

## FINANCIAL STATISTICS

2024-03-15

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<b>Time:</b>	08.00 - 13.00
<b>Place:</b>	TBD
<b>Approved aid:</b>	available to download at the SEB-imbedded homepage of the exam; calculator

**Questions about the content of the exam:** Examiner (or the TA) plans to stop by the exam venue at the start and close to the end of the exam. Otherwise, check with the personal that supervises the exam.

**To upload the R-packages use plain R.** If you try to upload the packages in RStudio, your PC might become irresponsive and you need to restart the RStudio or/and computer. There is “Word” help file that contains all commands to install packages that are easy to copy/paste. Remember to use a separate help file for R-commands available on the homepage of the exam. After the packages are uploaded using the nearest mirror site (usually, Umeå), you can link the libraries using RStudio. FinTS package is wise to unpack only at the end, when one tests for the ARCH effect. If you need to upload some additional packages, do so using plain R. 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 is available for this step.

**Remember to save your progress in RStudio frequently in case you need to re-start RStudio/PC.**

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 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. No IT help is available during the exam.

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

Your task is to analyze **WEEKLY** stock data **for the last 3 years** using RStudio and submit a written assignment in an essay form. Your essay should contain the 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. In case there is no output or interpretation of the output, zero credit is given.

Please attach your complete R-code as a separate file, preferably converted into the .pdf format for the reference purposes. The file that contains the R-code is not graded.

- **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. The answers (correct or not) without solutions receive zero credit for grading purposes.

**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 are graded)

- **Grading, minimum requirements:**

- E: fully answer “Part I” a-d and make a fair attempt on remaining of “Part I” & at least one of the questions in “Part II”. Satisfactory answers in “Part II” or remaining of “Part I” may compensate for somewhat lacking but not wrong answers in a)-d) of “Part I”
- C: fully answer Part I a-d, answer e-g in a satisfactory way; make a fair attempt on Part II (two questions) or solve one of the problems from Part II in a satisfactory way. Satisfactory answer to Part II (two questions) may compensate for lacking in e-g of Part I
- A: answer Part I in full with minor deficiencies. Answer Part II (two 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 cannot supplement for a higher grade.
- If you are not satisfied with your grade, you may contact the examiner for further instructions.

