Modelling the time-varying volatility of equities returns in Kenya

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Abstract

Purpose – The paper seeks to investigate the relationship between stock volatility and returns in the Nairobi Stock Exchange, Kenya. It uses daily returns data over the period January 2006 to April 2009.

Design/methodology/approach – Empirical analysis is based on quantitative analysis with emphasis on descriptive statistics, and advanced econometrics models which are well suited to capture the time-varying volatility. The models utilised in this study fall into the family of generalised autoregressive conditional heteroscedasticity models.

Findings – The main findings of the paper are as follows: the equities returns are symmetric but leptokurtic and thus not normally distributed; volatility of returns is highly persistent; the leverage effects are not significant; and the impact of news on volatility is not significantly asymmetric.

Practical implications – The findings of this paper will aid policy makers, policy analysts, investors, and academics to gain in-depth understanding of dynamics of the equities returns in Kenya particularly, with regard to leverage and impact of news.

Originality/value – The paper was conducted at a time when the volatility of the equity market returns in the global stock markets in general and Kenya in particular was high on account of the global financial crisis and the aftermath of the post-election violence in Kenya. Given that excess volatility in the stock market undermines the reliability of stock market prices as a signal to the true value of the firm, the findings of this paper will provide useful insights in the assessment of portfolio allocation and investment decisions in Kenya.

Keywords Economic conditions, Equity capitals, Stock returns, Stock exchanges, Kenya

Paper type Research paper

1. Introduction

In the last two decades, the development of the stock market has gained prominence in African countries not only as a possible alternative source of financing for investment but also as an avenue for risk diversification among investors. The strong linkages between stock market variables and the macro-economy and thus economic policy has generated considerable research interest in this area in the past (Loayza and Ranciere, 2006; Andersen and Tarp, 2003; Ross and Zava, 1998, 1996; Singh, 1997, 1993; Galeotti and Schiantarelli, 1994). In the wake of the global financial crisis, research focus has shifted towards analysis of the transmission of the crisis signals and related developments from the USA to the global economy. For the period up to the end of the crisis, most studies concentrated on stock market developments in developed economies and emerging markets (Sarkar *et al.*, 2009; Fotios and Panayotis, 2007; Diebold and Yilmaz, 2008; Syed *et al.*, 2007; Jaeun, 2005; Kohers and Kohers, 2005; Alessandro, 2001). However, with increased globalization and integration of the world economy and the financial sector, researchers in developing countries and some least

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developed countries have also started taking a keen interest in the equities return-volatility behaviour (Olowe, 2009; Mobarek, 2009; Chinzara and Aziakpono, 2009; N'dri.Konan, 2008; Kashif, 2007; Rajni and Mahendra, 2007; Frimpong and Oteng-Abayie, 2006; Ogum, *et. al.*, 2005; Malik *et al.*, 2009).

Nevertheless, there is still a dearth of this knowledge in the least developed countries. In Sub-Saharan Africa, with the exception of South Africa, very few empirical studies on stock market volatility are available. However, the rapid trends in terms of stock market development in African countries and its possible effects on policy has now generated research interests in financial markets and particularly in stock market volatility. In Kenya, for example, studies focusing on stock market development are sparse. The only study we have seen which focuses on stock market volatility is Ogum *et al.* (2005). It offers a comparative analysis of the behaviour of stock market performances in Kenya and Nigeria with main emphasis on:

- the predictability of returns from past observations;
- the auto-regressive behaviour of conditional volatility;
- the asymmetric response of conditional volatility to innovations; and
- the conditional variance risk premium.

The main findings of this paper are that the asymmetric volatility coefficient is significant and positive, suggesting that positive shocks increase volatility more than negative shocks of an equal magnitude in Kenya. In Nigeria, return series exhibit a significant and positive time-varying risk premium. The results also show that expected returns are predictable, that the auto-regressive return parameters are significant in both Kenya and Nigeria. Finally, the generalised autoregressive conditional heteroscedasticity (GARCH) parameter is statistically significant, indicating that volatility persistence is present in the two markets.

