFC



HEROMOTOCO

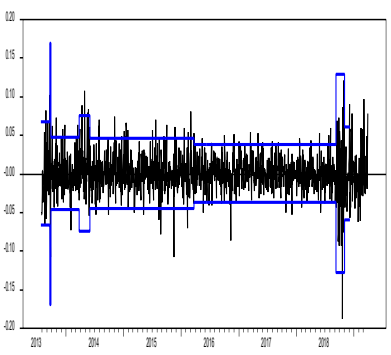


ICICIBANK

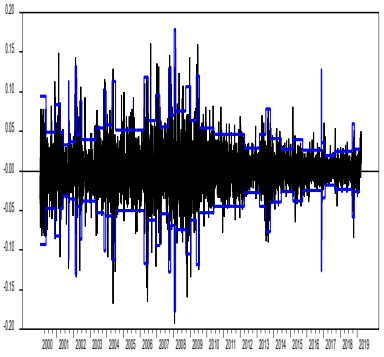


IDEA

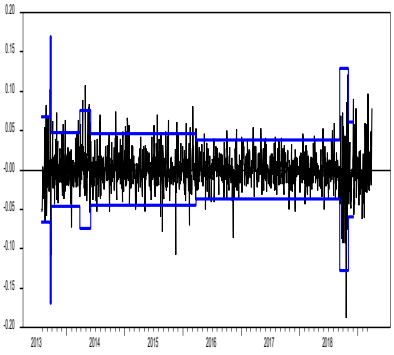
http://dx.doi.org/10.21511/imfi.17(2).2020.26