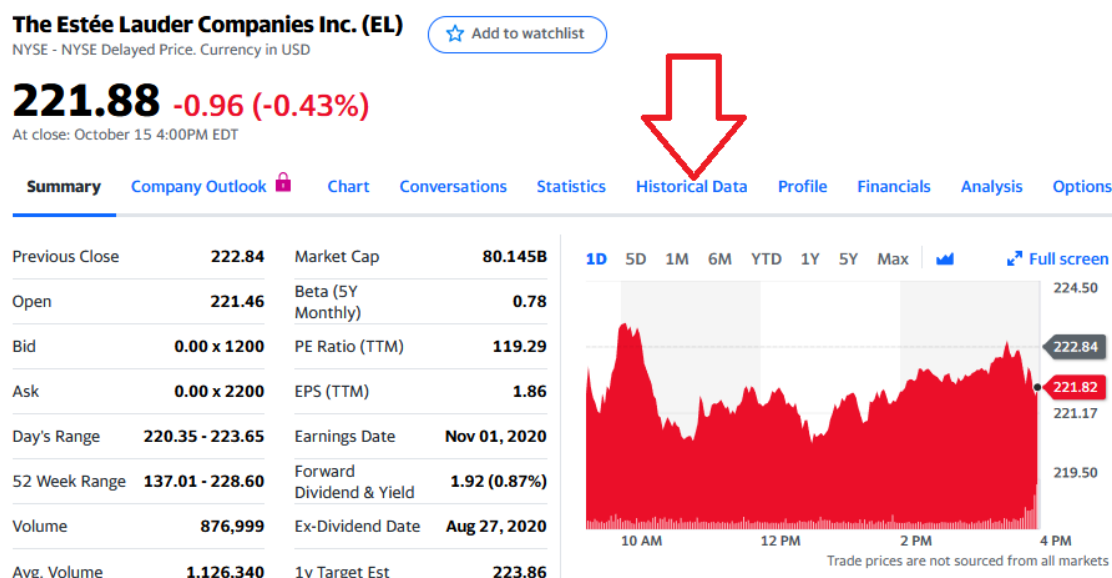
**GOOD LUCK**

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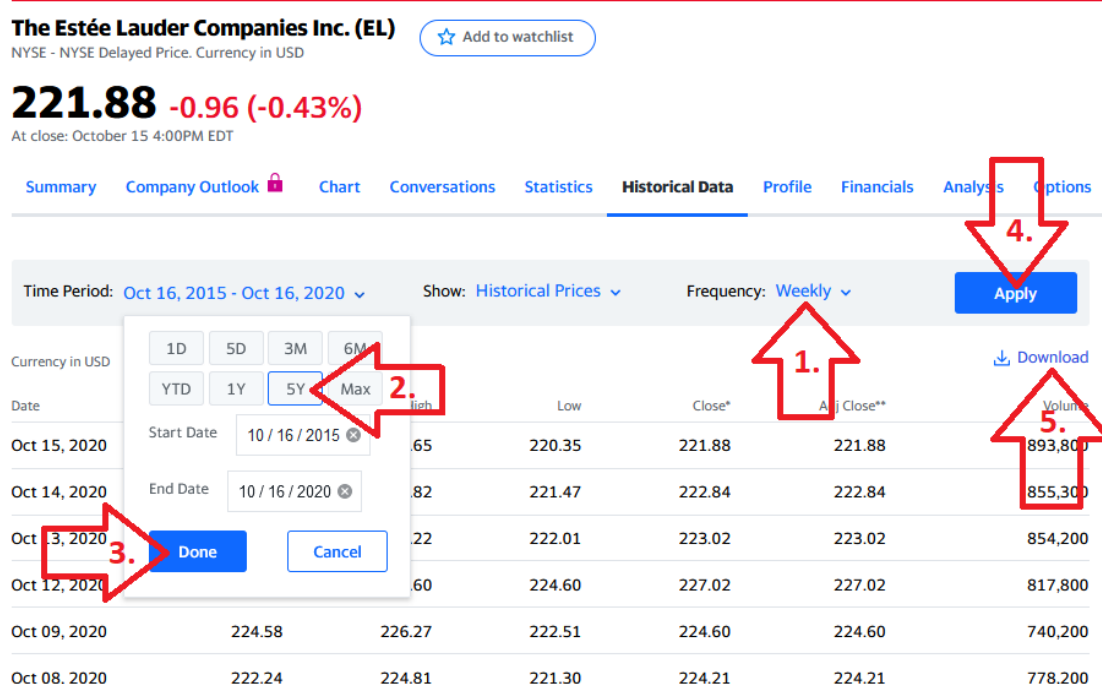
## **Part I, Data**

Below, you will find a selection of time series data sets. 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 “NVO’s”, Novo Nordisk A/S. Follow these instructions to download your stock but modify them to the frequency/length of the time series. **The example below exemplifies how to upload 1 year of daily data. The exam question might request something different.**

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 Estée 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 working directory. Save the .R-file and run it. Then verify that the data is correctly read into R.

Use Adj.Close price when available. State clearly what data you use.