Our study is distinct from Ogum *et al.* (2005) in terms of the choice of the period of study. The period 2006-2009 under study in this paper was characterised by both domestic and external shocks to the Kenyan economy, the effects of which created episodes of unprecedented volatility in the Nairobi Stock Exchange (NSE). In the 2006 to mid-2008 period, the Kenyan economy experienced a peak performance in the stock market, following the issuance of a number of initial public offerings (IPOs) that attracted both local and foreign investors. There was excess demand for the IPOs owing to the high expected yields. The IPOs were oversubscribed and investors earned high returns in the NSE during that time. However, after July 2007, the stock market index started plummeting steadily in anticipation of general elections in December 2007 with most foreign investors offloading their stocks in the market. After the contested general election results violence ensued across the country forcing more investors to offload most of their stocks in the market in a move which can be seen as "flight to safety". As the market started to recover from the post-election violence the financial crisis struck forcing the market index to plummet even further.

Excess volatility affects the economy in at least in two respects. First, excess volatility in the stock market not only distorts the role of stock market price as a signal to the true intrinsic value of the firm but it also acts as a deterrent to effective investment by occasioning prolonged periods of uncertainty. Second, excess stock market volatility complicates monetary policy decision making especially when there are episodes of stock price bubbles, which are likely to create asset inflation. Moreover, the equity market is an important channel of monetary transmission mechanism via the balance sheet effect, Tobin-q and household liquidity channels. It therefore influences both investors' behaviour and their portfolio allocation and consumer behaviour. This paper therefore seeks to address the following specific questions:

- What is the statistical nature of price and returns series at the NSE?
- What is the nature of volatility in the market?
- Is there leverage effect and asymmetric impact of news in the NSE?

The rest of the paper is organised as follows: Section 1.1 reviews the performance of the stock market in Kenya; Section 1.2 presents data sources and type; Section 2 presents the methodology; Section 3 presents empirical results while Section 4 concludes with some recommendations.

1.1 Linkage between the stock market and the economy

The developments that impact the stock market may be policy induced or not. The policy induced developments may arise from the conduct of monetary policy while non-policy induced developments may be due to major developments such as the global financial crisis.

The monetary policy stance is transmitted into the real economy through various channels: asset price channel, interest rate channel, exchange rate channel and credit channel. All of these channels affect stock prices directly or indirectly. The asset price channel draws its strength from the finding that the decline in asset prices owing to the stock market crash in the USA in 1929 and the same in Japan in the late 1980s and early 1990s, was followed by a slowdown in economic activity as well as increased financial and banking sector instability. Furthermore, several empirical studies indicate that the monetary policy stance adopted by the central bank impacts stock price movements. For example, Ehrmann and Fratzscher (2004), shows that monetary policy shocks have instantaneous and significant effects on stock prices in the US economy. A tightening of monetary policy by 50 basis points reduced US stock returns by about three percent on the announcement day. Any significant downturn in the stock market limits firms' ability to raise capital for further expansion, thus retards output growth, lowers consumer demand, and may cause financial instability.

As shown in Figure 1, the credit view argues that monetary policy influences the financing cost of a firm as well as the availability of loans. If a credit channel is at work for firms that are quoted on stock markets, one would expect that expansionary monetary policy will enable them to take bank loans on easier terms and gain on the bank lending rate. This interest differential gain will improve their balance sheets, make them more competitive, and induce them to expand business activities. The burgeoning effect of these activities will be reflected through the stock price. Conversely, contractionary monetary policy will affect the firms' share price in the opposite direction.

Own illustration. In addition, Figure 1 shows how financial developments in the global economy impacts the national economy. The financial crisis impacts the economy through four main channels: first, the declining migrant remittances. In a situation where the remittances are directed at asset prices, such as buying of real estate, the declining remittances will lead to declining demand for property. Alternatively,

