VU UNIVERSITY AMSTERDAM

Faculty of Economics and Business Administration

Empirical Finance 3.2

– Final Exam –

Name: _____ Student Id No: _____ Exam No: _____

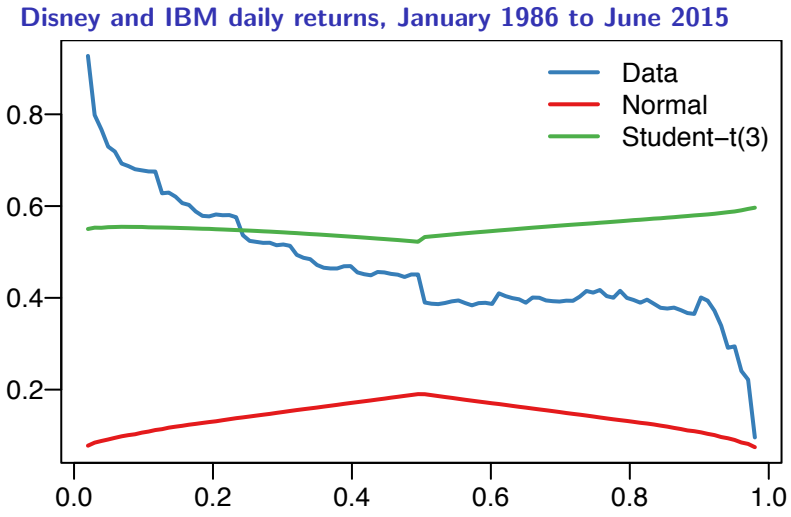
1. **Data Analysis** **(12 Points)**

   (a) We have used S&P 500 and single stock data to demonstrate three stylized facts of financial returns. What are the three stylized facts and how can those stylized facts be detected using the data? (6 points)

   The three stylized facts are: volatility clusters, fat tails and nonlinear dependence.

   - The S&P 500 data has very clear cycles of volatility, both over the long run (decades or years) and in the short run (months, weeks or days). Plotting a time series of returns provides substantial evidence of this.
   - The data also has much more extremes than would be predicted by a normal distribution. This indicates the presence of fat tails, which can be analyzed graphically with the help of QQ plots or sequential moments.
   - Finally, the existence of nonlinear dependence can be seen by comparing return correlations of individual stocks of the index. Tabulating correlation for different market scenarios shows how the dependence between different stocks tends to increase during periods of market panic, a sign of nonlinear dependence.

   (b) The following graph depicts a relationship between the Disney and IBM stock. A) What type of graph is shown here? B) Interpret the line in the graph which starts in the upper left corner and goes down to the right lower corner. (6 points)



The graph shows the empirical exceedance correlations for daily returns on Disney and IBM over 24 years, superimposed with exceedance correlations for the bivariate normal and the bivariate Student-t(3) distributions with the same correlation coefficient. The exceedance correlations exhibit substantial asymmetry for the two stocks considered. The stock returns become highly correlated at the left extreme, with correlations steadily decreasing when we move to the right of the distribution. This is precisely the type of dependence structure that risk-averse investors dislike.

2. Factor Models **(22 Points)**

(a) What is A) the basic economic concept used to derive the CAPM model and what is B) the basic concept used to derive the APT model? (6 points)

A) Prices are determined in equilibrium. B) No-arbitrage constraint: prices of assets are determined relative to each other.

(b) Describe how the CAPM model can be tested by means of a two-stage testing procedure. (10 points)

i. First stage: E.g. 100 stocks with 60 monthly return observations each. Run for each stock time series regression to estimate company beta.

$$R^e_{i,t} = \alpha + \beta_i R^e_{m,t} + u_{i,t}$$

ii. Second stage: Run a single cross-sectional regression of the average (over time) of the stock returns on a constant and the betas.

$$\bar{R}_i = \lambda_0 + \lambda_1 \beta_i + v_i$$

iii. If the CAPM is a valid model, two key predictions arise which can be tested using this second stage regression: $\lambda_0 = 0$ and $\lambda_1 = [R_m - R_f]$.

