NHH

TERM PAPER
TECH2

Fall, 2024

Start: November 1, 2024 15:30

End: November 8, 2024 12:00

THE TERM PAPER SHOULD BE SUBMITTED IN WISEFLOW

You can find information on how to submit your paper here:
https://www.nhh.no/en/for-students/examinations/home-exams-and-assignments/

Your candidate number will be announced on StudentWeb. The candidate number should be noted on all pages (not your name or student number). In case of group examinations, the candidate numbers of all group members should be noted.

Collaboration between individuals or groups on submission preparation, as well as exchange of self-produced materials between individuals or groups is prohibited. The answer paper must consist of individual's or the group's own assessments and analysis. All communication during the home exam is considered cheating. All submitted assignments are processed in Ouriginal, a plagiarism control system used by NHH.

SUPPLEMENTARY REGULATIONS FOR EXAMINATIONS

You can find supplementary regulations under the headline “Regulations”

https://www.nhh.no/en/for-students/regulations/

Find more information under chapter 4.0 in the Supplementary provisions to the regulations for fulltime study programmes

Number of pages, including front page: 5

Number of attachments: 1 (data.zip)

TECH2 Group term paper

About the exam:

- Deadline for submission is Friday, November 8 at 12:00. This is a hard deadline, and no late submissions will be accepted.
- You must register and submit as a group in Wiseflow. Please check Canvas to see which group you have been assigned to.
- Your submission must be a zipped folder that contains the following:
    1. A Jupyter notebook.
    2. All other files necessary to execute the notebook (e.g., data files).
    3. A conda environment file called "environment.yml" that specifies the version of Python and packages necessary to execute the notebook.
    4. All outputs of your code (e.g., figures).
- Be aware that you will most likely need to use functions and packages not explicitly covered in class. Consulting online sources for help with coding is an important learning outcome in this course.
- Note that you are allowed to use all online sources for help, e.g., Stackoverflow, official function documentation, generative AI etc.
- However, collaboration between groups (or receiving help from others) is strictly forbidden.

Norwegian and German electricity markets

Background

Following the European energy crisis in 2022 with soaring electricity prices, your boss has become interested in learning more about electricity markets. She is especially interested in exploring the characteristics of electricity prices and analyzing trade flows of electricity between countries. Therefore, she has asked you and your colleagues to explore and analyze data from the Norwegian and German electricity markets.

Norway and Germany are linked by a single subsea transmission cable called Nordlink. Testing of the cable started in September 2020, and it was officially opened for operation on December 9, 2020. While the German electricity market consists of a single price zone, the Norwegian electricity market has five different price zones: NO1, NO2, NO3, NO4 and NO5. It is the price zone in Southern Norway (NO2) that is linked with the German electricity market through Nordlink. Your boss has therefore asked you to focus on electricity prices in NO2 and Germany in this assignment.

Data

To complete the assignment, your boss has supplied you with two different datasets that have been downloaded from the ENTSO-E Transparency Platform. Both datasets can be found in the "data" folder. Note that both datasets start on January 1, 2019, and end on December 31, 2023. However, as the data is large, the datasets consist of several csv files that contain observations for a single month in the sample period.

The first dataset, "DayAheadPrices_12.1.D", contains csv files with observations on electricity prices for many different price zones in Europe. Each file contains several columns, but the relevant columns for this assignment are:

DateTime	Timestamp of the observation, contains both the date and time of the observation, e.g., 24th of October 2022 at 23:00.
ResolutionCode	Resolution of the timestamp, e.g., "PT60M" means that observation is on the hourly level, "PT15M" means that the observation is for each 15th minute.
MapCode	Code that indicates the price zone.
Price	Observation of the electricity price (in EUR/MWh).

Note that some price zones report the electricity price using multiple time resolutions. You should therefore make sure that you use the same time resolution for prices in both NO2 and Germany.

The second dataset, "PhysicalFlows_12.1.G", contains csv files with observations on the hourly transmission flows of electricity between price zones. Each file contains the following columns:

DateTime	Timestamp of the observation, contains both the date and time of the observation, e.g., 24th of October 2022 at 23:00.
InMapCode	Code that indicates the price zone that electricity is imported to.
OutMapCode	Code that indicates the price zone that electricity is exported from.
FlowValue	Hourly transmission of electricity (in MWh).

Note that the map code in both datasets is "NO2" and "DE_LU" for NO2 and Germany, respectively. In the following tasks, you should use observations only for these two price zones.

Before starting on the tasks, you should first import and familiarize yourself with the data in the two datasets.

Tasks

You and your colleagues have been asked to prepare a Jupyter notebook that solves the following tasks:

Task 1

Your boss wants to know how electricity prices in NO2 and Germany have developed over the sample period. Therefore, she has asked you to create a **line plot** that visualizes the hourly electricity price in NO2 and Germany. The graph should:

- consist of two subplots:
    - The first subplot shows the hourly electricity price in NO2 over time.
    - The second subplot shows the hourly electricity price in Germany over time.
- add a vertical line to each subplot to indicate the official opening of Nordlink (December 9, 2020).
- be stored as a png file called "figure_task1.png".

What is your conclusion? How has the electricity price in NO2 and Germany developed over time? Have the prices increased or decreased after the opening of Nordlink? Extra: Do you have any suggestions for why we sometimes observe negative electricity prices?

Task 2

Your boss has heard that electricity prices have become more volatile with extreme prices in recent years. Therefore, she has asked you to create a **table** with some descriptive statistics for the hourly electricity price in NO2 and Germany. The table should:

- contain the mean, median, standard deviation, min and max of the hourly electricity price in NO2 and Germany separately for each year in the sample (2019, 2020, 2021, 2022, 2023).
- round all descriptive statistics to two decimals.
- be stored as an excel file called "table_task2.xlsx".

What is your conclusion? Have electricity prices in NO2 and Germany become more extreme in recent years? Have the prices evolved differently in NO2 than in Germany?

Task 3

Your boss is interested in knowing whether NO2 exports more electricity than it imports from Germany, and if this has changed over time. Therefore, she has asked you to create a **bar plot** that shows the annual sums of imports and exports of electricity in NO2. The graph should:

- contain a single bar plot that shows the annual sums of exports and imports of electricity in NO2 from Nordlink for each year in the data.
- be stored as a png file called "figure_task3.png".

What is your conclusion? Does NO2 import or export more electricity to Germany? Have the annual sums of exports and imports changed over the years?

Task 4

Your boss wants to take a closer look at the transmission flows and investigate whether there are times during the year in which NO2 imports more electricity from Germany than it exports. Specifically, she wants to know whether there have been weeks in the data in which the sum of net exports of electricity from NO2 to Germany has been negative (i.e., NO2 imports more electricity than it exports to Germany). Note that the net export is defined as the export of electricity minus the import of electricity.

Therefore, she has asked you to create a **line plot** that shows the weekly sum of net exports of electricity from NO2 to Germany. The graph should:

- contain a single line plot that shows the weekly sum of net exports of electricity from NO2 to Germany over time.
- contain a horizontal line at y=0 to indicate when the weekly net export is zero.
- be stored as a png file called "figure_task4.png".

What is your conclusion? Have NO2 always exported more electricity to Germany than it has imported? Or have there been weeks in the data in which NO2 was a net importer of electricity? If so, at what times during the year does this usually occur?

Task 5

Your boss believes that NO2 tends to export more electricity to Germany whenever the electricity price in Germany is higher relative to the price in NO2. She has asked you to investigate this claim by creating a **scatter plot** between the weekly sum of net exports in NO2 and the weekly average price difference between Germany and NO2. Note that to find the weekly average price difference, you should first find the hourly price difference, and then take the weekly average.

The graph should:

- contain a single scatter plot that shows the weekly sum of net exports in NO2 on the y-axis and the weekly average price difference between Germany and NO2 on the x-axis.
- contain the correlation coefficient between the weekly sum of net exports and the weekly average price difference in the figure title.
- be stored as a png file called "figure_task5.png".

What is your conclusion? Does there seem to be a relationship between the weekly sum of net exports and the weekly average price difference? If so, is the relationship positive or negative?

Task 6

Your boss is curious to know how you have used online sources in completing the assignment. She has asked you to write a statement describing your use of online sources, e.g., Stackoverflow, official function documentation, generative AI etc. If you have copied code from online, you can use this statement to point out the code snippets that you have not written yourself along with a reference to the source. In addition, if you have used generative AI, e.g., ChatGPT, your statement should explain how you have used such tools to help with the assignment.

Assessment of the term paper:

You should submit a single Jupyter notebook that is clearly structured and well-documented with the use of Markdown cells and in-line comments. For each task, you should add a single Markdown cell with a short conclusion of the task. In addition, you should take care in creating graphs that are visually pleasing by e.g., adding titles and axis labels, modifying the graph size, adjusting line widths etc.

Your term paper will be assessed by the following criteria:

- Efficient data importing and processing (20 pts)
- Solution to task 1 (10 pts)
- Solution to task 2 (10 pts)
- Solution to task 3 (15 pts)
- Solution to task 4 (15 pts)
- Solution to task 5 (15 pts)
- Solution to task 6 (5 pts)
- Jupyter notebook runs without errors (5 pts)
- yml file that replicates your conda environment (5 pts)

Note that the points in the parenthesis are the maximum scores attainable, and the final score will depend on the assessment of each element in the list. This means that the solution to each task will be assessed by the efficiency and sophistication of your code.