IIMB Management Review (2012) 24, 123—136

available at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/iimb

Modelling asymmetry and persistence under the impact of sudden changes in the volatility of the Indian stock market

Dilip Kumar [a,*], S. Maheswaran [b,1]

[a] Institute for Financial Management and Research, 24, Kothari Road, Nungambakkam, Chennai 600034, India
[b] Centre for Advanced Financial Studies, Institute for Financial Management and Research, 24, Kothari Road, Nungambakkam, Chennai 600034, India

Available online 12 June 2012

KEYWORDS
ICSS algorithm;
GARCH class of models;
Regime shifts;
Volatility persistence;
Volatility forecasting

Abstract In this paper, we compare the performance of Inclan and Tiao's (IT) (1994) and Sanso, Arago and Carrion's (AIT) (2004) iterated cumulative sums of squares (ICSS) algorithms by means of Monte Carlo simulation experiments for various data-generating processes with conditional and unconditional variance. In addition, we investigate the impact of regime shifts on the asymmetry and persistence of volatility from the vantage point of modelling volatility in general and, in particular, in assessing the forecasting ability of the GARCH class of models in the context of the Indian stock market.

Introduction

Volatility, in general, represents risk or uncertainty associated with an asset and, hence, exploring the behaviour of volatility of asset returns is relevant for the pricing of financial assets, risk management, portfolio selection, trading strategies and the pricing of derivative instruments (Poon & Granger, 2003). Existing literature recognises the time varying nature of the conditional volatility of the financial asset returns. The dynamic nature of volatility can be modelled by using the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) class of models (Engle, 1982 and Bollerslev, 1986) by specifying the conditional mean and conditional variance equations. Numerous extensions of GARCH models have been proposed in the literature. For instance, Engle and Bollerslev (1986) propose the Integrated GARCH (IGARCH) model to capture the impact of a shock on the future volatility over an infinite horizon. The EGARCH model (Nelson, 1991), GJR-GARCH model (Glosten, Jagannathan, & Runkle, 1993) and APARCH model (Ding, Granger, & Engle, 1993) are all popular models that can in addition capture the asymmetric behaviour of the volatility of returns. The Indian stock market has shown significant growth in the last decade and has made available enormous opportunities for market participants. Like in other emerging markets, investors in India also face higher risk. (See the higher

* Corresponding author. Tel.: +91 (044) 2830 3427; fax: +91 (044) 2827 9208.
E-mail addresses: dksic212@gmail.com, dilip.kumar@ifmr.ac.in (D. Kumar), mahesh@ifmr.ac.in (S. Maheswaran).
[1] Tel.: +91 (044) 2830 3443; fax: +91 (044) 2827 9208.
Peer-review under responsibility of Indian Institute of Management Bangalore

Production and hosting by Elsevier

0970-3896 © 2012 Indian Institute of Management Bangalore. Production and hosting by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.iimb.2012.04.006

weekly standard deviation as shown in Table 5.) Hence, it is essential to study the dynamic behaviour of the volatility of returns from the Indian stock market under the impact of sudden changes in volatility.

Volatility of the returns of financial assets may be affected substantially by infrequent structural breaks or regime shifts due to domestic and global macroeconomic and political events. The standard GARCH model does not incorporate sudden changes in the variance and hence, may be inappropriate for investigating volatility persistence and volatility forecasting. Lastrapes (1989) applies the Autoregressive Conditional Heteroskedasticity (ARCH) model to exchange rates and finds a significant reduction in the estimated volatility persistence when he accounts for monetary regime shifts. Lamoureux and Lastrapes (1990) investigate the persistence of volatility in the GARCH family of models when there are sudden changes in the variance and find that volatility persistence is overstated if structural breaks are ignored. Sudden changes in the variance can also influence the intensity or the direction of information flow among markets, stocks or portfolios as shown by Ross (1989).

