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| Student number | ……(dubbelclick and fill in)…… |

# E_EOR3_EFIN

19 December 2017 – 15:15 – 18:00

1. Following files will be provided to you to work and save your work in
   a. word.docx
   b. excel.xlsx
   c. matlab.m
   d. sp500Returns.csv
2. You might want to make a copy of these files and right away rename them into, e.g. word_yourstudentnumber.docx, in case something goes wrong and you have to resume to the original files.
3. Important!!! Save your work regularly with CTRL+s
4. After finishing the exam submit your solution files digitally. Follow the instructions at the end of this documents. Files have to be submitted one after another.

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***Type your answers in the respective text fields***

## 1. Data

a) The following table shows summary statistics for S&P 500 data. Name three essential facts about the return data/distribution you can infer/learn from these statistics and explain in one sentence your reasoning. [9 points] - [ ]

**S&P 500 Statistics**

January 1929 to June 2015, daily returns

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|---|---|
| Mean | 0.019% |
| Standard deviation | 1.15% |
| Min | −22.9% |
| Max | 15.4% |
| Skewness | −0.4 |
| Kurtosis | 22.1 |
| Autocorrelation (one lag) of returns | 2.9% |
| Autocorrelation (one lag) of squared returns | 21.7% |

- Returns are not normally distributed since slightly skewed and large kurtosis
- Return distribution is fat tailed given large kurtosis value
- Low autocorrelation in returns hints towards no predictability in returns
- Substantial autocorrelation in squared returns hints towards predictability in squared in returns and is first indication of volatility clustering

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## 2. Factor Models

a) Name three different approaches to come up with a factor specification for a multi-factor model. [6 points] - [ ]

- Macroeconomic approach
- Fundamental approach
- Statistical approach

b) State the most commonly quoted equation of the CAPM. Define all components of the model and in particular state what type of systematic-risk the employed factors proxy for. [10 points] - [ ]

The most commonly quoted equation for the CAPM is $E(R_i)=R_f +\beta_i [E(R_m)-R_f]$

- So the CAPM states that the expected return on any stock i is equal to the risk-free rate of interest, $R_f$ , plus a risk premium.
- This risk premium is equal to the risk premium per unit of risk, also known as the market risk premium, $[E(R_m) – R_f ]$, multiplied by the measure of how risky the stock is, known as 'beta', $\beta_i$
- Excess return proxies for market wide risk

## 3. Volatility Modeling

a) Describe in 2-3 sentences how the MA model and the EWMA model differ in modeling volatility. Which model is in your opinion more reasonable to use from an economic perspective [8 points] - [ ]

The MA model uses equally weighted historical observations to calculate and estimator for future volatility, whereas the EWMA model exponentially weights historical observations. That is, more recent observations have a higher weight in calculating the variance than older observations. Therefore, the EWMA model is economically more reasonable since more recent events should have a stronger impact on future volatility than events further back in the past.

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b) In the following you see a model which can be used to model variance.

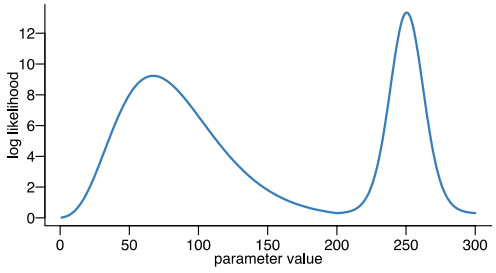
$$y_t = \mu + \epsilon_t \text{ with } \epsilon_t = \sigma_t u_t$$
$$\sigma_t^2 = \omega + \alpha \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

First, give the precise name of the model. Second, list all parameters of the model and give an economical interpretation of those parameters. [10 points] - [ ]

- The model is an AR(1) for the return process and a GARCH(1,1) for the variance process
- The parameters are μ (expected return over one time interval), ω (roughly the long-run mean of variance), α (news factor), β (memory factor)

## 4. Model Estimation

a) Assume the log-likelihood function of a model has the form depicted in the following graph. What problem arises when estimating the model parameters with maximum likelihood for such a model? [6 points] - [ ]




The maximization algorithm could get stuck in a local minima which results in a parameter estimate of around 70 versus the globally optimal parameter estimate of around 250.

