CRAM 1 - Programming Lab

Problem Set 6: The Volatility of Stock Returns and ARCH Modeling

WS 2017/18

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Goals

This set of exercises has four goals:

- First, working with intra-day stock prices.
- Second, how ECB monetary policy decisions (can) affect equity markets.
- Third, how to make the volatility of an asset observable.
- Fourth, how to estimate an ARCH model and use it to forecast expected volatility.

Submission

The solution to the problem set has to be submitted in form of two files:

- *ps6.py*: Containing the code to reproduce the quantitative results.
- A power point presentation answering the qualitative questions ($\sim$ 1-2 slide per question). Please upload it as a pdf file.

Submit your solution via the Praktomat https://praktomat.cs.kit.edu/cram_2017_WS latest 11:59 a.m. on Wednesday, 29/11/2017. Note, please name your Python file 'ps6.py' to allow for evaluation by the Praktomat and set the status along your code to SOLN.

The Volatility of Stock Returns and ARCH Modeling

Question 1a: Euro Stoxx 50 - Intra-Day Index Values

Read-in the provided csv-file with the intra-day index values of the Euro Stoxx 50. Prepare the data and plot the time series for the whole time period.

Then, select the index values for the *10th of June 2010* and plot its intra-day time series. What important decision was made on this day?

Calculate the intra-day returns and cumulative return series for this day and plot the respective series.

Question 1b: Stock Return Volatility

Use the calculated returns from the previous question to approximate the intra-day volatility of the Euro Stoxx 50. Therefore, sum-up the 15 seconds (tick-by-tick) squared returns over a 5 minute interval:

$$\sum_{t=1}^{20} r_t^2.$$

Plot the resulting intra-day volatility time series along with the stock returns and describe the series.

Question 1c: ECB Monetary Policy Decisions

Go to the Webpage of the European Central Bank and briefly describe the decision making process of the ECB:

https://www.ecb.europa.eu/press/govcdec/html/index.en.html

How often does the ECB meet? What kind of decisions are made upon these meetings?

Then, go to the *press release* and the *press conference transcript* for the 10th of June 2010 and briefly summarize the most important decisions.

Characterize the fundamental economic environment in the euro area during these times.

Question 1d: Class 'ARMA_ARCH'

Create a class 'ARMA_ARCH' which allows for the estimation of an ARMA(p, q)-ARCH(m) model. Therefore, implement the function 'two_pass_est()' which implements the *two pass estimation* approach for estimating a model with ARCH effects:

1. Pass 1: Estimate the mean equation of a return series by e.g. OLS.
2. Take the residuals from pass 1 and square them $\{\epsilon_t^2\}$.
3. Pass 2: Treat $\{\epsilon_t^2\}$ as an observed time series and apply e.g. MLE (Maximum Likelihood Estimation) to estimate the variance equation.

Hint: Use the 'arch' package for the estimation of the variance equation.

Question 1e: Model-Implied Volatility

Use the class 'ARMA_ARCH' to estimate a 'better' volatility proxy for the intra-day index values of the Euro Stoxx 50.

Therefore, assume that the best model to describe the dynamics of the given stock return series is an AR(1)-ARCH(1) specification. Estimate the model via the two pass estimation and extract the volatility time series.

Then, plot the implied volatility series and compare it with the 5 min sum of squared returns from the previous question. Calculate the correlation matrix between the different volatility measures.

Question 1f: Volatility Forecasting

Based on the estimated model from Question 1e and the last known value make a variance forecast 1, 2 and 3 periods ahead.

Use the following recursive relationship:

$$E[\sigma^2_{t+h}] = \alpha_0 + \alpha_1 * E[\epsilon^2_{t+h-1}].$$

How can you characterize the expected stock return distribution 1 step ahead?