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Abstract

This paper studies the impact of inflation and exchange rate on conditional stock market volatility. Sentana's QGARCH model is generalized to include the asymmetries in inflation and exchange rate that are not allowed in linear GARCH (p, q) model of Bollerslev (1986). Nonlinear specifications of QGARCH model then show the significant relationship of inflation and exchange rate to conditional stock market volatility.

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1. Introduction

Volatility, the conditional standard deviation of the stock return and its determinants has been studied over the years and many facts have been presented in the literature. Schwert (1989) in his classic paper studied the relationship between stock market volatility and volatility of real and nominal macroeconomic variables. He looked at the impact of the level of economic activity, financial leverage and stock trading. He concluded that movements in inflation and real output have weak predictive power on volatility of stock market and return. Davies and Kutan (2003) extended Schwert's study by accounting for volatility in an international setting.

Other studies carried out by Huang and Kracaw (1984); Kaul (1987) and Hamilton and Lin (1996) have variously found from their study that other macroeconomic factors such as GDP growth, and short term interest rates are important explanatory variable in explaining volatility in stock market returns. None of them have looked at the impact of the combination of inflation and exchange rate and volatility of stock returns having known that exchange rate provides evidence for the impact of international market on the overall health of an economy. This is particularly so in a developing economy like Nigeria with high inflation rate and very strong dependence of its economy on foreign trade. This study therefore focuses on the examination of the predictive power of inflation and Naira/US Dollar exchange rate on Nigerian's stocks market volatility. The result of this research would give important implication for policy makers, investors and economic forecasters.

2. Methodology

Most economic and financial time series and especially conditional stock market volatility have always been studied using the ARCH and GARCH models introduced by Engle (1982) and Bollerslev (1986) respectively. These models help to study volatility clustering. Assuming linearity, the first and second conditional moments of return series (given its past behaviours) can be jointly estimated by GARCH (*p,q*) in order to characterize the dependence of future observations on past values.

Consider a univariate stochastic process for stock market returns where the information set Ω_t of monthly returns is defined to be $\{r_t, r_{t-1}, ..., r_{t-q}, ..., 1\}$. The jointly estimated GARCH (1,1) model introduced by Bollerslev (1986) is given by,

$$r_t = \mu + \varepsilon_t, \quad \varepsilon_t = \sigma_t z_t, \quad z_t \sim N(0,1) \tag{1}$$

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

where σ_t^2 is measurable with respect to Ω_{t-1} and $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$ and $\alpha + \beta < 1$ such that the first two moments of the unconditional distribution of the series are time invariant. It should be noted that the conditional variance σ_t^2 is only linear in the squares of the past values and not in the information set r_{t-1} (Sentana, 1995).

In this work, the impact of volatility on the return series will be measured using the GARCH-M model,

$$r_t = \mu + c\sigma_{t-1}^2 + \varepsilon_t \qquad \varepsilon_t = \sigma_t z_t, \qquad z_t \sim N(0,1) \tag{3}$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4)$$

where c is the risk premium parameter which indicates that the return is related to its volatility (Tsay, 2005). Following Saryal (2007), the impact of asymmetric effect of shocks on volatility will be estimated using Sentana's QGARCH (1,1) model,

$$r_t = \mu + \varepsilon_t, \quad \varepsilon_t = \sigma_t z_t, \qquad z_t \sim N(0,1) \quad (5)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma\varepsilon_{t-1} \quad (6)$$

where the term $\gamma\varepsilon_{t-1}$ makes it possible for positive and negative shocks to have different effects on conditional volatility. Once the appropriate model is determined, thus the estimation of the impact of inflation and exchange rate on stock market volatility can be investigated by specifying two models:

Model I

$$r_t = \mu + \lambda_1 (Inflation)_t + \lambda_2 (Exchrate)_t + \varepsilon_t, \quad \varepsilon_t = \sigma_t z_t, \quad z_t \sim N(0,1) \quad (7)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \theta(Inflation)_{t-1} + \phi(Exchrate)_{t-1} \quad (8)$$

The above model estimates the impact of the previous period inflation rate and exchange rate in order to capture time-variation in the (conditional) mean and variance equations.

Model II

$$r_t = \mu + \lambda_1 \Delta(Inflation)_{t-1} + \lambda_2 \Delta(Exchrate)_{t-1} + \varepsilon_t, \quad \varepsilon_t = \sigma_t z_t, \quad z_t \sim N(0,1) \quad (9)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \theta\Delta(Inflation)_{t-1} + \phi\Delta(Exchrate)_{t-1} \quad (10)$$

Here, the standard GARCH (1,1) model is extended by including the impact of changing inflation rate and exchange rate.

Whenever there is evidence that an asymmetric GARCH specification is suitable for conditional volatility estimation, then the above models should be replaced with the appropriate conditional variance specification given by QGARCH.

3. Results and Discussion

The monthly share indices, inflation rate and average monthly Nigeria/US dollar exchange rate from 1991 to 2008 were used in this study. The data were collected from Central Bank of Nigeria (Exchange rates and Share indices) and Nigerian Bureau of Statistics (Inflation rates). These data range from 1991 to 2008. Nominal Stock return is given by, $r_t = 100 \times \ln\left(\frac{S_t}{S_{t-1}}\right)$ where S_t is the stock index. Table 1 shows the descriptive statistics for all the three variables under study. The results indicate that the average monthly return on stock is 1.9%, the average exchange rate is N75.48/ 1 US Dollar and inflation rate is 22.60% per month. It can be observed that inflation rate is very high and one could expect higher nominal stock return in line with the simple Fisher effect.

