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.

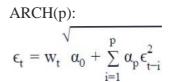
 ϵ (t) is an *autoregressive conditional heteroskedastic model of order unity*, denoted by ARCH(1).

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

similarly ARCH(2):

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

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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:

$$\epsilon(t) = w(t) * \sigma(t)
\epsilon(t) = w(t) * (a0 + a1 * \epsilon^{2}(t-1)) + \beta1 * \sigma^{2}(t-1)$$

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=s haring