(c) Consider the following multifactor (APT) model of security returns for a particular stock. If T-bills currently offer a 6% yield, find the expected rate of return on this stock if the market views the stock as fairly priced. (6 points)

Factor	**Factor Beta**	**Factor Risk Premium**
Inflation	1.2	6%
Industrial production	0.5	8
Oil price	0.3	3

$E(r) = 6 + (1.2 \times 6) + (0.5 \times 8) + (0.3 \times 3) = 18.1\%$

3. Volatility Modeling **(24 Points)**

(a) Give the model equations for an AR(1) model with non-zero drift for returns and a GARCH(1,1) model for the variance of the return residuals. State the interpretation of the GARCH parameters and give the necessary restrictions for the parameters (12 points)

i. We can summarize the model and properties as follows:

$$y_t = \mu + \phi y_{t-1} + \varepsilon_t = \mu + \phi y_{t-1} + \sigma_t u_t \quad (1)$$
$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (2)$$

with $u_t = N(0, 1)$.

ii. ω: long-run mean of variance; α: news; β: memory

iii. To ensure positive volatility forecasts:

$$\omega, \alpha, \beta > 0$$

(b) State the steps of an appropriate approach to test for 'ARCH effects' in a time series of a risk factor? (6 points)

Run a regression, collect the residuals, regress the squared residuals on their lags and conduct a hypothesis test to check whether the coefficients of the lagged squared residuals are equal to zero

(c) Assume that you have estimated a GJR model of monthly stock returns and you obtain the following equations:

$$y_t = 0.125 + u_t$$
$$\sigma_t^2 = 1.102 + 0.115u_{t-1}^2 + 0.641\sigma_{t-1}^2 + 0.175u_{t-1}^2 I_{t-1}$$

Suppose that $\sigma_{t-1}^2 = 0.721$, what would be the fitted conditional variance for time t if $\hat{u}_{t-1} = 0.5$ and then if $\hat{u}_{t-1} = -0.5$? (6 points)

1.59 and 1.64, respectively

4. **VaR and Historical Simulation** **(16 Points)**

(a) Define the terms: estimation window, testing window, VaR violation and violation ratio. (8 points)

Estimation window (W_E): the number of observations used to forecast risk / estimate model parameters. If different procedures or assumptions are compared, the estimation window is set to whichever one needs the highest number of observations.

Testing window (W_T): the data sample over which risk is forecast (i.e., the days where we have made a VaR forecast).

VaR violation: an event such that:

$$\eta = \begin{cases} 1, & \text{if } y_t \leq -VaR_t \\ 0, & \text{if } y_t > -VaR_t \end{cases}$$

Violation ratio:

$$\text{VR} = \frac{\text{Observed number of violations}}{\text{Expected number of violations}}$$

(b) Explain how historical simulation can be used to calculate a one-day ahead VaR forecast. (8 points)

i. Decide on size of estimation window
ii. Order past observations according to size
iii. look the the $p * W_E$th observation which is the VaR(P) forecast.
iv. apply that forecast to the current portfolio level

5. **Programming** **(25 Points)**

(a) Using matlab code define a function ("sumOneToTen") that calculates the sum of the integer numbers from 1 to 10. (5 points)

```
function y = sumOneToTen()
    sum=0;
    for i=1:10
        sum=sum+i;
    end
    y=sum;
end
```

(b) The following code snippets stem from the problems we discussed in the tutorials. For each snippet state A) in which software they are produced, and B) the overall analysis they are used for, and C) what the lines of code calculate specifically in the context of the overall analysis.

i. Snippet 1 (6 points)

```
157  gen abnormal_return=ret-predicted_return if event_window==1
158  by id: egen cumulative_abnormal_return = sum(abnormal_return)
159  by id: egen ar_sd = sd(abnormal_return)
160  gen test =(1/sqrt(5)) * ( cumulative_abnormal_return /ar_sd)
161  list company_id cumulative_abnormal_return test if dif==0
```

A. Stata

B. Event Study

C. Calculation of abnormal and cumulative abnormal returns and calculate test statistic

ii. Snippet 2 (6 points)

```
arch rjpy, arch(1/4) garch(1/1)
estimates store garch41
arch rjpy, arch(1/1) garch(1/1)
estimates store garch11
arch rjpy, arch(1/1) garch(1/1) distribution(t 6)
estimates store tgarch11
estimates table arch1 arch4 garch41 garch11 tgarch11, stats(r2 ll)
lrtest garch41 garch11
lrtest garch11 tgarch11
```