Code	Symbol	Name
0001	NVO	Novo Nordisk A/S
0002	NVDA	Nvidia Corporation
0003	TSLA	Tesla, Inc.
0004	JPM	JPMorgan Chase & Co.
0005	MSFT	Microsoft Corporation
0006	HPE	Hewlett Packard Enterprise Company
0007	SHB-B.ST	Svenska Handelsbanken AB (publ)
0008	AEGN.AT	Aegean Airlines S.A.
0009	AZN	AstraZeneca PLC
0010	Telia.ST	Telia Company AB
0011	ERIC	Telefonaktiebolaget LM Ericsson
0012	BTC-USD	Bitcoin USD
0013	NVO	Novo Nordisk A/S
0014	NVDA	Nvidia Corporation
0015	TSLA	Tesla, Inc.
0016	JPM	JPMorgan Chase & Co.
0017	MSFT	Microsoft Corporation
0018	HPE	Hewlett Packard Enterprise Company
0019	SHB-B.ST	Svenska Handelsbanken AB (publ)
0020	AEGN.AT	Aegean Airlines S.A.
0021	AZN	AstraZeneca PLC
0022	Telia.ST	Telia Company AB
0023	ERIC	Telefonaktiebolaget LM Ericsson
0024	BTC-USD	Bitcoin USD
0025	NVO	Novo Nordisk A/S
0026	NVDA	Nvidia Corporation
0027	TSLA	Tesla, Inc.
0028	JPM	JPMorgan Chase & Co.
0029	MSFT	Microsoft Corporation
0030	HPE	Hewlett Packard Enterprise Company
0031	SHB-B.ST	Svenska Handelsbanken AB (publ)
0032	AEGN.AT	Aegean Airlines S.A.
0033	AZN	AstraZeneca PLC

0034	Telia.ST	Telia Company AB
0035	ERIC	Telefonaktiebolaget LM Ericsson
0036	BTC-USD	Bitcoin USD
0037	NVO	Novo Nordisk A/S
0038	NVDA	Nvidia Corporation
0039	TSLA	Tesla, Inc.
0040	JPM	JPMorgan Chase & Co.
0041	MSFT	Microsoft Corporation
0042	HPE	Hewlett Packard Enterprise Company
0043	SHB-B.ST	Svenska Handelsbanken AB (publ)
0044	AEGN.AT	Aegean Airlines S.A.
0045	AZN	AstraZeneca PLC
0046	Telia.ST	Telia Company AB
0047	ERIC	Telefonaktiebolaget LM Ericsson
0048	BTC-USD	Bitcoin USD
0049	NVO	Novo Nordisk A/S
0050	NVDA	Nvidia Corporation
0051	TSLA	Tesla, Inc.
0052	JPM	JPMorgan Chase & Co.
0053	MSFT	Microsoft Corporation
0054	HPE	Hewlett Packard Enterprise Company
0055	SHB-B.ST	Svenska Handelsbanken AB (publ)
0056	AEGN.AT	Aegean Airlines S.A.
0057	AZN	AstraZeneca PLC
0058	Telia.ST	Telia Company AB
0059	ERIC	Telefonaktiebolaget LM Ericsson
0060	BTC-USD	Bitcoin USD
0061	NVO	Novo Nordisk A/S
0062	NVDA	Nvidia Corporation
0063	TSLA	Tesla, Inc.
0064	JPM	JPMorgan Chase & Co.
0065	MSFT	Microsoft Corporation
0066	HPE	Hewlett Packard Enterprise Company
0067	SHB-B.ST	Svenska Handelsbanken AB (publ)
0068	AEGN.AT	Aegean Airlines S.A.
0069	AZN	AstraZeneca PLC
0070	Telia.ST	Telia Company AB
0071	ERIC	Telefonaktiebolaget LM Ericsson
0072	BTC-USD	Bitcoin USD
0073	NVO	Novo Nordisk A/S
0074	NVDA	Nvidia Corporation
0075	TSLA	Tesla, Inc.
0076	JPM	JPMorgan Chase & Co.
0077	MSFT	Microsoft Corporation
0078	HPE	Hewlett Packard Enterprise Company

0079	SHB-B.ST	Svenska Handelsbanken AB (publ)
0080	AEGN.AT	Aegean Airlines S.A.
0081	AZN	AstraZeneca PLC
0082	Telia.ST	Telia Company AB
0083	ERIC	Telefonaktiebolaget LM Ericsson
0084	BTC-USD	Bitcoin USD
0085	NVO	Novo Nordisk A/S
0086	NVDA	Nvidia Corporation
0087	TSLA	Tesla, Inc.
0088	JPM	JPMorgan Chase & Co.
0089	MSFT	Microsoft Corporation
0090	HPE	Hewlett Packard Enterprise Company

The goal of the assignment in Part I is to analyze assigned time series in **R** and then write an 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.” Preferably, use a new page when you answer a new question. It is important that you include plots/tables that are outputs from R and the key R-commands.