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b) Suppose the following model is given

$$y_t = m + \epsilon_t \text{ with } \epsilon_t = \sigma_t u_t$$
$$\sigma_t^2 = \omega + \alpha \epsilon_{t-1}^2$$

with $u_t \sim N(0,1)$. The normal density function is given by

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{1}{2}\frac{(x-\mu)^2}{\sigma^2}\right)$$

Write down the density $f(y_2|y_1)$ for the given model. [8 points] - [ ]

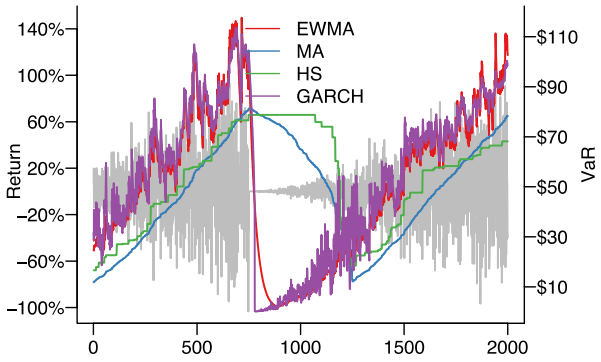
$$f(x) = \frac{1}{\sqrt{2\pi(\omega + \alpha\epsilon_{t-1}^2)}} \exp\left(-\frac{1}{2}\frac{(x-m)^2}{(\omega + \alpha\epsilon_{t-1}^2)}\right)$$

**5. Value-at-Risk Forecasting**

a) Outline one disadvantages of obtaining a VaR forecasts using a parametric method combined with a GARCH model. [5 points] - [ ]

Parametric methods are based on estimating some distribution of the data, from which a VaR forecast is obtained. this inevitably means that estimation error and model risk become a serious concern, often making the choice of model difficult.

b) Argue which of the models depicted in the following graph used to forecast value-at-risk values you prefer the least and why. [6 points] - [ ]



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I dislike the most HS model since it takes the most time to adapt to a change market environment in terms of changed volatility. Therefore, it can produce for a prolonged period of time a biased VaR forecast.

## 6. Multiple Choice

The answer of the following multiple choice questions have to be stored in the file excel.xlsx on the sheet "Multiple Choice Solutions". To indicate the solution use i, ii, iii, iv, respectively. Each correct answer earns you 3 points. [42 points] - [ ]

a) Factore models can be used to
   (i) price assets
   (ii) evaluate the performance of fund managers
   (iii) manage risk
   (iv) All of the above

….

…

## 7. Programming

All the following questions have to be solved in the file matlab.m. While programming remember to save regularly. The outcome/results of running your code has to be stored for each sub question in the file excel.xlsx on the sheet "Matlab Programming Solutions".

a) Use the matlab function "*importdata*" or "*csvread*" to import the file "*sp500Returns.csv*" which contains S&P 500 return data. Calculate the
   (i) mean
   (ii) standard deviation
   (iii) the autocorrelation of the returns based on the first lag
   (iv) the autocorrelation of the squared returns based on the first lag

[20 points] - [ ]

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b) In the "*matlab.m*" file there are two functions provided to you: "*portfolioVaR*" and "*simPathFunc*". The goal is to use those two functions to simulate/calculate the 5% VaR of a portfolio consisting of one stock. All needed input parameters are predefined in "*matlab.m*" under "*8 b) Start run MC simulation to calculate VaR*". In the two provide functions there are three bugs. In order to calculate the 5% VaR one needs to call the functions accordingly and debug.

[15 points] - [ ]

c) Use matlab code to program a function ("*bsOption*") that calculates the Black & Scholes call option price. The formula which needs to be implemented is given by

$$C = S_0 N(d_1) - e^{-r(T-t)} K N(d_2)$$

with $d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}}$ and $d_2 = d_1 - \sigma\sqrt{(T-t)}$. The $N(.)$ denotes the CDF of a standard normal distribution. Calculate the value for the Black & Scholes formula for the parameter values given in the following: $S_0 = 100$ is the stock price today, $K = 100$ is the strike price, $r = 0.05$ is the risk free interest rate, $(T-t) = 0.5$ is the time to maturity, $\sigma = 0.2$ is the volatiltiy of the stock. Matlab functions that you might want to use: normcdf(), exp(), log().

[20 points] - [ ]

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## HANDING IN YOUR EXAM

- Save your files as
  - word_yourstudentnumber.docx (e.g. word_1234567.docx)
  - excel_yourstudentnumber.xlsx (e.g. excel_123456.xlsx)
  - matlab_yourstudentnumber.m (e.g. matlab_123456.m)
- Submit all three files separately:
  - Click on the link "Submit Exam" and log on with your VU-net-ID (you can change the language of the website by clicking on the flag in the right top corner).
  - Upload your document and click on the button "inleveren/submit".
  - Green check mark?
- Your document has been submitted, leave the hall quietly!