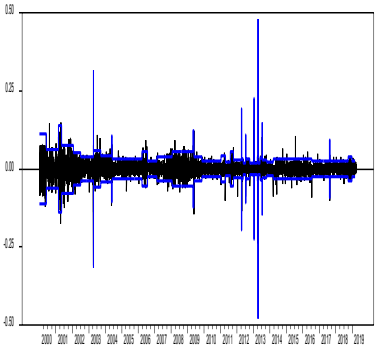
IBULHSGFIN



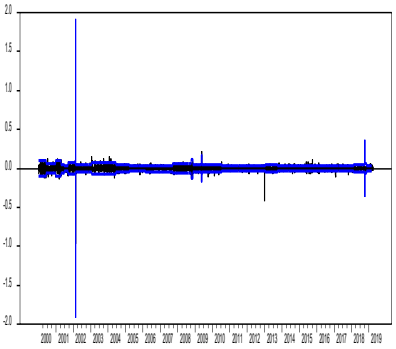
INDUSINDBK



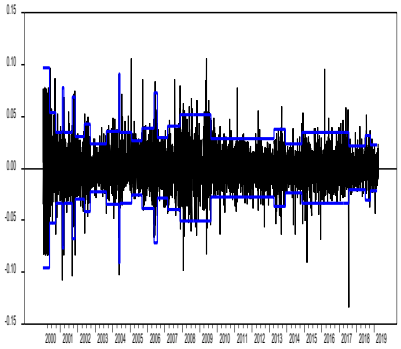
INDIGO



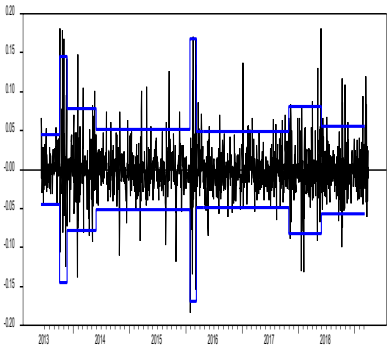
INFY



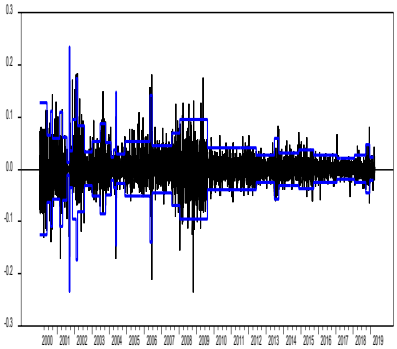
INFRATEL



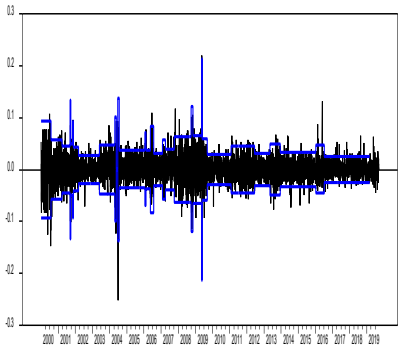
ITC



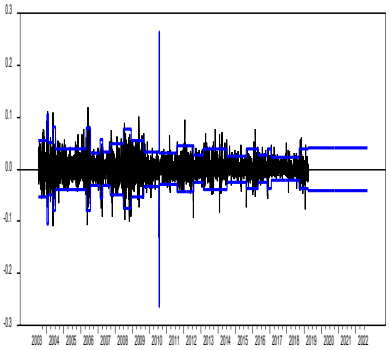
JUSTDIAL



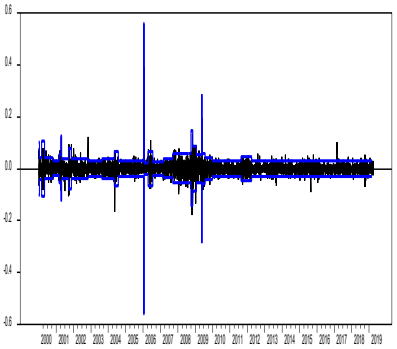
KOTAKBANK



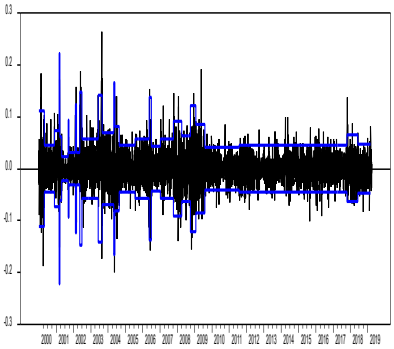
LT



MARUTI



RELIANCE



SBIN

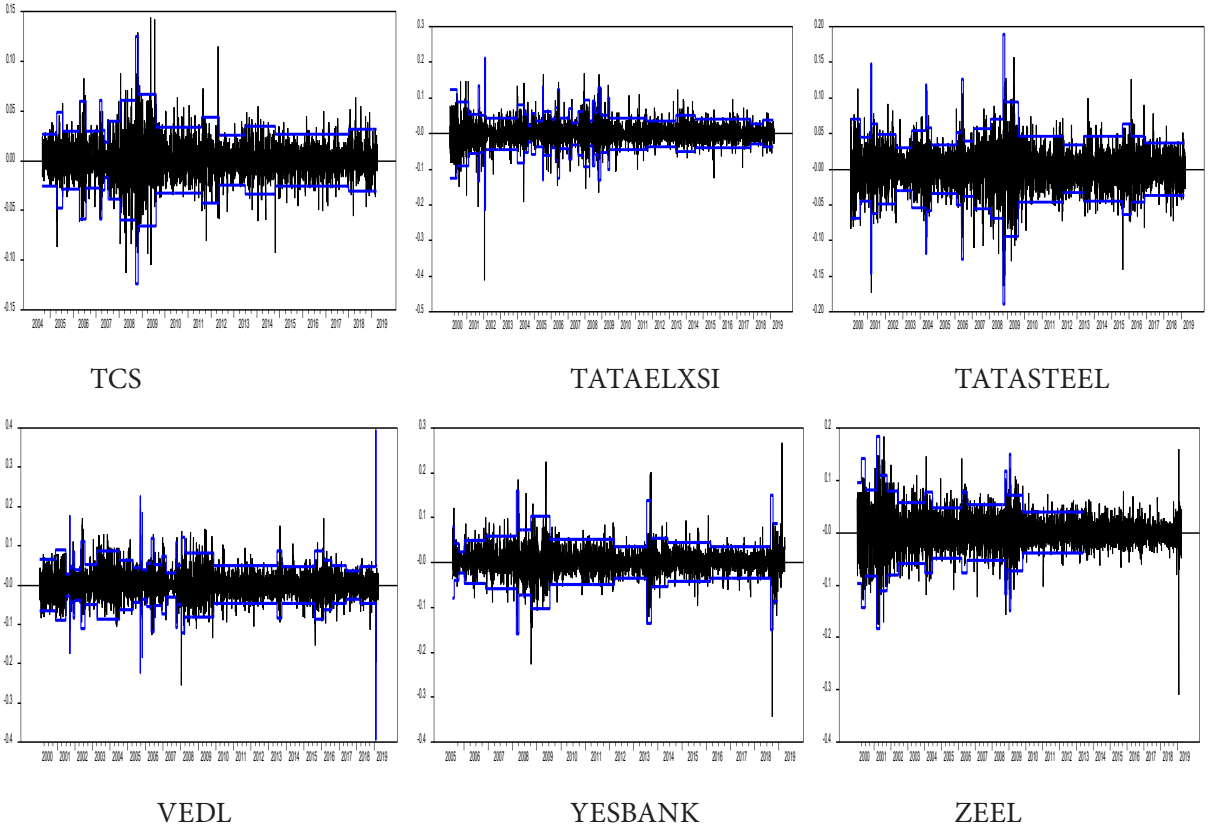


Figure 1. Multiple Structural Breaks (Iterated Cumulative Sums of Squares (ICSS) algorithm of Inclan and Tiao (1994)

