FINANCIAL STATISTICS
2023-10-24

Time:	08.00 - 13.00
Place:	**TBD**
Approved aid:	available at the homepage of the exam; calculator

Questions about the content of the exam: Examiner plans to stop by the exam venue at the start of the exam and after about 1.5-2h. Otherwise, check with the personal that supervises the exam.

You are expected to upload R-packages you need and link the corresponding libraries. Preferably, you do it in plain R, rather than in the RStudio. See a separate help file for R-commands available on the homepage of the exam. Below are the examples of possible instructions if you decide to make separate uploads:

```
install.packages("forecast")
library(forecast)
install.packages("tseries")
library(tseries)
install.packages("lmtest")
library(lmtest)
install.packages("FinTS")
FinTS::ArchTest()
```

If an R-package you want to use is missing from the provided list, indicate clearly in your exam report the name of the package and for what purpose you use it. No IT help will be provided for this step, except for if R-Studio does not work as expected.

If you ask a question during the exam, you will get a clarifying answer about the content of the exam question, not an answer how to solve it.

- **Part I (Time Series, R-Studio based)**

You are asked to analyze **DAILY** stock data for year 2023 (the data starts from the 1st of January 2023) using R and submit a written assignment in an essay form. Your essay should contain key R-commands, the output from R-Studio as well as clear interpretation of results. Submissions in .docx and .pdf formats are ok but the .pdf format is preferred. In case no key R commands are clear in the text of your answers, the final grade will be reduced.
You are also asked to attach the whole R code, preferably converted into .pdf format for the reference purposes. It is not expected to be checked.

- **Part II (Exercises)**

You are expected to provide detailed solutions to the asked questions and write them clearly on the paper provided at the exam. Submit your solutions on time. Answers without solutions are not accepted.

Reminder (both parts): all the sheets you are submitting should contain your anonymous code and be ordered the way you want your answers are read. If labelling of the pages is not properly done, we cannot guarantee that the pages that are not marked properly will be graded.

Upload Deadline: 13:00 (no submissions after the deadline will be graded)

- **Grading, minimum requirements:**
    - <u>E:</u> fully answer "Part I" a-d. Satisfactory answers in "Part II" or remaining of "Part I" may compensate for somewhat lacking but nor wrong answer in d) of Part I
    - <u>C:</u> fully answer Part I a-d, answer e-g in a satisfactory way; make a fair attempt on Part II (both questions) or solve one of the problems from Part II in a satisfactory way. Satisfactory answer to Part II (both parts) may compensate for lacking in e-g of Part I
    - <u>A:</u> answer Part I in full with minor deficiencies. Answer Part II (both questions) in a satisfactory way

These are preliminary requirements. The examiner might adjust the scale upward, if necessary.

- NOTE! Fx and F are failing grades that require re-examination. Students who receive the grade Fx or F <u>cannot</u> supplement for a higher grade.
- If you are not satisfied with your grade, you may contact the examiner for further instructions.

GOOD LUCK

Part I, Data

Below, you will find a selection of data sets, mostly the time series of stock price for the companies from the S&P 500. Your data corresponds to the number from the anonymous code, assigned to you for this exam. For instance, if you have the anonymous code 311-0001-XXX, your data is "BA's", The Boeing Company. Follow these instructions to download your stock:

1. Go to https://finance.yahoo.com/
2. Enter the "Symbol" for your stock into the Yahoo! Finance search field and press enter. *For example, if your stock is The Estee Lauder Companies Inc. enter "EL" into the search field and press enter.*