- (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 8 observations** that will be referred to as “the testing set”.

- (b) Stationarity. Use a formal test for stationarity and for detecting a trend in the time series. If it is clear from the diagram that your data is non-stationary, you may apply an appropriate transformation but perform both tests first. State the hypotheses and interpret the outcome of each test. Use 5% significance level. If the data does not seem to be stationary even after transformation, attempt another transformation and repeat the stationarity testing. Make sure that you have the figure containing the original and 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 **fourth (4th)** bar in the PACF plot and explain how to use it in the analysis. Compare with the same bar in the ACF. What is the difference? For the A-B 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 get, choose (by performing proper statistical analysis) at least four the most promising ARIMA models that are the top candidates to fit the data (leaving out the testing set). One of the remaining models 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 calculate 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 your testing set to calculate RMSE. The calculations should be explicit and easy to follow. Compare the two and interpret the difference. If needed, perform an exploratory residual analysis to select the best model. 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 and make conclusions on the quality of the models. Finally, use Holt method to have a benchmark model. Compare the quality predictions of the selected ARIMA models and the Holt method. Discuss the differences.
- (f) Pick “the best” ARIMA model from part (e). Test it for “ARCH effect”. State the hypothesis and explain the outcome of your test. Explain what presence of ARCH effect would mean for your results in (d), even if you do 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.

----- END OF PART I -----

**Part II (“Pen-and-Paper-Answer” questions: one cannot provide RStudio based solutions. Write your detailed answers on paper)**

**In this part, choose to solve two out of the three below stated problems.** If you solve all three problems, the two best answers form the base for grading.

- Let us assume that we consider an ARCH-style time series  $X_t$  without a drift, i.e.  $X_t = X_{t-1} + \varepsilon_t$  with  $\text{Var}(\varepsilon_t) = h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2$ ; further, let us assume that  $\alpha_0 = 0.0006$ ,  $\alpha_1 = 0.16$  and the error terms to be normally distributed. Calculate the standard deviations  $\sqrt{h_3}$ ,  $\sqrt{h_4}$  for the time stamps  $t=3$ ,  $t=4$  and the probability  $\mathbf{P}(X_4 > 11)$  if we observe that  $X_1 = 9.71$ ,  $X_2 = 9.70$ ,  $X_3 = 9.90$ . Further, assume that  $\alpha_0 = 0.0006$ ,  $\alpha_1 = 0$  and calculate  $\mathbf{P}(X_4 > 11)$ .

What is the difference between two probabilities? Why? Provide “financial intuition” to the difference of the probabilities.

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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  $Z_t = \varepsilon_t - 1.6\varepsilon_{t-1}$ . Assume that  $Z_t$  is stationary.
  - b) Derive the autocorrelation function for the following MA(2) process  $Z_t = \varepsilon_t - 1.6\varepsilon_{t-1} + 0.6\varepsilon_{t-2}$ . Assume that  $Z_t$  is stationary.
- 

3. Let us consider a time series with the following path generating process:  $X_t = t \cdot a_0 + \varepsilon_t$ , where  $\varepsilon_t \sim N(0, \sigma^2)$ . Test this time series for stationarity. In case it is not stationary, find a transformation that makes this time series stationary and prove the stationarity. RStudio visualization is a good supplement to the pen and paper solution but cannot substitute theory-based calculations.

----- **GOOD LUCK** -----