Inclán and Tiao (1994) propose the Iterated Cumulative Sum of Squares (ICSS) algorithm which can help in detecting structural breaks in the volatility of a financial time series. The ICSS algorithm detects both a significant increase and decrease in volatility and, hence, can help in identifying both the beginning and the ending of volatility regimes. Wilson, Aggarwal, and Inclan (1996) apply the ARCH model on oil price futures and the associated firm portfolios and find that volatility persistence gets reduced if sudden changes in volatility are accounted for in the model. Aggarwal, Inclan, and Leal (1999) apply the ICSS algorithm on some emerging market indices for the period from 1985 to 1995, and find that volatility shifts are impacted mainly by the local macroeconomic events and the only global event over the sample period that affected several emerging markets was the October 1987 stock market crash in the United States. Malik (2003) applies the ICSS algorithm in detecting time periods of sudden changes in the volatility of five major exchange rates, and finds that volatility persistence is overstated if those sudden changes are ignored. Fernandez and Arago (2003) utilise the ICSS algorithm to detect structural changes in the variance for European stock indices and their findings are in confirmation with the findings of Aggarwal that the markets not only react to local economic and political news, but also to news originating in other markets. Malik, Ewing, and Payne (2005) find that controlling for regime shifts in volatility dramatically reduces the persistence of volatility in the Canadian stock market. Hammoudeh and Li (2008) also obtain similar findings for the Gulf Cooperation Council (GCC) stock markets. Wang and Moore (2009) find that, with the new European Union members, the persistence in volatility is significantly reduced when the model incorporates regime changes.

The central aim of this paper is to study of the impact of sudden changes in the variance on the asymmetry and persistence of volatility in the Indian stock market (specifically S&P CNX Nifty, CNX 100, S&P CNX 500, CNX Nifty Junior, CNX Midcap and CNX Smallcap) from the vantage point of volatility modelling and to assess the forecasting ability using the GARCH class of models. The most widely used methods for detecting sudden changes in volatility are Inclán and Tiao's (1994) (IT) ICSS algorithm and the Sanso, Arago, and Carrion (2004) (AIT) ICSS algorithm. It is also a widely known fact that the financial time series exhibit fat tails. The present study compares the performance of these two methods for various data-generating processes, such as GARCH and stochastic volatility processes. In particular, earlier studies had not assessed these two methods with respect to stochastic volatility processes. In addition, we take into account leptokurtosis by making use of the Student *t* distribution with 5 degrees of freedom in the simulations. We then investigate empirically whether or not the inclusion of regime shifts in the GARCH class of models reduces the asymmetry and persistence of volatility in the Indian stock market. In addition, we compare the out-of-sample performance of the GARCH class of models with and without sudden changes by considering the one-step-ahead forecasting ability. We find that incorporating regime shifts in the GARCH model provides better performance in terms of forecasting ability. The study of the impact of structural changes in volatility on the accuracy of volatility forecasts has largely been ignored in the context of the Indian stock market and hence, our paper has a significant contribution to make in this area.

The remainder of this paper is organised as follows: The next section introduces the tests we will use in this study. In the third section, we undertake Monte Carlo simulation experiments to evaluate the IT and AIT ICSS algorithms. The fourth section describes the data and discusses the computational details. The fifth section reports the empirical results and the sixth section concludes with a summary of our main findings.

Methodology

Detecting points of sudden changes in variance

Inclan and Tiao's (IT) (1994) ICSS algorithm

Suppose ε_t is a time series with zero mean and with unconditional variance σ^2. Suppose the variance within each interval is given by ${\tau_j}^2$, where $j = 0, 1, \ldots\ldots\ldots, N_T$ and N_T is the total number of variance changes in T observations, and $1 < k_1 < k_2 < \ldots. < k_{NT} < T$ are the change points.

$$\sigma_t^2 = \tau_0^2 \quad \text{for} \quad 1 < t < k_1 \tag{1a}$$

$$\sigma_t^2 = \tau_1^2 \quad \text{for} \quad k_1 < t < k_2 \tag{1b}$$

$$\sigma_t^2 = \tau_{NT}^2 \quad \text{for} \quad k_{NT} < t < T \tag{1c}$$

In order to estimate the number of changes in variance and the time point of each variance shift, a cumulative sum of squares procedure is used. The cumulative sum of the squared observations from the start of the series to the kth point in time is given as: