IE 582 Statistical Learning for Data Mining

Homework 1, Due November 2, 2023

1. Introduction:

In the era of big data, extracting meaningful patterns from vast datasets is a valuable skill for various disciplines, from engineering to social sciences. Financial markets, with their multifaceted influences and complex behaviors, offer a rich area for data-driven exploration. This homework invites you to dive into the patterns within Borsa İstanbul stock data, enabling you to apply and enhance your knowledge in statistical learning and data mining.

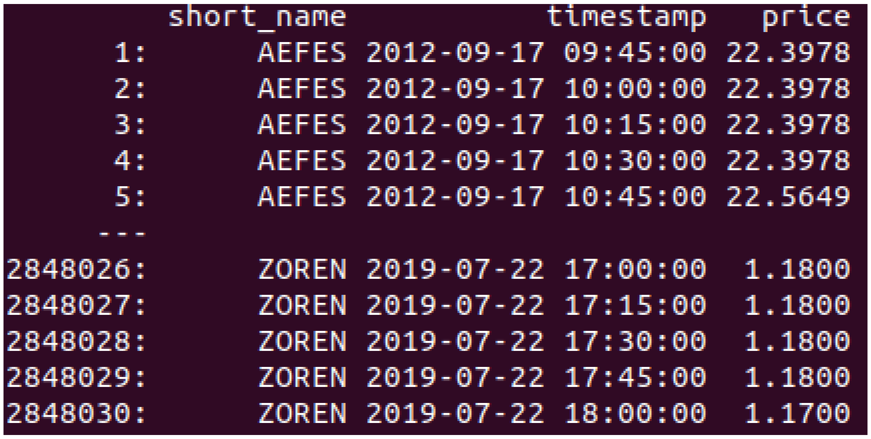
2. Data:

You will retrieve your data from the provided link:
https://drive.google.com/drive/folders/1IMQmUOI_XNg5TSGZkbsglvIcoczSs3YR

The data comprises the closing prices of selected stocks from Borsa İstanbul. The frequency of the observations is 15 minutes. Under the shared folder, you will find the same information in two alternative formats, namely long and wide format. Long and wide formats are illustrated in Figures 1 and 2 respectively. You can choose one of them for your analyses. Note that the data is provided as csv files which are compressed with gzip.

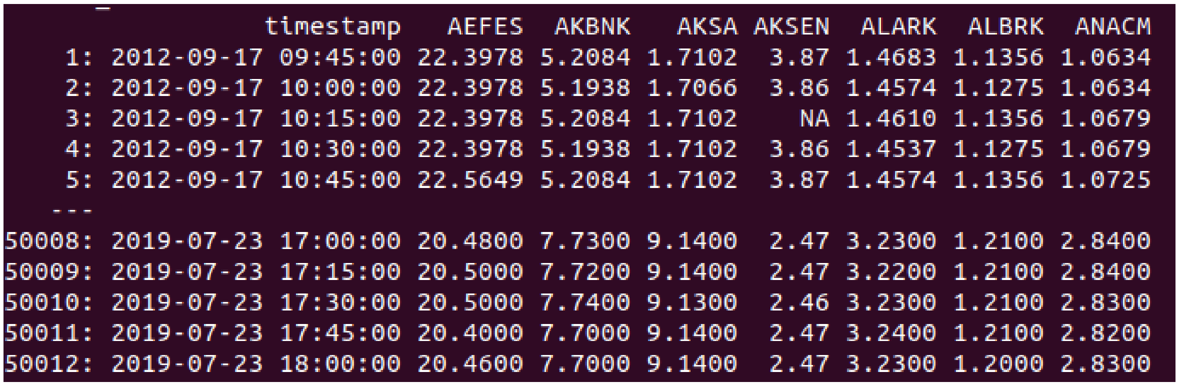
You can find detailed information about these formats in the following links:

- https://www.statology.org/long-vs-wide-data/
- https://www.thedataschool.com.au/mipadmin/the-shape-of-data-long-vs-wide/
- https://libguides.princeton.edu/R-reshape
- https://stefvanbuuren.name/fimd/sec-longandwide.html



```
          short_name           timestamp   price
       1:      AEFES 2012-09-17 09:45:00 22.3978
       2:      AEFES 2012-09-17 10:00:00 22.3978
       3:      AEFES 2012-09-17 10:15:00 22.3978
       4:      AEFES 2012-09-17 10:30:00 22.3978
       5:      AEFES 2012-09-17 10:45:00 22.5649
     ---
2848026:      ZOREN 2019-07-22 17:00:00  1.1800
2848027:      ZOREN 2019-07-22 17:15:00  1.1800
2848028:      ZOREN 2019-07-22 17:30:00  1.1800
2848029:      ZOREN 2019-07-22 17:45:00  1.1800
2848030:      ZOREN 2019-07-22 18:00:00  1.1700
```

