MODELLING AND FORECASTING VOLATILITY (ASYMMETRIC GARCH MODELS)

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Outline of the Presentation

- Background
- Exponential GARCH Model
- GJR GARCH Model
- Model Selection Criteria
- Empirical Applications

Background

- A feature of many financial time series that is not captured by ARCH and GARCH models is the 'asymmetry effect', also known as the 'leverage effect'.
- The underlying assumption: an unexpected fall in asset prices may increase volatility more than an unexpected increase of the same magnitude.
- In other words, 'bad news' may increase volatility more than 'good news'.

Background contd.

- ARCH and GARCH models do not capture this effect. Why?
- Their lagged error terms are squared in the equations for the conditional variance, and therefore a positive error has the same impact on the conditional variance as a negative error.

- How do we model asymmetry effect in financial series with evidence of volatility?
- There are two prominent volatility models often used to capture asymmetry effect.
- They are:
- Exponential GARCH (EGARCH) Model
- GJR GARCH or Threshold GARCH (TGARCH) Model

Let us take each in turn

EGARCH Model

- The EGARCH Model was developed by Nelson (1991) to specifically capture asymmetries in the volatility. In this model, asymmetries are taken into account exponentially.
- In the EGARCH Model, the natural logarithm of the condition variance is allowed to vary over time as a function of the lagged error terms rather than lagged squared errors.

EGARCH Model contd.

- Specification of EGARCH Model:
- EGARCH (p, q) can be specified as:

$$\ln(\sigma_t^2) = \omega + \sum_{j=1}^{q} \xi_j \left| \frac{u_{t-j}}{\sqrt{\sigma_{t-j}^2}} \right| + \sum_{j=1}^{q} \eta_j \frac{u_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{i=1}^{p} \delta_i \ln\left(\sigma_{t-i}^2\right)$$

- To test for asymmetries, the parameters of importance are the ηs. If $\eta_j > 0$; then positive shocks (good news) generate higher volatility than negative shocks (bad news), and vice versa.

EGARCH Model contd.

- If $\eta_j = 0$; then the model is symmetric.
- Let us now specify EGARCH (1,1):

$$\ln\left(\sigma_t^2\right) = \omega + \xi \left| \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| + \eta \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \delta \ln\left(\sigma_{t-1}^2\right)$$

- ξ captures the effect of the conditional shock on the conditional variance.
- η is the asymmetry effect and δ measures the persistence of shocks to the variance.

TGARCH Model

- The GJR-GARCH Model developed by Glosten, Jagannathan and Runkle - GJR (1993) also takes into account the asymmetries in the volatility by adding another term to the conditional variance (GARCH) equation.
- Unlike the EGARCH, the effect is captured in a linear fashion in the GJR-GARCH Model.
- The asymmetry effect here is captured using a dummy variable.

TGARCH Model contd.

GJR-GARCH(p,q) model:

$$\sigma_t^2 = \theta + \sum_{i=1}^{p} \lambda_i u_{t-i}^2 + \sum_{j=1}^{q} \gamma_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \delta_i u_{t-i}^2 I_{t-i}$$

where $I_{t-i} = 1$ if $u_{t-i} > 0$

$I_{t-i} = 0$ otherwise

TGARCH Model Contd.

- GJR-GARCH(1,1) model is expressed below:

$$\sigma_t^2 = \theta + \lambda_1 u_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 + \delta u_{t-1}^2 I_{t-1}$$

where $I_{t-1} = 1$ if $u_{t-1} > 0$

$I_{t-1} = 0$ otherwise

TGARCH Model contd.

- To test for asymmetries, the parameters of importance are the δs. If $\delta_i > 0$; then positive shocks (good news) give rise to higher volatility than negative shocks (bad news), and vice versa.
- If $\delta_i = 0$; then the model is symmetric.

❑Note the following:

- One of the prominent pre-tests required when dealing with volatility modelling is the test for ARCH effects;
- In other words, volatility models are considered only when the series in question has been empirically tested to be volatile.
- The procedure for testing for ARCH effects as earlier described is consistent with the ARCH LM test proposed by Engle (1982);
- Thus, when testing for ARCH effects using any of the standard econometric softwares, the ARCH LM test should be employed.

- Post-estimation test is also required to validate the choice of GARCH-type model(s) estimated.
- This test follows the procedure for testing for ARCH effects.
- The only difference however is the fact that the test is carried out after the estimation of the chosen GARCH-type model(s).

Estimation Procedure

- Preliminary Analyses

- Descriptive Statistics: Mean, Minimum, Maximum, Standard Deviation, Skewness, Kurtosis and Jarque-Bera statistics.
- Heteroscedasticity test: ARCH LM test at different lags.

Estimation Procedure Contd.

- Estimation:
  - Justification for the choice of GARCH-type model; or
  - Select the appropriate model using model selection criteria such as the Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQC)

Estimation Procedure Contd.

- Post-estimation analysis:
  - Heteroscedasticity test: ARCH LM test at different lags.

- An Empirical application with Eviews.
- Topic: Modelling volatility in *naira* exchange rates.