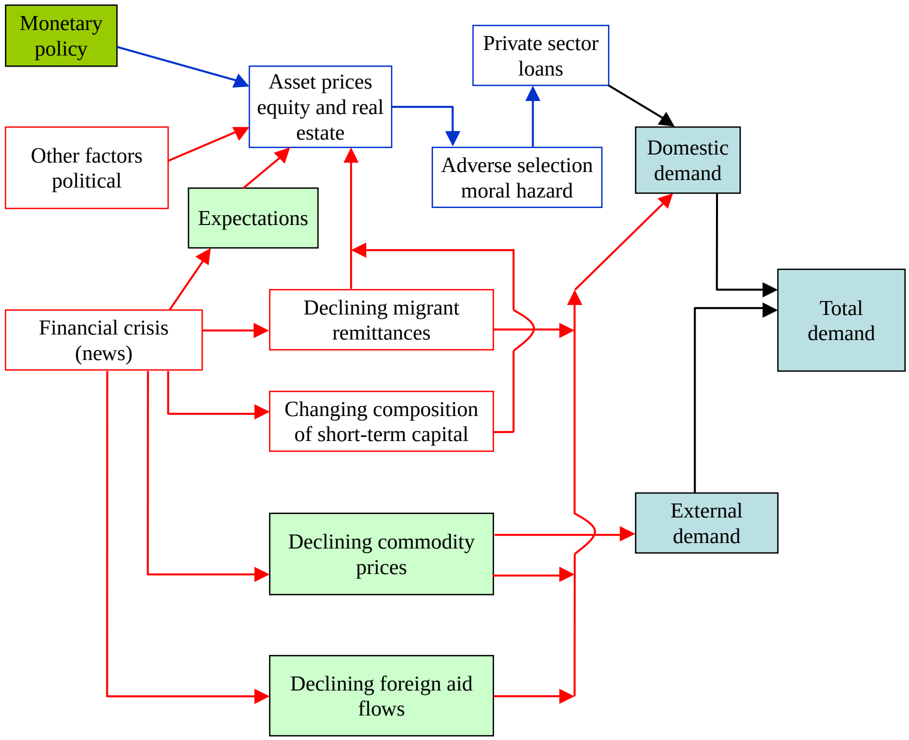


Figure 1.
Monetary policy and financial crisis transmission mechanisms

where the remittances are invested in the stock market, a slow down in the remittances will lead to lower demand for stocks leading to reduced economic activity and hence declining stock market index. Second, there is a changing of composition and direction of short-term capital flows. A global financial crisis occasions a change of direction of flow of short-term capital, for example, foreign investors in the stock market will be forced to sell domestic securities and remit the proceeds abroad. This will impact on the level of activity in the stock market.

Other factors which may impact on stock market performance include political developments in the country. Positive political developments, such as successful and democratic elections, will improve the stock market performance. On the other hand, negative political developments, such as bungled elections, will impact the stock market negatively.

Therefore, stock market performance is a critical element in the outlay of the national economy. Any developments, whether internal or external, will impact on the stock market which will eventually affect aggregate demand.

1.2 Review of the performance of the stock market in Kenya

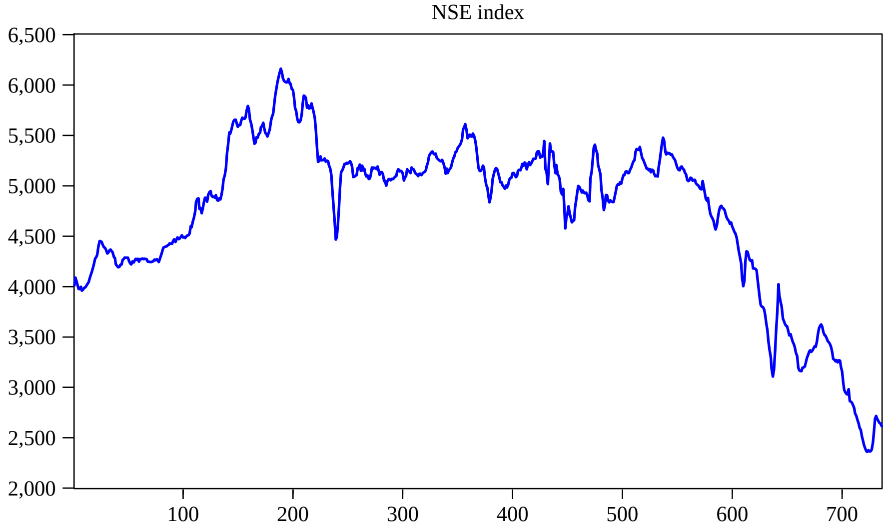
In Kenya, during the period prior to the 2007 post-election crisis and global financial crisis, the NSE registered impressive growth in all the stock market indicators as a result of successful privatization programs which saw unprecedented levels of oversubscriptions during IPOs. However, in the period following the December 2007 general elections, a bearish trend and high levels of uncertainty dominated the stock market performance.