A. Statat

B. Estimating GARCH models and comparing model performance

C. GARCH(4,1), GARCH(1,1),T-GARCH(1,1) model is estimated and estimated parameters are stored; estimates are output in table; likelihood ratio test is performed between GARCH(1,1) and GARCH(4,1) and between GARCH(1,1) and T-GARCH(1,1)

iii. Snippet 3 (8 points)

```
function mcOptPrice=mcSimPricer(startS, K, r, tauYears, sigma, numSim, optionType)
simPathSum = 0;
    for itCount=1:numSim
      simPriceT=simPathFunc(startS,r,tauYears,sigma);
      if strcmp(optionType,'C')
         simPathSum = simPathSum + exp((-tauYears) * r) * max(simPriceT - K, 0);
      elseif strcmp(optionType,'P')
         simPathSum = simPathSum + Exp((-tauYears) * r) * max(K - simPath, 0);
      end
    end
   mcOptPrice = simPathSum / numSim;
end
```

A. Matlab

B. Pricing an option by means of Monte Carlo simulation

C. function mcOptPrice is declared; simPathSum variable is initiated with value 0; a for loop runs over number of simulations where in each loop a terminal stock price is simulated, the discounted terminal option payoff is calculated depending whether it is a call or a put and added to the simPathSum variable; the simPathSum variable is divided by number of simulations to give the estimator of the option price

6. **Multiple Choice.** **(21 Points)**

Give the correct answer to every stated multiple choice problem. Every correct answer earns you 3 points.

(a) Which number of degrees of freedom for a Student-t distribution implies a standard normal distribution?

(i) df=3

(ii) df=0

(iii) df=1

(iv) df=∞

Answer iv

(b) Volatility clustering is

(i) The tendency for financial asset returns to have distributions that exhibit fat tails

(ii) The tendency for financial asset return volatility to appear in bunches

(iii) The tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude

(iv) All of the above

Answer ii

(c) The general arbitrage pricing theory (APT) differs from the single-factor capital asset pricing model (CAPM) because the APT:

(i) Places more emphasis on market risk.

(ii) Minimizes the importance of diversification.

(iii) Recognizes multiple unsystematic risk factors.

(iv) Recognizes multiple systematic risk factors.

Answer iv

(d) In contrast to the capital asset pricing model, arbitrage pricing theory:

(i) Requires that markets be in equilibrium.

(ii) Uses risk premiums based on micro variables.

(iii) Specifies the number and identifies specific factors that determine expected returns.

(iv) Does not require the restrictive assumptions concerning the market portfolio.

Answer iv

(e) Which statement holds true in an event study setup:

(I) The estimation window consists of more data observations than the event window

(II) The variance estimator of the absolute returns is calculated as the squared returns of the estimation window

(III) Event studies are joint test of non-zero abnormal returns and whether the model to construct expected returns is correct.

(IV) Recognizes multiple systematic risk factors.

(i) I only

(ii) I and II only

(iii) I, II and III only

(iv) I, II, III and IV

Answer iii

(f) Which of the following is true about ARCH and GARCH models?

I They are used for modelling and forecasting volatility

II They are non-linear models

III They can both be estimated using OLS

IV Series estimated using these models must have a unit root process

(i) I only

(ii) I and II only

(iii) I, II and III only

(iv) I, II, III and IV

Answer ii

(g) Which of the following methods is not a way to increase the precision of an Monte Carlo simulation estimator?

(i) Increasing number of simulations

(ii) Standard errors

(iii) Antithetic variate technique

(iv) Control variate technique

Answer ii

(h) Which method cannot be used to calculate the expected market return in an event study?

(i) Using a market model
(ii) Average return over the estimation window
(iii) Average return over the event window
(iv) Using a return of a market portfolio

Answer iii

(i) Observing a violation ratio that is less than 1 implies that a risk forecasting model

(i) overforecasts the risk
(ii) underforecasts the risk
(iii) correctly forecasts the risk
(iv) does not forecast the risk

Answer i

(j) Which of the following statements holds for the Bernoulli coverage test:

I Tests the accuracy of the VaR forecast
II Has much statistical power for small sample sizes
III Tests independence of VaR forecast violations
IV makes use of the likelihood ration test method

(i) I only
(ii) I and II only
(iii) I, II and III only
(iv) I, II, III and IV

Answer i