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1−α−β)
Volatility Breaks in ASHOKLEY					
Date of commencement of Derivative trading: 20-04-2005					
05/07/2002_30/12/2004	1.311	0.194	0.669	0.864	9.611
31/12/2004_17/11/2005	0.717	0.165	0.764	0.928	9.994
18/11/2005_29/09/2008	1.830	0.157	0.630	0.786	8.553
30/09/2008_02/11/2009	−0.021	0.109	0.898	1.007	3.062
03/11/2009_10/02/2010	0.513	0.038	0.868	0.906	5.461
11/02/2010_20/05/2011	0.732	0.155	0.718	0.872	5.719
21/05/2011_16/02/2016	0.684	0.060	0.762	0.823	3.856
17/02/2016_02/06/2017	0.954	0.366	0.397	0.763	4.021
03/06/2017_29/03/2019	1.270	0.067	0.449	0.516	2.623
Volatility Breaks in AUROPHARMA					
Date of commencement of Derivative trading: 12-05-2005					
05/01/2000_30/04/2001	12.687	0.411	−0.084	0.327	18.856
10/05/2001_17/09/2003	0.064	0.087	0.910	0.997	22.097
18/09/2003_11/05/2004	4.754	0.043	0.425	0.468	8.938
12/05/2004_05/08/2005	0.071	−0.076	1.063	0.987	5.376
06/08/2005_09/01/2006	3.321	0.076	0.353	0.429	5.818
10/01/2006_15/01/2008	0.492	0.113	0.761	0.874	3.899
16/01/2008_04/08/2009	0.962	0.057	0.882	0.940	15.928
05/08/2009_09/02/2010	2.761	-0.091	0.581	0.490	5.409
10/02/2010_09/02/2011	1.707	0.043	0.341	0.384	2.770

http://dx.doi.org/10.21511/imfi.17(2).2020.26

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
10/02/2011_07/03/2012	1.148	0.152	0.741	0.893	10.707
08/03/2012_28/08/2015	1.129	0.042	0.790	0.831	6.690
29/08/2015_29/03/2019	0.550	0.076	0.784	0.861	3.951
Volatility Breaks in AXISBANK					
Date of commencement of Derivative trading: 20-04-2005					
05/01/2000_16/11/2001	3.256	0.310	0.540	0.850	21.713
17/11/2001_01/01/2003	0.142	0.266	0.784	1.051	–2.803
02/01/2003_06/06/2005	0.172	0.096	0.888	0.984	10.853
07/06/2005_18/01/2006	3.323	0.085	0.411	0.497	6.601
19/01/2005_18/01/2008	2.728	0.259	0.453	0.712	9.478
19/01/2008_18/08/2009	2.281	0.079	0.815	0.894	21.560
19/08/2009_07/06/2012	1.175	0.146	0.558	0.704	3.962
08/06/2012_20/11/2014	0.056	0.039	0.940	0.979	2.657
21/11/2014_24/09/2015	0.840	0.032	0.703	0.735	3.169
25/09/2015_31/01/2017	1.287	–0.019	0.264	0.245	1.705
01/02/2017_29/03/2019	1.037	0.276	0.123	0.400	1.726
Volatility Breaks in BHARTIARTL					
Date of commencement of Derivative trading : 20-04-2005					
05/01/2000_22/11/2001	3.995	0.197	0.462	0.658	11.698
23/11/2001_20/01/2003	1.738	0.367	0.372	0.739	6.649
21/01/2003_14/06/2004	1.967	0.023	0.808	0.831	11.613
15/06/2004_22/07/2005	2.967	0.059	0.465	0.524	6.234
23/07/2005_19/09/2007	0.620	0.134	0.710	0.843	3.959
20/09/2007_10/10/2008	2.520	0.004	0.678	0.682	7.925
11/10/2008_27/05/2009	1.247	0.444	0.575	1.019	–64.730
28/05/2009_12/07/2010	3.565	0.257	0.166	0.423	6.175
13/07/2010_10/01/2013	2.566	0.110	0.274	0.384	4.166
11/01/2013_29/03/2019	2.790	0.058	0.089	0.147	3.272
Volatility Breaks in CIPLA					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_19/07/2000	13.355	0.229	0.021	0.249	17.791
20/07/2000_23/10/2001	1.187	0.049	0.772	0.820	6.605
24/10/2001_28/04/2003	0.779	0.046	0.466	0.513	1.599
29/04/2003_06/07/2004	1.756	0.187	0.476	0.663	5.214
07/07/2004_02/02/2006	1.546	0.100	0.384	0.484	2.994
03/02/2006_18/08/2009	0.745	0.135	0.729	0.864	5.466
19/08/2009_15/08/2014	0.946	0.014	0.549	0.562	2.162
16/08/2014_03/09/2015	0.217	0.011	0.930	0.941	3.664
04/09/2015_28/12/2016	1.343	0.252	0.138	0.390	2.201
29/12/2016_23/05/2017	0.210	0.197	0.547	0.744	0.818
24/05/2017_29/03/2019	0.530	0.144	0.646	0.790	2.527
Volatility Breaks in GLENMARK					
Date of commencement of Derivative trading: 28-09-2013					
25/02/2000_11/12/2001	0.396	0.058	0.907	0.965	11.238
12/12/2001_05/07/2002	0.479	–0.120	1.060	0.940	8.007
06/07/2002_30/12/2004	1.311	0.194	0.669	0.864	9.611
31/12/2004_17/11/2006	0.717	0.165	0.764	0.928	9.994
18/11/2006_29/09/2008	1.830	0.157	0.630	0.786	8.553
30/09/2008_02/11/2009	–0.021	0.109	0.898	1.007	3.062
03/11/2009_10/02/2010	0.513	0.038	0.868	0.906	5.461
11/02/2010_20/05/2011	0.732	0.155	0.718	0.872	5.719
21/05/2011_16/02/2016	0.684	0.060	0.762	0.823	3.856
17/02/2016_02/06/2017	0.954	0.366	0.397	0.763	4.021
03/06/2017_29/03/2019	1.270	0.067	0.449	0.516	2.623

