Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC Accredited with "A" Grade (CGPA : 3.18)

Department of Computer Science and Engineering (Data Science)

Subject: Time Series Analysis

Experiment 9

(Volatility Models)

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Aim: Implement a model to predict the volatility of returns in financial assets.

Theory:

There are two time-series model(s) — ARCH and GARCH. These model(s) are also called volatility model(s). These models are exclusively used in the finance industry as many asset prices are conditional heteroskedastic.

ARCH — Autoregressive Conditional Heteroskedasticity
GARCH — Generalized Autoregressive Conditional Heteroskedasticity

- These models relate to economic forecasting and measuring volatility.
- Some of the techniques adopted in the finance sector — ARCH, ARCH-M, GARCH, GARCH-M, TGARCH, and EGARCH.
- ARCH model is concerned about modeling volatility of the variance of the series.
- These model(s) deals with stationary (time-invariant mean) and nonstationary (time-varying mean) variable(s).

Some of the real-time examples where ARCH model(s) applied: Stock prices, oil prices, bond prices, inflation rates, GDP, unemployment rates, etc.,

Why an ARCH model?

- Autoregressive models can be developed for univariate time-series data that is stationary (AR), has a trend (ARIMA), and has a seasonal component (SARIMA). But, these Autoregressive models do not model is a **change in the variance over time**.
- The error terms in the stochastic processes generating the time series were **homoscedastic**, i.e. with constant variance.
- There are some time series where the variance **changes consistently over time**. In the context of a time series in the financial domain, this would be called increasing and decreasing volatility.

$\epsilon(t)$ is an *autoregressive conditional heteroskedastic model of order unity,* denoted by ARCH(1).

$$\epsilon(t) = w(t) * \sigma(t) = w(t) * \sqrt{(a0 + a1 * \epsilon^2(t-1))}$$

similarly ARCH(2):

$$\epsilon(t) = w(t) * \sigma(t) = w(t) * \sqrt{(a0 + a1 * \epsilon^2(t-1) + a2 * \epsilon^2(t-2))}$$

ARCH(p):

$$\epsilon_t = w_t \sqrt{\alpha_0 + \sum_{i=1}^{p} \alpha_p \epsilon_{t-i}^2}$$

Why a GARCH model?

Generalized Autoregressive Conditional Heteroskedasticity, or GARCH, is an extension of the ARCH model that incorporates a **moving average component** together with the **autoregressive component**.

Thus GARCH is the "ARMA equivalent" of ARCH, which only has an autoregressive component. GARCH models permit a wider range of behavior more persistent volatility.

GACH Model of Order p, q — GARH(p,q):

GARCH(1,1):

Here we are going to consider a single autoregressive lag and a single "moving average" lag. The model is given by the following:

$\epsilon(t) = w(t) * \sigma(t)$

$\epsilon(t) = w(t) * \sqrt{(a0 + a1 * \epsilon^2(t-1)) + \beta 1 * \sigma^2(t-1)}$

Similarly GARH(p,q):

A time-series $\{\epsilon(t)\}$ is given at each instance by $\epsilon(t) = w(t)*\sigma(t)$ and $\sigma^2(t)$ is given by:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

Lab Assignments to complete:

Perform the following tasks using the datasets mentioned. Download the datasets from the link given:

Link:

https://drive.google.com/drive/folders/1dbqJuZJULas76_Zzkqs-yRd2DbJReJup?usp=sharing

Dataset 1: Facebook Stock Market Performance

1. Iterate through combinations of models to best fit our time series.
2. Pick the GARCH model orders according to the PACF plot.
3. Fit the GARCH(p, q) model to our time series and predict the future volaitily.
4. Examine the model residuals and squared residuals for autocorrelation.
5. Implement the Rolling Forecast Origin.

https://colab.research.google.com/drive/1VMwMxAuzcrIyHLkVeKvkLVUIFV87sUFF?usp=sharing