3. Click historical data:
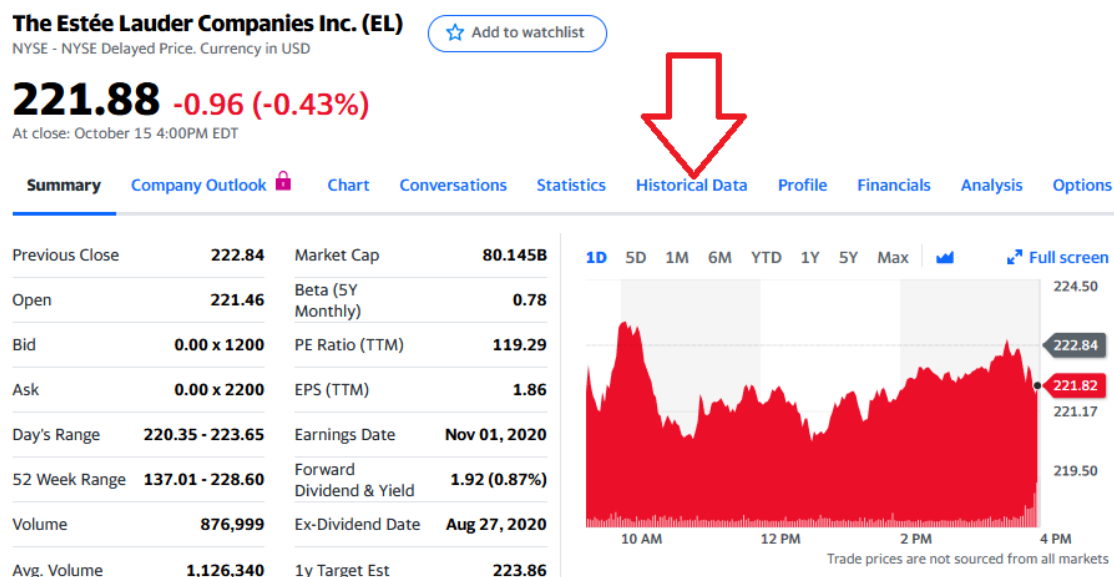
4. Change Frequency to "**Daily**"; Click Time Period, choose "**1Y**", and click "**Done**"; Click "**Apply**"; finally, click "**Download**." Make sure that you have one year of daily data, or slightly more (252 observations or so). If your stock does not have 1 year of data, choose "**Max.**" In this case, you will of course have less than 252 observations.
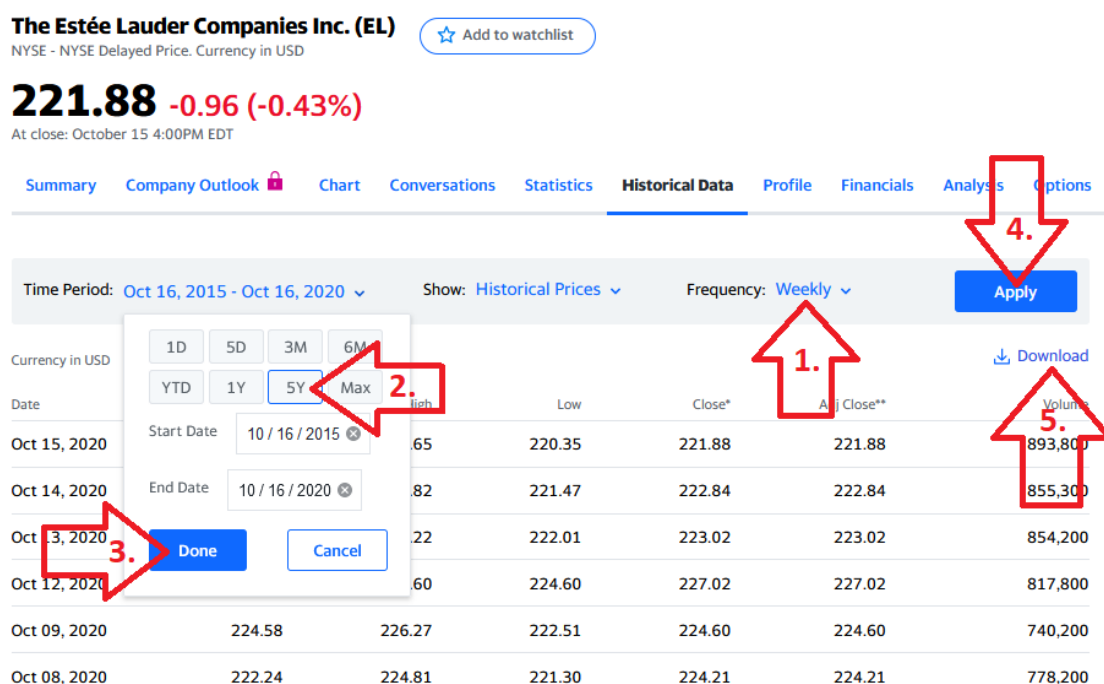
5. You may read the data into R any way you want; the following step is just a suggestion. Open a new .R-file and paste in the following code:

```
EL <- read.csv("EL.csv")
```