In the period under review, the NSE index displays four distinct phases. During the first phase, the NSE index appears to increase over time which is the period 2006:1 to the end of 2006:6. During this period, the NSE index rose from 4,000 to a high of 6,400 which implies that the level of activity during this time was high. During this period, the returns appear to be stable (Figure 3) in the sense that the returns from one period to the other do not display extreme swings. The second phase which appears to be the shortest covers the month of January 2008 when the stock market was under pressure following the post-election violence that rocked the country with devastating effects on the real and financial sectors of the economy (Figure 2).

During this short time, the NSE index plummeted to a low of 4,500 from a high of 6,400 in late December 2007 with returns appearing to display large swings. The third phase reveals a period when the NSE index appears relatively stable but with high volatility in returns. The fourth phase is characterised by the declining trend of the NSE index. Coincidentally, this is the period of the global financial crisis which started in the USA. During this period, it appears that returns tend to display large swings (from one period to another). Overall, as shown in Figure 3, the returns series tend to display volatility clustering or volatility pooling, where large changes in returns series tend to be followed by large changes while small changes tend to be followed by small changes in returns.

1.3 Data sources and type

The data on the stock market price is taken as the stock market index. The stock market index used in this study comprises 736 daily observations on the NSE index covering the period 2006-2009. Daily returns are computed as logarithmic price relatives: $R_t = \ln P_t - \ln P_{t-1}$, where P_t is the daily price at time t.



Source: NSE

Figure 2.
Trend of the NSE index

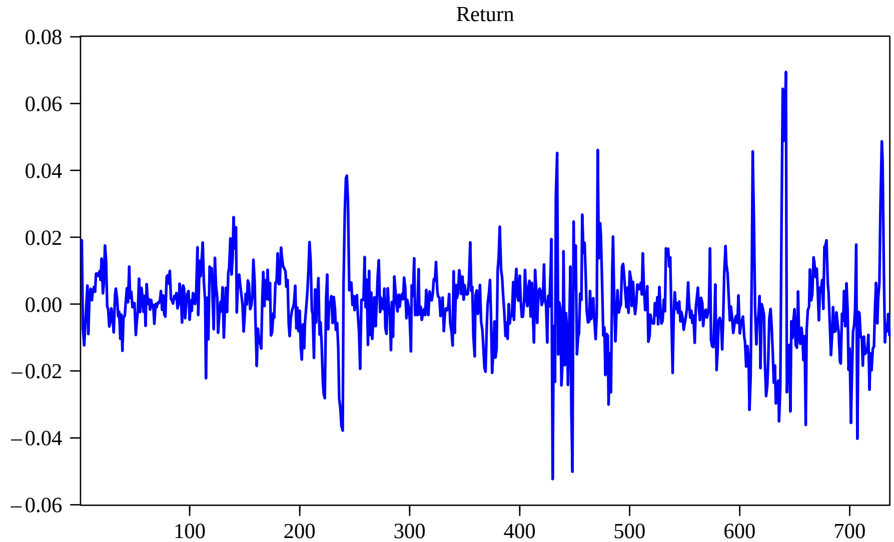


Figure 3.
Returns in the NSE

2. Modelling volatility

The descriptive statistics show that the returns series is not normally distributed. Therefore, modelling a series that is not normally distributed using the conventional time series methods which appeal to the constant variance or homoscedasticity and the normality of the error term may not yield the desired results. As shown in the literature (Engle, 1982; Bollerslev, 1986; Floros, 2008), financial markets tend to show high level of volatility as a result of unexpected events, uncertainty in prices (and returns), and non-constant variance. Thus, analysis of the financial market calls for models which do not dependent on the classical assumptions.