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
Volatility Breaks in GRASIM					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_04/10/2001	5.439	0.159	0.458	0.617	14.200
05/10/2001_17/06/2003	0.006	–0.021	1.017	0.996	1.761
18/06/2003_16/07/2004	0.793	0.060	0.815	0.875	6.353
17/07/2004_12/09/2005	0.480	0.033	0.692	0.725	1.749
13/09/2005_13/03/2007	0.331	0.224	0.736	0.960	8.348
14/03/2007_21/01/2008	0.720	0.038	0.748	0.786	3.368
22/01/2008_06/10/2009	1.128	0.096	0.776	0.872	8.822
07/10/2009_03/07/2012	1.592	0.241	0.100	0.341	2.415
04/07/2012_25/07/2013	1.019	0.167	0.085	0.252	1.362
26/07/2013_10/03/2015	0.166	0.087	0.861	0.947	3.148
11/03/2015_05/08/2016	0.354	0.104	0.623	0.728	1.299
06/08/2016_29/03/2019	0.513	0.022	0.807	0.829	3.004
Volatility Breaks in HDFCBANK					
Date of commencement of Derivative trading: 29-08-2003					
05/01/2000_05/01/2001	1.467	0.188	0.651	0.839	9.129
06/01/2001_09/10/2003	0.336	0.187	0.744	0.931	4.841
10/10/2003_11/05/2004	0.968	–0.108	0.862	0.754	3.933
12/05/2004_18/05/2006	0.416	0.081	0.799	0.881	3.488
19/05/2006_27/06/2008	0.160	0.056	0.921	0.976	6.773
28/06/2008_22/12/2011	0.050	0.055	0.934	0.990	4.850
23/12/2011_06/08/2013	0.904	0.023	0.553	0.576	2.133
07/08/2013_06/10/2015	0.178	0.054	0.890	0.944	3.172
07/10/2015_29/03/2019	0.216	0.052	0.833	0.885	1.872
Volatility Breaks in HDFC					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_05/02/2001	0.602	0.241	0.724	0.965	17.222
06/02/2001_16/10/2001	1.111	0.386	0.474	0.860	7.939
17/10/2001_22/05/2003	0.501	0.306	0.484	0.791	2.393
23/05/2003_14/05/2004	1.487	0.145	0.448	0.593	3.656
15/05/2004_30/03/2006	0.548	0.028	0.770	0.798	2.712
31/03/2006_28/11/2008	0.352	0.103	0.855	0.958	8.337
29/11/2008_08/11/2010	0.036	0.045	0.941	0.985	2.477
09/11/2010_04/01/2012	3.047	–0.064	0.009	–0.055	2.889
05/01/2012_03/06/2014	0.032	0.039	0.948	0.986	2.355
04/06/2014_07/10/2015	0.598	0.024	0.521	0.545	1.314
08/10/2015_29/03/2019	0.407	0.057	0.461	0.517	0.843
Volatility Breaks in HEROMOTOCO					
Date of commencement of Derivative trading: 31-01-2003					
05/01/2000_15/03/2001	0.263	0.071	0.893	0.964	7.290
16/03/2001_25/04/2003	0.427	0.266	0.707	0.973	15.935
26/04/2003_27/04/2004	0.073	0.082	0.900	0.981	3.916
28/04/2004_26/07/2005	0.149	0.047	0.919	0.966	4.339
27/07/2005_15/05/2006	0.767	0.074	0.639	0.713	2.671
16/05/2006_08/10/2007	0.305	0.015	0.919	0.935	4.669
09/10/2007_31/07/2009	0.569	0.079	0.875	0.954	12.340
01/08/2009_01/08/2011	0.271	0.060	0.861	0.921	3.418
02/08/2011_24/10/2017	0.215	0.071	0.874	0.946	3.953
25/10/2017_08/06/2018	0.484	–0.111	0.976	0.865	3.582
09/06/2018_29/03/2019	0.179	0.081	0.869	0.950	3.598

http://dx.doi.org/10.21511/imfi.17(2).2020.26

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
Volatility Breaks in ICICIBANK					
Date of commencement of Derivative trading: 31-01-2003					
05/01/2000_11/04/2000	0.748	–0.161	1.133	0.972	26.559
12/04/2000_01/10/2001	8.059	0.329	0.179	0.508	16.380
02/10/2001_05/07/2002	1.035	0.153	0.716	0.869	7.885
06/07/2002_21/03/2003	0.198	0.054	0.897	0.950	3.989
22/03/2003_11/05/2004	2.431	0.143	0.498	0.641	6.771
12/05/2004_28/02/2005	0.043	–0.054	1.041	0.987	3.219
29/02/2005_12/10/2007	0.526	0.062	0.822	0.884	4.531
13/10/2007_18/08/2009	0.778	0.109	0.857	0.966	22.936
19/08/2009_16/07/2013	0.106	0.042	0.930	0.973	3.868
17/07/2013_24/07/2015	0.034	0.003	0.985	0.988	2.970
25/07/2015_16/11/2016	3.588	0.050	0.198	0.249	4.776
17/11/2016_29/03/2019	2.071	–0.008	0.357	0.349	3.181
Volatility Breaks in IDEA					
Date of commencement of Derivative trading: 08-03-2007					
13/03/2007_10/08/2007	1.942	–0.050	0.589	0.540	4.219
11/08/2007_15/05/2009	0.982	0.093	0.831	0.923	12.803
16/05/2009_06/08/2010	0.384	0.004	0.935	0.940	6.357
07/08/2010_04/06/2013	3.145	0.198	0.007	0.205	3.958
05/06/2013_12/01/2017	3.275	0.150	0.600	0.750	13.101
13/01/2017_29/03/2019	7.650	0.306	–0.082	0.224	9.861
Volatility Breaks in IBULHSGFIN					
Date of commencement of Derivative trading: 30-09-2010					
26/07/2013_19/09/2013	10.009	0.113	–0.079	0.034	10.358
20/09/2013_02/06/2014	1.584	0.032	0.771	0.803	8.039
03/06/2014_22/03/2016	1.929	0.037	0.589	0.626	5.158
23/03/2016_01/11/2018	0.271	0.086	0.855	0.942	4.641
02/11/2018_29/03/2019	3.118	–0.063	0.716	0.652	8.969
Volatility Breaks in INDUSINDBK					
Date of commencement of Derivative trading: 29-10-2010					
05/01/2000_15/03/2001	2.278	0.189	0.655	0.844	14.638
16/03/2001_06/02/2002	2.859	0.356	0.041	0.397	4.743
07/02/2002_05/05/2003	0.372	0.081	0.855	0.937	5.862
06/05/2003_07/12/2006	1.365	0.118	0.754	0.872	10.630
08/12/2006_09/03/2007	0.969	–0.211	1.177	0.966	28.330
10/03/2007_22/07/2009	0.736	0.094	0.872	0.966	21.552
23/07/2009_02/06/2010	3.850	0.260	0.223	0.483	7.450
03/06/2010_02/04/2012	5.351	0.184	–0.181	0.002	5.364
03/04/2012_20/06/2014	0.049	0.057	0.933	0.989	4.644
21/06/2014_16/11/2016	0.362	0.034	0.808	0.842	2.292
16/11/2016_29/03/2019	0.127	0.101	0.833	0.935	1.957
Volatility Breaks in INFRATEL					
Date of commencement of Derivative trading: 24-09-2015					
28/12/2012_07/06/2013	1.175	0.146	0.558	0.704	3.962
08/06/2013_20/11/2014	0.056	0.039	0.940	0.979	2.657
21/11/2014_24/09/2015	0.840	0.032	0.703	0.735	3.169
25/09/2015_31/01/2017	1.287	–0.019	0.264	0.245	1.705
01/02/2017_29/03/2019	1.037	0.276	0.123	0.400	1.726
Volatility Breaks in INDIGO					
Date of commencement of Derivative trading: 31-03-2017					
12/11/2015_22/01/2016	11.610	0.304	–0.109	0.196	14.436
23/01/2016_16/02/2016	10.775	–0.123	0.663	0.540	23.432
17/02/2016_19/08/2016	2.533	–0.050	0.600	0.550	5.632