This assumes that you have copied the downloaded stock data file to your work directory. Remember that you can find out what your work directory is with the command

```
getwd()
```

You can list the files in your work directory with

list.files()

If you are having trouble loading the file, first make sure that your file is in the work directory. Save the .R-file and run it. Then verify that the data is correctly read into R.

Use Adj.Close price when available. Otherwise, state clearly what data you use.

Code	Symbol	Name
0001	BA	The Boeing Company
0002	TSLA	Tesla, Inc.
0003	NVDA	Nvidia Corporation
0004	BTC-USD	Bitcoin USD
0005	ERIC	Telefonaktiebolaget LM Ericsson
0006	Telia.st	Telia Company AB
0007	AZN	AstraZeneca PLC
0008	MSFT	Microsoft Corporation
0009	LLY	Eli Lilly and Company
0010	JPM	JPMorgan Chase & Co.
0011	CVX	Chevron Corporation
0012	ACN	Accenture plc
0013	BA	The Boeing Company
0014	TSLA	Tesla, Inc.
0015	NVDA	Nvidia Corporation
0016	BTC-USD	Bitcoin USD
0017	ERIC	Telefonaktiebolaget LM Ericsson
0018	Telia.st	Telia Company AB
0019	AZN	AstraZeneca PLC
0020	MSFT	Microsoft Corporation
0021	LLY	Eli Lilly and Company
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0023	CVX	Chevron Corporation
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0046	JPM	JPMorgan Chase & Co.
0047	CVX	Chevron Corporation
0048	ACN	Accenture plc
0049	BA	The Boeing Company
0050	TSLA	Tesla, Inc.
0051	NVDA	Nvidia Corporation
0052	BTC-USD	Bitcoin USD
0053	ERIC	Telefonaktiebolaget LM Ericsson
0054	Telia.st	Telia Company AB
0055	AZN	AstraZeneca PLC
0056	MSFT	Microsoft Corporation
0057	LLY	Eli Lilly and Company
0058	JPM	JPMorgan Chase & Co.
0059	CVX	Chevron Corporation
0060	ACN	Accenture plc
0061	BA	The Boeing Company
0062	TSLA	Tesla, Inc.
0063	NVDA	Nvidia Corporation
0064	BTC-USD	Bitcoin USD
0065	ERIC	Telefonaktiebolaget LM Ericsson
0066	Telia.st	Telia Company AB
0067	AZN	AstraZeneca PLC
0068	MSFT	Microsoft Corporation
0069	LLY	Eli Lilly and Company
0070	JPM	JPMorgan Chase & Co.
0071	CVX	Chevron Corporation
0072	ACN	Accenture plc

The goal of the assignment in Part I is to perform the analysis of your assigned stock in R and then write a short essay answering the questions below. Make one headline in the essay for each part that you answer, e.g. "a. Introduction and Trend" and "b. Stationarity." It is important that you include plots/tables that are outputs from R as well as key R-commands you use.

(a) Describe the time series with an appropriate plot/diagram. Comment on the diagram and provide summary statistics. Is there a visible trend? Test for the trend using simple linear regression. You can choose different time intervals to "prove" that the time series has extensive time periods of trends, if any.

   For steps b, c, and d, leave out the last 5 observations that will be referred to as "the testing set".

(b) Stationarity. Use a formal test for stationarity. If it is clear from the diagram that your data is non-stationary, you may apply an appropriate transformation but perform testing first. State the hypotheses and interpret the outcome of the test. Use 5% significance level. If the data does not seem to be stationary even after transformation, attempt another transformation and repeat this step. Make sure that you have the figure containing the stationary time series. In case you have to choose between mildly (visualize the time series in question) non-stationary time series and "white noise" style time series, choose the former in favor of the latter.

(c) Plot the ACF and PACF plots. Choose the number of lags appropriately and justify your choice. Explain what the plots show. Specifically state and interpret the value of the second (2nd) bar in the ACF plot and explain how it has been used in the analysis. For the higher grade, remember to return to this question when you have chosen "the best" model. Make specific references to the models you selected for the step (d). Use these plots as the basis for your choices in (d).

(d) Whatever the (P)ACF plots you got, choose at least four the most promising ARIMA models that are top candidates to fit the data (leaving out the testing set). One of them should be an ARIMA(0,d,0): indicate what "d" you have chosen and why. You have to have a detailed description of your selection process: why selected by you models are better than other potential candidates. Provide output, analysis and the AIC scores for each "potentially good" model. Interpret your findings. Which model seems most promising? Should any of your models be disregarded completely? Why?

(e) Choose the two "best" models from (d). Use the last 5 observations, i.e. your testing set, to calculate RMSE. The calculations should be explicit and easy to follow. Compare the two and interpret the difference. Moreover, visualize both predictions and discuss the figures. Make clear and well-motivated conclusions. Specifically discuss the values of the RMSE for the selected models.

(f) Pick "the best" model from question (e). Test that model for ARCH effect. State the hypothesis and explain the outcome of your test. Explain what the presence of ARCH effect would mean for your results in (d), even if you did not find any. Discuss briefly why estimating variance is important in financial forecasting. Visualize the ARCH effect for your model.

(g) Pick "the best" model from question (e). Write down the model explicitly and discuss the coefficients. Discuss connection to the (P)ACF plots. Provide residual analysis of the model and report your conclusions. Further, provide overall conclusions for your analysis.

Part II ("Pen-and-Paper-Answer" questions: one cannot use R-Studio to solve it. Write your answers on a paper.)

1. Let A denote the event: "a randomly selected student passes the Financial Statistics exam." Consider the logistic regression model, where p(A|x) is the probability of passing the exam, given x number of hours studied per week

$$\log\left(\frac{p(A|x)}{1-p(A|x)}\right) = -4 + 5 * 0.YY * x,$$

where "YY" is exactly the number you used in Part I for selecting your individual stock. For instance, if you have your anonymous code 311-0011-XXX, the right-hand part of the equation above will be "-4 + 5 * 0.11 * x = -4 + 0.55 * x".

(a) Find the odds-ratio of the variable x
(b) Find the estimated number of hours one needs to study to have at least 50% probability of passing the exam
(c) Find the probability that a randomly chosen student passes the exam, given that she studies 20 hours per week.

Moreover, describe the expected outcome if one does not study at all. If you have time and desire (optional) suggest your own logistic regression that in your view would fit the expected outcome better. Motivate your choice.

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2. Provide detailed calculations for the following questions (note that the correct answer without calculations is not accepted as a solution):

    a) Derive the autocorrelation function for the following MA(1) process $Z_t = \varepsilon_t + 1.4\varepsilon_{t-1}$. Assume that Z_t is stationary.

    b) Derive the autocorrelation function for the following MA(2) process $Z_t = \varepsilon_t + 1.4\varepsilon_{t-1} - 0.6\varepsilon_{t-2}$. Assume that Z_t is stationary.