The earliest work on modelling volatility is from Engle (1982) who came up with the autoregressive conditional heteroscedaticity (ARCH) model which was later generalised as GARCH by Bollerslev (1986). The GARCH(1,1) takes the form [i]:

$$Y_t = X_t^{'}\phi + \varepsilon_t \tag{1}$$

and:

$$\sigma_t^2 = \varpi + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{2}$$

Equation (1) is the mean equation and is a function of exogenous variables X and the error term $\varepsilon(\sim N(0, \sigma^2)$. Equation (2), on the other hand, is the conditional variance equation which is a one-period ahead forecast variance based on past information. Here ϖ is a constant term, ε_{t-1}^2 (the ARCH term) is lag of the squared residual from equation (1) and it shows news about volatility from the previous period, while σ_{t-1}^2 (the GARCH term) is last period's forecast variance. In equation (2), α is the reaction parameter or GARCH error coefficient. If α is large, volatility reacts quite intensely to market movements. The parameter, β is the persistence parameter or GARCH lag coefficient. Large values of β indicate that shocks to conditional variance take a long time to die out, so volatility is very persistent.

As shown in the literature (Akgiray, 1989; Connolly, 1989; Baillie and DeGennaro, 1990; Bera and Higgins, 1993; Bollerslev *et al.*, 1992; Floros *et al.*, 2007; Floros, 2008), a simple GARCH model is parsimonius and gives significant results and allows one to easily compute the *j*-period ahead forecast of volatility. However, the forecasts of the future variance in the standard GARCH model are linear in current and past variances. This means that the GARCH model treats the impact of news as symmetric. That is, negative and positive shocks have the same effect on conditional volatility.

As shown in the financial theory, increases in variance results in higher-than-expected returns. To account for this phenomenon, the GARCH-in-mean was developed by Engle *et al.* (1987). The GARCH-M model is given as:

$$Y_t = \mu + \beta_1 \sigma_t^2 + \varepsilon_t \quad \varepsilon_t \sim N(0, \sigma_t^2) \quad \sigma_t^2 = \varpi + \alpha \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 \tag{3}$$

If $\beta_1 > 0$ and significant, then increased risk leads to a rise in the mean return with $\beta_1 \sigma_{t-1}^2$ being interpreted as a risk premium.

The GARCH models assume that both negative and positive news have a symmetric effect on volatility. That is, both negative and positive news to the market tend to impact volatility in equal magnitude. However, as shown in the literature (Engle and Ng, 1993; Floros, 2008), negative and positive news tend to have differential (asymmetric) effects on volatility. To account for this limitation of the GARCH models, other specifications were developed such as the TGARCH and EGARCH, CGARCH and AGARCH models which take into account the asymmetric effects of news.

Specifically, the EGARCH model was developed by Nelson (1991) to account for leverage effect which was first noted by Black (1976). The EGARCH model takes the form:

$$\log(\sigma_t^2) = \varpi + \beta \sigma_{t-1}^2 + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \lambda \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \tag{4}$$

The logarithmic form of the conditional variance implies that the leverage effect is exponential suggesting that the variance is non-negative. Leverage effects is shown by $\lambda < 0$. If $\lambda \neq 0$ then the impact of news is asymmetric.

The threshold GARCH (TGARCH) model was developed independently by Zakoian (1994) and Glosten *et al.* (1993) and its generalised version is given as:

$$\sigma_t^2 = \varpi + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \lambda \varepsilon_{t-1}^2 \Gamma_{t-1} \tag{5}$$

where $\Gamma_t = 1$, if $\varepsilon_t < 0$ and $\Gamma_t = 0$ otherwise impying $\varepsilon_{t-1}^2 \Gamma_{t-1}$ is an interaction dummy variable. In the model, good news, $\varepsilon_{t-1} > 0$, and bad news $\varepsilon_{t-1} < 0$, have differential effects on the conditional variance. Here, α represents the impact of good news while $\alpha + \lambda$ represents the impact of bad news. If $\lambda > 0$, bad news increases volatility in the market suggesting existence of leverage effect of the first order. If $\lambda \neq 0$, the news impact is asymmetric.

3. Empirical results

3.1 Descriptive statistics of price and returns

The descriptive statistics reveal that during this period the difference between the highest and lowest value of NSE index is 3,801.450 points while the standard deviation is large suggesting that during this period there was high volatility in the market.

However, the estimated coefficient is not significantly different from zero, which is ideal. The coefficient of skewness is negative suggesting that the NSE index has a long tail to the left. The coefficient of kurtosis exceeds three and implies that the NSE index series has fat tails or leptokurtic. The normal test shows that the price is not normally distributed.

In terms of the returns series of the NSE (Table I), it appears that generally there is a very large difference between the minimum and maximum returns. In addition, the standard deviation is high indicating a high level of fluctuation of the NSE daily returns. The coefficient of skewness is positive but not far from zero. Absence of strong skewness suggests that the NSE return series is symmetric. The NSE's returns series appear to have high coefficient of kurtosis which suggests that there is evidence of fat tails or is leptokurtic which is a common feature of financial market returns. Overall, according to the Jarque-Bera test the returns are not normally distributed.

3.2 Estimation results

We estimate some GARCH-family models to explain conditional variance and volatility clustering in the Nairobi stock market. An iterative procedure is used to compute quasi-maximum algorithm. Heteroscedacitiy consistent covariance is used to compute quasi-maximum likelihood covariates and standard errors in a manner consistent with Bollerslev and Woolridge (1992).

Table II reports the parameter estimates of all the conditional volatility models defined in the previous section. In the GARCH(1,1) model the estimated coefficient of the lagged squared returns is positive, as expected, and significant at 1 percent level of testing. This finding suggests that strong GARCH effects are apparent in the NSE. In addition, the coefficient of lagged conditional variance is positive, as expected, and significant at one percent level. The magnitude of the estimated parameters, which is less than unity, indicates that the impact of old news on volatility is significant. The sum of the ARCH and GARCH coefficients in the GARCH(1,1) is 0.909 which is very close to 1, indicating that the volatility shocks are quite persistent. The fact that these terms sum to less than unity is a necessary condition for the mean equation (1) to be covariance stationary.

In the TGARCH model, the estimated coefficients of the reaction and persistence parameters are consistent with those obtained in the GARCH(1,1) model. Therefore, the impact of good news α is found to be 0.338, while the impact of negative news $\alpha + \lambda$ is found to be 0.391. The $\lambda > 0$ implies that bad news impacts volatility

	NSE index	NSE returns
Mean	4,729.079	−0.000582
Median	5,013.365	−0.000711
Maximum	6,161.460	0.069476
Minimum	2,360.010	−0.0552339
Standard deviation	797.6687	0.012380
Skewness	−1.041296	0.560357
Kurtosis	3.584152	7.907785
Jarque-Bera	143.4718	776.109
Probability	0.000	0.000

Table I.
Descriptive statistics of stock price and returns

Table II. Estimation results: variance equations

	ARCH(1,0)		TARCH(1,0)		GARCH(1,1)		TGARCH(1,1)		EGARCH(1,1)	
ϖ	$5.55 \times 10^{-5***}$	(6.899)	$5.76 \times 10^{-5***}$	(7.091)	1.46×10^{-5}	(3.288)	1.41×10^{-5}	(3.281)	−1.599	(−4.399)
α	0.523***	(4.399)	0.575***	(3.021)	0.366***	(3.610)	0.338**	(2.087)	0.503***	(5.062)
λ	–		−0.145	(−0.703)	–		0.053	(0.321)	−0.020	(−0.316)
β	–		–		0.535***	(6.358)	0.542	(6.646)	0.869***	(24.061)

Note: Significance at: *10, **5 and ***1 percent more than positive news. This finding is also taken to mean that there is evidence of leverage effects in the Nairobi stock market. However, an estimated coefficient of 0.053 is not statistically significant at the conventional levels of testing. In addition, using the Wald coefficient restriction it is shown that λ is not statistically different from zero implying that though negative news impacts volatility more than positive news, the resulting impact is not significantly asymmetric.

In the EGARCH model, the α is found positive, as expected, and significant at a conventional level of testing (Figure 4). The high estimated parameter is an indication that the magnitude of the shocks has a significant impact on volatility. The estimated parameter, β of 0.869 shows that persistence of volatility is quite high. In terms of the decay process of volatility it is found that it takes approximately five days for the effect of a shock in the returns to lose half of its effect on the variance of the returns. In addition, the parameter, β of 0.869 which is less than unity suggests that the unconditional variance exists, and is a mean-reverting process. The direction of effect $\lambda < 0$ is not significant at the conventional levels of testing. The negative sign suggests that there are leverage effects in the returns series. However, being insignificant implies that these effects are not pronounced during the sample periods. This finding is consistent with those from the TGARCH(1,1) model.

