Advanced Risk Management
Computer Lab 2

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Assignment 1 (Lab)

Question 1

Tips

- Install and import relevant libraries
- Import data: Excel file "raw_data_2021".
  - ▷ Remove irrelevant parts (seconds) from "Date" string: str[]
  - ▷ Transform "Date" string to format datetime: to_datetime()
  - ▷ Set index of Pandas DataFrame to "Date" column, allows to refer to a string using time index: set_index()
  - ▷ Calculate close-to-close returns (multiply by 100 to define % growth) and select for one particular index: loc[]
  - ▷ Select RV for one particular index: loc[]; multiply 100^2
- Define new Pandas DataFrame: first column - returns, second column - RV
  - ▷ Plot: (i) return series, (ii) autocorr of return series, (iii) autocorr of squared return series

Question 2

Tips (1/2)

- Model with constant mean is given by:

$$
\begin{aligned}
r_t &= \mu + \varepsilon_t \\
\sigma_t^2 &= \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \\
\varepsilon_t &= \sigma_t e_t, \quad e_t \sim N(0,1)
\end{aligned} \tag{1}
$$

  - ▷ stationarity condition: $\alpha + \beta < 1$
- Use arch_model("Returns", p =..., o =..., q = ...)
- Obtain results: fit(last_obs = , disp = "off")
  - ▷ "last_obs" defines the last observation of sub-period to estimate the model
  - ▷ "disp" controls whether convergence information is show

Tips (2/2)

- Construct standardised residuals:

$$e_t = \frac{r_t - \mu}{\sigma_t} \tag{2}$$

- Obtain non-standardised residuals (ε_t) using method resid() applied to model estimation results
- Obtain conditional volatility using method *conditional_volatility*() applied to model estimation results
- Alternatively, plot() applied to results after fitting the model: plots e_t and σ_t
- Conduct diagnostic tests based on standardised residuals

Question 3

Tips (1/2)

- GJR-GARCH(1,1):

$$\sigma_t^2 = \omega + (\alpha + \gamma \mathbf{1}_{\varepsilon_{t-1} \leq 0})\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{3}$$

  - NIC is asymmetric iff $\gamma \neq 0$
  - present leverage effect if $\gamma > 0$
  - stationarity condition: $\alpha + \frac{1}{2}\gamma + \beta < 1$
- arch_model(): $o = 1$ (asymmetric terms)
- Conduct diagnostic tests based on standardised residuals

Tips(2/2)

- Is the log likelihood of the GJR model significantly higher?
- Does the LR test for the GARCH model, as a restricted version of the GJR-GARCH model, reject the null hypothesis?
    - $H0 : \gamma = 0$
    - $LR = 2(LL_{GJR} - LL_{GARCH}) \sim \chi_1^2$
    - One degree of freedom in chi-squared distribution because we test only one restriction

HAR model (additional)

Tips

- HAR model: heterogeneous autoregressive model for the realised variance

$$RV_{t+1} = \phi_0 + \phi_d RV_{d,t} + \phi_w RV_{w,t} + \phi_m RV_{m,t} + \varepsilon_{t+1}, \quad (4)$$

  where
  - $RV_{d,t}$ is daily mean
  - $RV_{w,t}$ is weakly mean
  - $RV_{m,t}$ is monthly mean
- Estimate rolling averages using .rolling(window = ...).mean() in pandas
- Estimate model using OLS: smf.ols(): shift regressors by one!

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