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
20/08/2016_27/04/2017	2.401	0.212	–0.098	0.114	2.711
28/04/2017_29/03/2019	0.977	0.024	0.828	0.852	6.613
Volatility Breaks in INFY					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_27/02/2001	0.710	0.100	0.852	0.951	14.612
28/02/2001_03/11/2001	6.251	–0.196	1.046	0.850	41.605
05/11/2001_17/05/2004	1.033	0.108	0.778	0.886	9.097
18/05/2004_28/03/2006	0.447	0.005	0.810	0.814	2.408
29/03/2006_24/07/2006	5.691	0.336	–0.126	0.210	7.206
25/07/2006_01/05/2009	0.053	0.061	0.931	0.992	6.624
02/05/2009_12/07/2012	0.628	0.230	0.598	0.828	3.650
13/07/2012_11/01/2013	0.360	0.030	0.737	0.767	1.545
12/01/2013_13/03/2014	0.560	1.277	0.205	1.482	-1.163
14/03/2014_18/07/2016	0.850	-0.018	0.699	0.681	2.661
19/07/2016_ 3/29/2019	1.292	0.170	0.137	0.307	1.864
Volatility Breaks in ITC					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_07/02/2001	–0.038	–0.023	1.026	1.003	11.359
08/02/2001_09/11/2001	3.004	0.577	0.097	0.674	9.213
10/11/2001_21/05/2002	0.579	0.078	0.662	0.740	2.226
22/05/2002_01/02/2005	0.387	0.111	0.759	0.869	2.959
02/02/2005_05/09/2005	0.744	0.001	0.565	0.566	1.715
06/09/2005_12/11/2007	0.357	0.076	0.836	0.912	4.045
13/11/2007_25/08/2009	0.459	0.084	0.845	0.928	6.416
26/08/2009_10/11/2014	0.561	0.096	0.629	0.725	2.039
11/11/2014_20/07/2017	2.498	0.272	–0.110	0.162	2.980
21/07/2017_29/03/2019	0.202	0.015	0.842	0.857	1.409
Volatility Breaks in JUSTDIAL					
Date of commencement of Derivative trading: 02-04-2013					
12/07/2012_06/06/2013	0.360	0.030	0.737	0.767	1.545
07/06/2013_04/10/2013	0.296	–0.186	1.113	0.927	4.057
05/10/2013_29/05/2014	1.163	0.056	0.877	0.933	17.414
30/05/2014_28/01/2016	5.033	0.366	–0.084	0.282	7.013
29/01/2016_09/03/2016	3.886	–0.478	1.427	0.950	77.137
10/10/2017_29/05/2018	2.735	0.242	0.632	0.873	21.582
30/05/2018_29/03/2019	2.368	0.094	0.608	0.702	7.942
Volatility Breaks in KOTAKBANK					
Date of commencement of Derivative trading: 29-12-2005					
05/01/2000_16/11/2001	3.256	0.310	0.540	0.850	21.713
17/11/2001_01/01/2003	0.142	0.266	0.784	1.051	–2.803
02/01/2003_18/11/2004	0.172	0.096	0.888	0.984	10.853
19/11/2004_04/05/2006	3.323	0.085	0.411	0.497	6.601
05/05/2006_18/01/2008	2.728	0.259	0.453	0.712	9.478
19/01/2008_18/08/2009	2.281	0.079	0.815	0.894	21.560
19/08/2009_07/06/2012	1.175	0.146	0.558	0.704	3.962
08/06/2012_20/11/2014	0.056	0.039	0.940	0.979	2.657
21/11/2014_24/09/2015	0.840	0.032	0.703	0.735	3.169
25/09/2015_31/01/2017	1.287	–0.019	0.264	0.245	1.705
01/02/2017_29/03/2019	1.037	0.276	0.123	0.400	1.726
Volatility Breaks in LT					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_21/11/2001	–0.038	–0.023	1.026	1.003	11.359
22/11/2001_22/04/2004	0.041	0.031	0.956	0.987	3.098
23/04/2004_24/07/2006	1.172	0.283	0.532	0.815	6.352