3.3 The news impact curves

To graphically show the asymmetric effect of news, Engle and Ng (1993), developed the news impact curve. The news impact curve measures how new information is incorporated into volatility estimates. It is constructed by plotting the volatility (sig2) against the impact (e/sig). In this regard, we fix the last period's volatility to the median of the estimated conditional variance series. We then estimate the one-period impact, conditional on the last period's volatility as shown in Figure 5. Using the GARCH(1,1) and EGARCH(1,1) model, we construct news impact curves shown in Figure 5.

As expected, the news impact curve from the GARCH(1,1) model is symmetric in nature and therefore does not reveal any differential impact of positive and negative news. Using the EGARCH(1,1) it appears that negative and positive news have differential impact but such impact is not significant in the NSE. It is shown, for example, news measuring positive and negative eight reveals that negative news

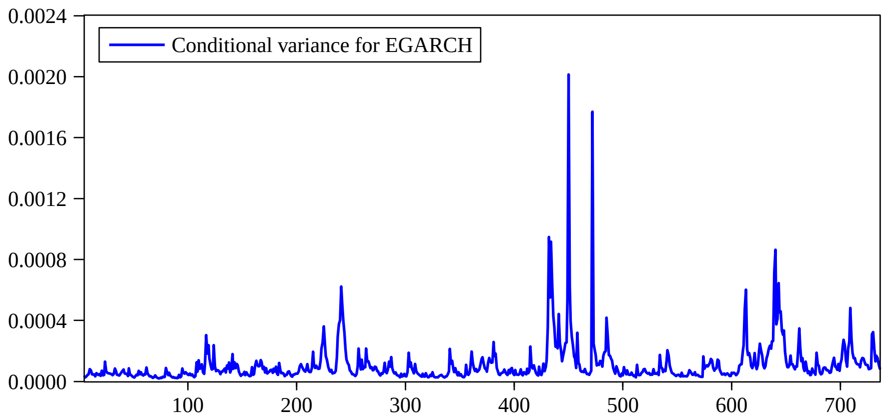


Figure 4.
Conditional variance for EGARCH

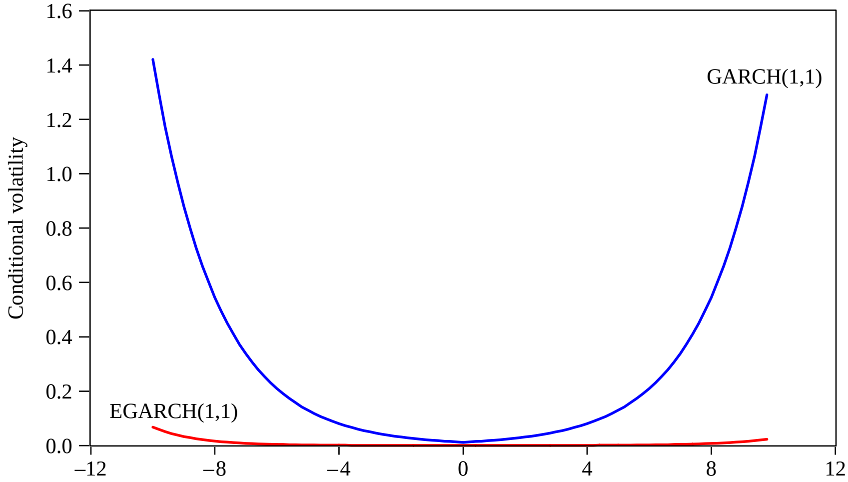


Figure 5.
News impact curves

yields a slightly higher variance compared with that resulting from positive news. Therefore, in the overall sense it means that negative news impacts volatility to a much greater degree than good news does of an equivalent magnitude.

4. Conclusions

This study seeks to investigate volatility in the NSE over the period 2006:1-2009:4 using daily returns series. It uses the GARCH(1,1), TGARCH(1,1) and EGARCH(1,1). Using the GARCH model, it is shown that there is a high level of persistence of volatility in the stock market and also the historical behaviour of volatility tends to explain the current volatility. To account for the asymmetric effects, the TGARCH and EGARCH models reveal that volatility is highly persistent but the leverage effects are not significant. In addition, it is found that the impact of news on volatility is insignificantly asymmetric with negative news impacting volatility more than positive news.

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