Figure 1. The stock price data in long format



```
                 timestamp   AEFES  AKBNK   AKSA AKSEN  ALARK  ALBRK  ANACM
    1: 2012-09-17 09:45:00 22.3978 5.2084 1.7102  3.87 1.4683 1.1356 1.0634
    2: 2012-09-17 10:00:00 22.3978 5.1938 1.7066  3.86 1.4574 1.1275 1.0634
    3: 2012-09-17 10:15:00 22.3978 5.2084 1.7102    NA 1.4610 1.1356 1.0679
    4: 2012-09-17 10:30:00 22.3978 5.1938 1.7102  3.86 1.4537 1.1275 1.0679
    5: 2012-09-17 10:45:00 22.5649 5.2084 1.7102  3.87 1.4574 1.1356 1.0725
   ---
50008: 2019-07-23 17:00:00 20.4800 7.7300 9.1400  2.47 3.2300 1.2100 2.8400
50009: 2019-07-23 17:15:00 20.5000 7.7200 9.1400  2.47 3.2200 1.2100 2.8400
50010: 2019-07-23 17:30:00 20.5000 7.7400 9.1300  2.46 3.2300 1.2100 2.8300
50011: 2019-07-23 17:45:00 20.4000 7.7000 9.1400  2.47 3.2400 1.2100 2.8200
50012: 2019-07-23 18:00:00 20.4600 7.7000 9.1400  2.47 3.2300 1.2000 2.8300
```

Figure 2. The stock price data in wide format

3. Requirements:

3.1. Software & Tools:

- R or Python for data manipulation and analysis.
- Relevant libraries/packages for time series data, PCA, and correlation calculations.
- Google Trends for real-world data correlation.

3.2. Prerequisite Knowledge:

- Basics of R or Python programming with emphasis on data manipulation.
- Foundational concepts in statistical learning, PCA, and data mining.

4. Tasks:

4.1. Descriptive Analysis

- Begin by exploring the data to get a feel for its structure, distribution, and potential patterns.
- Calculate summary statistics for the indices, including measures of central tendency, dispersion, and shape.

4.2. Moving Window Correlation

- Choose pairs of stock prices you deem interesting.
- Calculate correlations over a moving window (e.g., monthly) to see how relationships between selected stocks evolve over time. Visualize these correlations using appropriate plots.
- Discuss any observed deviations or patterns in correlation. Are there periods where correlations seem unusually high or low?

4.3. Principal Component Analysis (PCA)

- Apply PCA on the dataset to reduce dimensionality.
- Interpret and comment on the first few principal components. Can these be seen as latent variables capturing underlying patterns in the data? If so, elaborate.

4.4. Inference with Google Trends:

Another interesting data source is Google Trends (http://trends.google.com/). The Wikipedia definition for Google Trends is:

“Google Trends is a public web facility of Google Inc., based on Google Search that shows how often a particular search-term is entered relative to the total search-volume across various regions of the world, and in various languages. The horizontal axis of the main graph represents time (starting from 2004), and the vertical is how often a term is searched for relative to the total number of searches, globally. Below the main graph, popularity is broken down by countries, regions, cities and language. Note that what Google calls "language", however, does not display the relative results of searches in different languages for the same term(s). It only displays the relative combined search volumes from all countries that share a particular language (see "flowers" vs "fleurs"). It is possible to refine the main graph by region and time period.”