The standard deviation of the return series, exchange rate and inflation are 5.5, 50.6 and 20.30% respectively. It could be seen that the figure are quite high as well. This is due to frequent political changes in Nigeria along with incessant fiscal and economic changes that took place within this period.

Table 1: Descriptive Statistics on Return Series, Exchange rates and Inflation rates

Statistics	Nominal Stock Returns, r_t	Exchange Rates, E_t	Inflation Rates, I_t	Change in Exchange Rates, ΔE_t	Change in Inflation, ΔI_t
Minimum	24.0799	8.869000	0.900000	-10.07600	-4.800000
Maximum	19.1879	137.2230	78.50000	64.11400	3.900000
Mean	1.90035	75.48187	22.59674	0.545400	0.026512
Standard Dev.	5.510498	50.60006	20.30065	4.656747	1.537140
Skewness	-0.444245	-0.138914	1.273709	11.95399	-0.344580
Kurtosis	6.138192	1.144679	3.315890	163.3378	3.995244
Jarque-Bera	95.29574	31.52800	59.02755	235423.1	13.12801
Prob.	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.001410)

The Impact of Inflation and Exchange Rate on Stock market Volatility

The appropriate model for stock return volatility considering the effect of exchange rate and inflation rate is given as,

$$\underset{(0.0000)}{r_t = 13.4167} + \underset{(0.0000)}{0.3746 r_{t-1}} - \underset{(0.0770)}{0.0714 I_{t-1}} + \underset{(0.0193)}{0.0543 E_{t-1}} - \underset{(0.0000)}{5.0852 \log \sigma_t} + \varepsilon_t$$

$$\underset{(0.0004)}{\sigma_t^2 = 12.6250} + \underset{(0.0004)}{0.3017 \varepsilon_{t-1}^2} + \underset{(0.0054)}{0.1321 E_{t-1}} - \underset{(0.0001)}{0.1670 I_{t-1}} - \underset{(0.0074)}{0.4155 \varepsilon_{t-1}}$$

$R^2 = 0.1592$, Adj. $R^2 = 0.1219$, DW =2.1300, AIC = 5.8547, SIC = 6.0125, Sk. = -0.2772, Kurt. = 7.6230, JB. = 192.4050 (0.0000), ARCH-LM (3) = 0.9465 (0.4191)

The impact of inflation and exchange rates on the mean equation is not significant, but the effect of exchange rate on conditional variance is positive and significant. The estimated sample variance $\left(\omega/(1-\alpha)\right)$ is 18.08 which indicates that the impact of shocks on the conditional variance will last for a long time period.

Model I

Here the predictive power of the previous period Inflation and Exchange rate on stock market volatility is examined by using ARCH (1). As seen from the model, the estimated coefficient of exchange and inflation rates are 0.179684 and -0.077602 respectively and these are significant.

$$\underset{(0.0000)}{r_t = 2.1616} + \underset{(0.0000)}{0.5503 r_{t-1}} - \underset{(0.3149)}{0.1383 \log \sigma_t} + \varepsilon_t$$

$$\underset{(0.0053)}{\sigma_t^2 = 3.6526} + \underset{(0.0001)}{0.5087 \varepsilon_{t-1}^2} + \underset{(0.0000)}{0.1797 E_{t-1}} - \underset{(0.0000)}{0.0776 I_{t-1}} + \underset{(0.0030)}{1.4175 \varepsilon_{t-1}}$$

R^2 = 0.1214, Adj. R^2 = 0.0914, DW =2.4249, AIC = 5.6753, SIC = 5.8016, Sk. = 0.4331, Kurt. = 4.6350, JB. = 30.3850 (0.0000), ARCH-LM (3) = 0.8527 (0.4666)

A 1% increase in exchange rate causes increases in the conditional volatility of stocks in Nigeria by 21%. The estimated sample variance $\left(\omega/(1-\alpha)\right)$ is 7.25 which indicate a high persistent volatility of stock returns.

Model II

The impact of variability in the inflation and exchange rate is investigated by Model II. This is achieved by modelling conditional variance on the changes in the predictor variables.

$$\underset{}{r_t} = \underset{(0.0822)}{2.3909} + \underset{(0.0000)}{0.3996} r_{t-1} - \underset{(0.7335)}{0.1737} \log \sigma_t + \varepsilon_t$$

$$\underset{}{\sigma_t^2} = \underset{(0.0000)}{13.4284} + \underset{(0.0000)}{0.7173}\varepsilon_{t-1}^2 + \underset{(0.6680)}{0.0342}\sigma_{t-1}^2 - \underset{(0.7906)}{0.1621}\Delta E_{t-1} + \underset{(0.0000)}{2.0054}\Delta I_{t-1} + \underset{(0.0065)}{2.7544}\varepsilon_{t-1}$$

R^2 = 0.1479, Adj. R^2 = 0.1145, DW =2.1154, AIC = 5.8983, SIC = 6.0404, Sk. = 0.1947, Kurt. = 4.2748, JB. = 15.7695 (0.0004), ARCH-LM (3) = 1.2776 (0.2831)

As seen from the model, the estimated coefficients are all significant but surprisingly with different signs indicating different type of impact on the volatility of stock market return. The estimated sample variance $\left(\omega/(1-\alpha)\right)$ is 47.50 which indicate a higher persistent volatility of stock returns.

4. Conclusion

In this paper, we have shown that previous exchange rates and inflation rates have significant effects on conditional stock market volatility. Changes in exchange rates and inflation rates, as measured by changes in these rates also have greater impact in predicting the stock market volatility in Nigeria. These results are in agreement with Fisher's effect in international stock market. this result will serve as a guide to the policy makers on finance, the stock brokers and investors. Our findings are in line with that of Saryal (2007).

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