http://dx.doi.org/10.21511/imfi.17(2).2020.26

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
25/07/2006_02/02/2007	1.070	–0.072	0.602	0.531	2.278
03/02/2007_10/03/2008	0.540	0.205	0.742	0.947	10.227
11/03/2008_08/09/2009	6.429	0.237	0.380	0.617	16.790
09/09/2009_28/01/2011	2.361	0.120	–0.251	–0.131	2.087
29/01/2011_11/12/2013	0.071	0.049	0.935	0.985	4.583
12/12/2013_13/01/2016	1.073	–0.009	0.621	0.612	2.765
14/01/2016_05/07/2016	2.895	0.753	–0.085	0.668	8.710
06/07/2016_13/09/2019	1.767	0.047	–0.054	–0.007	1.755
Volatility Breaks in MARUTI					
Date of commencement of Derivative trading: 08-07-2003					
15/03/2001_06/02/2002	2.859	0.356	0.041	0.397	4.743
07/02/2002_05/12/2003	0.372	0.081	0.855	0.937	5.862
06/12/2003_21/01/2005	0.187	0.098	0.866	0.964	5.223
22/01/2005_05/08/2009	0.526	0.083	0.853	0.937	8.304
05/08/2009_31/05/2010	0.048	–0.065	1.045	0.980	2.422
01/06/2010_19/08/2011	0.118	–0.024	0.986	0.962	3.140
20/08/2011_21/06/2013	2.590	0.232	0.087	0.319	3.804
22/06/2013_17/12/2014	2.754	0.147	–0.080	0.067	2.951
18/12/2014_06/12/2016	0.547	0.195	0.602	0.798	2.703
07/12/2016_29/03/2019	0.025	0.031	0.955	0.986	1.830
Volatility Breaks in RELIANCE					
Date of commencement of Derivative trading: 29-11-2001					
05/01/2000_28/02/2001	0.322	0.128	0.808	0.936	4.993
28/02/2001_21/12/2001	1.941	0.386	0.471	0.857	13.560
22/12/2001_02/08/2004	1.299	0.288	0.399	0.687	4.154
03/08/2004_24/07/2006	1.832	0.870	0.072	0.942	31.407
25/07/2006_24/12/2009	0.101	0.096	0.898	0.994	17.804
25/12/2009_22/08/2011	1.164	–0.014	0.510	0.496	2.309
23/08/2011_02/04/2012	1.980	–0.100	0.733	0.633	5.401
03/04/2012_29/03/2019	0.372	0.067	0.774	0.840	2.332
Volatility Breaks in SBIN					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_15/03/2001	0.263	0.071	0.893	0.964	7.290
16/03/2001_25/09/2001	0.427	0.266	0.707	0.973	15.935
26/09/2001_27/04/2004	0.073	0.082	0.900	0.981	3.916
28/04/2004_26/07/2005	0.149	0.047	0.919	0.966	4.339
27/07/2005_15/05/2006	0.767	0.074	0.639	0.713	2.671
16/05/2006_08/10/2007	0.305	0.015	0.919	0.935	4.669
09/10/2007_31/07/2009	0.569	0.079	0.875	0.954	12.340
01/08/2009_01/08/2011	0.271	0.060	0.861	0.921	3.418
02/08/2011_24/10/2017	0.215	0.071	0.874	0.946	3.953
25/10/2017_08/06/2018	0.484	–0.111	0.976	0.865	3.582
09/06/2018_29/03/2019	0.179	0.081	0.869	0.950	3.598
Volatility Breaks in TCS					
Date of commencement of Derivative trading: 23-08-2004					
27/04/2004_26/08/2004	0.149	0.047	0.919	0.966	4.339
27/08/2004_15/04/2005	0.634	0.012	0.608	0.619	1.666
16/04/2005_25/07/2006	0.463	0.169	0.709	0.878	3.796
26/07/2006_06/07/2007	1.290	0.342	0.159	0.501	2.588
07/07/2007_29/10/2008	0.333	0.116	0.856	0.971	11.669
30/10/2008_13/08/2009	11.142	0.241	–0.171	0.070	11.982
14/08/2009_05/08/2011	1.133	0.134	0.460	0.594	2.794
06/08/2011_10/05/2012	0.168	0.041	0.921	0.961	4.366
11/05/2012_26/06/2013	0.021	–0.041	1.030	0.988	1.823
27/06/2013_20/10/2014	0.808	0.027	0.692	0.719	2.873