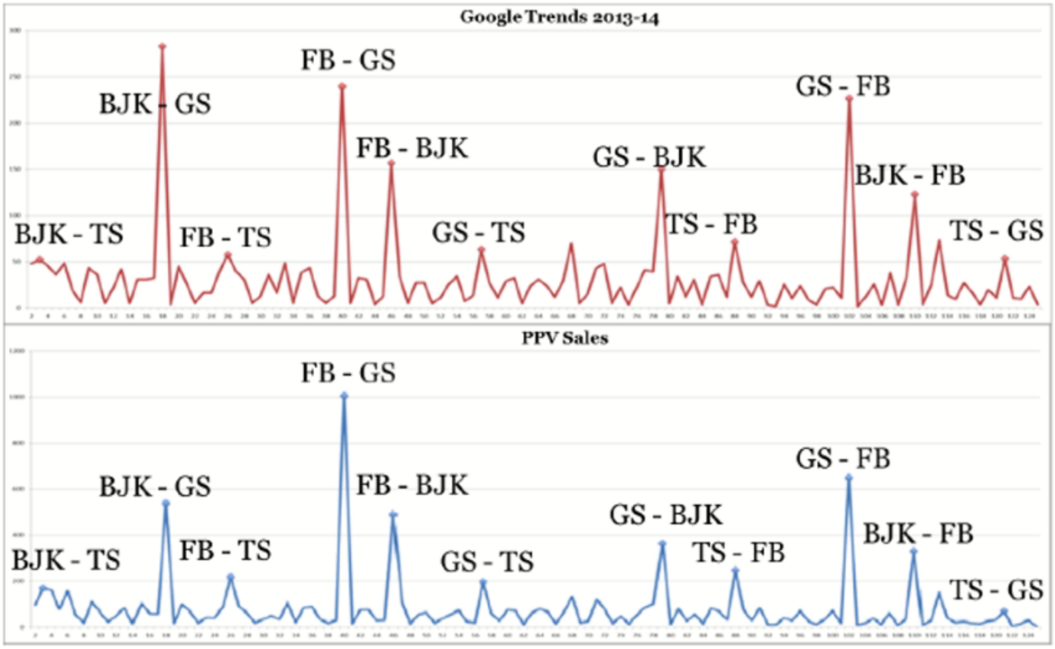


Figure 3. Search volume versus PPV sales

Sometimes it is interesting to check if search volume of a certain keyword has some relation to an event. For example, number of searches for “flu” can give you an idea about the number of people affected by the flu over the world. Another example is from a senior design project we have worked on last year. It was about understanding if Google Trends provide information about the number of pay-per-view (PPV) customers of Digiturk. To be more specific, Lig TV is a football channel of Digiturk holding rights to broadcast Turkish Super League live since 2001. It serves its customer through different channels such as the Internet platform “Digiturkplay” or satellite TV “Digiturk Plus”. All channels include a service called pay-per-view (PPV) providing customer to pay for the particular programs that they watch via private telecast. The aim here is to see if it is possible to forecast demand for PPV through the Internet search data, namely Google Trends Data. To achieve this, we obtained PPV data from Digiturk. For each soccer game, we obtained the daily search volume information for each team playing a game (i.e. if the game is between Beşiktaş and Fenerbahçe, we obtained the search volume for each team on the game day and sum these values to find out a measure that will quantify the popularity). The plot of the PPV sales versus the search volume information for each game is schematized in Figure 3. As you can see, Google Trends data is highly correlated with the sales.

Determine search keywords that can be relevant to the prices you consider in the earlier parts (i.e. if you are interested in AEFES you can check the search volume for "IST:AEFES").

- Just as in the previous task, use Google Trends to cross-reference dates or periods with unusual patterns or correlations. This might offer insights into external events influencing the stock prices.
- Systematically draw parallels between deviations in data patterns and spikes or news items from Google Trends.

5. Report & Code Documentation:

Combine your results and visual aids into a comprehensive report. Your report should:

- Discuss your methodologies and findings.
- Draw conclusions based on the patterns observed and their possible real-world implications.
- Offer insights into any challenges faced and how you overcame them.

Please solve the following exercises using R (http://www.r-project.org/) or Python (https://www.python.org/). You are expected to use GitHub Classroom and present your work as an html file (i.e. web page) on your progress journals. There are alternative ways to generate an html page for you work:

- A Jupyter Notebook including your codes and comments. This works for R and Python, to enable using R scripts in notebooks, please check:
    - https://docs.anaconda.com/anaconda/navigator/tutorials/r-lang/
    - https://medium.com/@kyleake/how-to-install-r-in-jupyter-with-irkernel-in-3-steps917519326e41

  Things are little easier if you install Anaconda (https://www.anaconda.com/). Please export your work to an html file. Please provide your *. ipynb file in your repository and a link to this file in your html report will help us a lot.

- A Markdown html document. This can be created using RMarkdown for R and Python. Markdown for Python

Note that html pages are just to describe how you approach to the exercises in the homework. They should include your codes. You are also required to provide your R/Python codes separately in the repository so that anybody can run it with minimal change in the code. This can be presented as the script file itself or your notebook file (the one with *.ipynb file extension).

The last and the most important thing to mention is that academic integrity is expected! Do not share your code (except the one in your progress journals). You are always free to discuss about tasks but your work must be implemented by yourself.

Please mention if you utilize Large Language Models (i.e. chatGPT, BART and etc). You are expected to provide your prompt and resulting response of these models at the end of your reports as Appendix if you have utilized any of these tools.

As a fundamental principle for any educational institution, academic integrity is highly valued and seriously regarded at Boğaziçi University.

6. Conclusion

Data mining is both an art and science. As you journey through this homework, remember that the process is as valuable as the outcome. Your ability to connect the dots between seemingly unrelated pieces of information will shape your growth in the realm of data science.

We're eager to see the unique insights each of you will bring to this project, especially given the diverse academic backgrounds of our cohort. Best of luck, and happy mining!