Period	ω	α	β	Total Persistence: (α+β)	Unconditional Volatility: ω/(1–α–β)
21/10/2014_29/12/2017	1.048	0.151	0.232	0.383	1.699
30/12/2017_29/03/2019	0.363	0.047	0.799	0.846	2.353
Volatility Breaks in TATAELXSI					
Date of commencement of Derivative trading: 26-02-2016					
05/01/2000_01/10/2001	0.369	0.029	0.953	0.982	20.001
02/10/2001_25/12/2003	3.042	–0.007	0.590	0.584	7.307
26/12/2003_29/03/2006	1.135	0.211	0.675	0.886	9.962
30/03/2006_29/11/2007	0.331	0.080	0.880	0.959	8.164
30/11/2007_11/12/2008	5.212	0.284	0.498	0.782	23.918
12/12/2008_30/08/2011	0.938	0.222	0.644	0.865	6.976
31/08/2011_23/05/2013	1.213	0.019	0.608	0.627	3.251
24/05/2013_16/07/2014	10.945	0.049	–0.712	–0.663	6.581
17/07/2014_01/11/2017	0.357	0.027	0.882	0.910	3.944
02/11/2017_29/03/2019	0.959	0.072	0.568	0.641	2.670
Volatility Breaks in TATASTEEL					
Date of commencement of Derivative trading: 02-07-2001					
05/01/2000_27/07/2000	3.121	0.193	0.559	0.752	12.592
28/07/2000_20/07/2001	1.703	0.276	0.534	0.810	8.986
21/07/2001_12/08/2002	1.010	0.084	0.750	0.834	6.066
13/08/2002_10/07/2003	1.885	0.270	–0.044	0.226	2.436
11/07/2003_28/06/2006	0.155	0.092	0.888	0.979	7.480
29/06/2006_26/01/2007	0.250	–0.002	0.923	0.921	3.177
27/01/2007_23/05/2013	0.089	0.079	0.912	0.990	8.987
24/05/2013_11/08/2015	0.262	0.061	0.887	0.948	4.996
12/08/2015_28/11/2016	0.233	0.007	0.955	0.962	6.183
29/11/2016_29/03/2019	5.508	–0.035	–0.640	–0.674	3.289
Volatility Breaks in VEDL					
Date of commencement of Derivative trading: 29-12-2006					
05/01/2000_24/12/2001	4.740	0.234	0.385	0.618	12.419
25/12/2001_07/04/2003	0.624	0.096	0.839	0.935	9.618
08/04/2003_08/03/2007	2.851	0.203	0.597	0.800	14.255
09/03/2007_26/03/2008	0.698	0.468	0.591	1.059	–11.844
27/03/2008_08/08/2016	0.206	0.076	0.904	0.980	10.189
09/08/2016_29/05/2017	5.367	–0.044	0.112	0.068	5.756
30/05/2017_29/03/2019	2.337	–0.018	0.582	0.565	5.369
Volatility Breaks in YESBANK					
Date of commencement of Derivative trading: 06-09-2007					
14/07/2005_03/02/2008	2.310	0.158	0.510	0.668	6.951
04/02/2008_16/03/2012	0.244	0.112	0.870	0.982	13.216
17/03/2012_03/03/2016	0.196	0.068	0.900	0.968	6.100
04/03/2016_24/08/2018	0.676	0.083	0.689	0.772	2.969
25/08/2018_29/03/2019	9.789	–0.024	0.577	0.553	21.892
Volatility Breaks in ZEEL					
Date of commencement of Derivative trading: 07-10-2010					
05/01/2000_12/10/2001	3.815	0.137	0.740	0.877	31.114
13/10/2001_08/01/2004	2.143	0.105	0.698	0.803	10.882
09/01/2004_02/10/2008	4.177	0.163	0.307	0.470	7.887
03/10/2008_28/10/2009	0.719	0.114	0.851	0.966	20.982
29/10/2009_09/06/2010	3.145	0.321	0.032	0.354	4.865
10/06/2010_29/11/2015	0.538	0.053	0.802	0.855	3.710
30/11/2015_05/10/2018	0.562	0.050	0.649	0.699	1.868
06/10/2018_29/03/2019	17.897	0.138	–0.556	–0.417	12.629

http://dx.doi.org/10.21511/imfi.17(2).2020.26