

**Boğaziçi University**, Department of Economics

**Course Code:** EC 48E

**Course Name:** Financial Applications of Machine Learning

### **Problem Set 1**

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**Deadline 18 October 2024**

#### **Instructions:**

- This is a group project, each group can have up to 3 students. You are urged to find a group
- We may be using this data set for future assignments.
- If you have a question regarding the data you can consult our TA: Sami Boz or Melih Karaköse.

**Data set:** Data should be downloaded from yahoo finance ([Yahoo Finance](#)). For the sample size you can use the same period for your choice of variables.

Download the following 9 series from yahoo finance.

- *US Tech Stocks:* GOOGL, AAPL, AMZN, NVDA, Bitcoin (BTC)
- *US Tech Index:* NASDAQ
- *Turkish Stock Index:* XU100 (BIST100) Please use only the years between 2021-2024 as there is a problem in the data before.
- *Turkish Stocks:* AKBNK, TUPRS (note that if Turkish stocks are not in good shape in yahoo finance try some other sources).
- *Please check my Risk and Return Chapter to see the definitions of Arithmetic Return, Sharpe Ratio and interpretation of your findings. Calculations and computations are straightforward you should be careful in interpreting your results.*

**You will find some helpful python code snippets attached to this document. You are welcome to try your own approach too.**

## Part A. Data ANALYSIS OF FINANCIAL TIME SERIES using Python

Collect the specified data set using Python. Below there is an example to retrieve daily Bitcoin prices. You may use your own alternative method to retrieve data.

```
import yfinance as yf
import numpy as np
import matplotlib.pyplot as plt

# Retrieve Bitcoin prices from Yahoo Finance API
btc = yf.download('BTC-USD', start='2017-01-01')
```

1) For each of the analysis, use the closing prices as the index (other inputs open, high etc can be ignored for our PS). Calculate the % changes of these closing prices (i.e. arithmetic returns) for the above chosen financial variables.

Here is a simple formula to calculate arithmetic returns using *pandas*

```
import pandas as pd

# Example price data
prices = [100, 110, 120, 115, 125]

# Create a pandas Series with the prices
price_series = pd.Series(prices)

# Calculate linear return series
linear_returns = price_series.pct_change()

# Print the result
print("Linear Return Series:")
print(linear_returns)
```

2) Find the sample mean, sample standard deviation, skewness, and excess kurtosis estimates on these daily, weekly and monthly return series.

Below there is an example to show calculation of the descriptive statistics in python.

```
import numpy as np
from scipy.stats import skew

# Example dataset
data = [10, 12, 15, 18, 20]

# Mean calculation
mean = np.mean(data)

# Variance calculation
variance = np.var(data)
```

```
# Standard deviation calculation
std_dev = np.std(data)
```

```
# Skewness calculation
skewness = skew(data)
```

Here, there is an example of how you can convert the daily returns into weekly, monthly, yearly data

```
tickers = ["AAPL"]
start_date = "2013-01-01"
end_date = "2023-12-31"

# Retrieve data from Yahoo Finance
data = yf.download(tickers, start=start_date, end=end_date, interval='1d', group_by='ticker')

# Get yearly closing prices
yearly_data = data.resample('Y').last()['Close']
monthly_data = data.resample('M').last()['Close']
weekly_data = data.resample('W').last()['Close']
```

3) Make a table where you have different frequencies and different descriptive statistics. Make the table to show them all in a compact way. Please summarize your findings clearly but briefly by looking at the chapter you are given. Please present US index (SP500) and US stocks in same plot. Plot Turkish Stock index BIST100 and single Turkish stocks in the same time series plots.

- Here you can find an example plot. Please create subplots. You can use any library you seem fit such as matplotlib, seaborn, plotnine...

```
# Plot Bitcoin close prices and log returns on the same graph
fig, ax = plt.subplots(figsize=(12,8))
ax.set_title('Bitcoin Prices and Log Returns', fontsize=20)
ax.set_xlabel('Date', fontsize=16)
ax.set_ylabel('Price / Log Returns', fontsize=16)
ax.tick_params(labelsize=12)
ax.plot(btc['Close'], label='Close Price')
ax.plot(btc['log_returns'], label='Log Returns')
ax.legend(fontsize=14)
plt.show()
```

4) Plot histograms of daily return plots of US Stocks against Bitcoin prices. Compare the expected return (sample mean) and risk (standard deviation) of Bitcoin with that of other US stocks. Comment briefly how does the expected return and risk (i.e. standard deviation) trade off work. Do you see any pattern among these stocks. How does it compare it with the Turkish Stocks mean and standard deviation trade off.

You can find an example python snippet below.

```
# Plot histograms
plt.figure(figsize=(12, 6))
# Plot histogram for yearly closing prices
plt.subplot(1, 2, 1)
plt.hist(yearly_data, bins=20, color='blue', alpha=0.7)
plt.title('Yearly Closing Prices Histogram')
plt.xlabel('Closing Price')
plt.ylabel('Frequency')
# Plot histogram for monthly closing prices
plt.subplot(1, 2, 2)
```

```
plt.hist(monthly_data, bins=20, color='green', alpha=0.7)
plt.title('Monthly Closing Prices Histogram')
plt.xlabel('Closing Price')
plt.ylabel('Frequency')
plt.tight_layout()
plt.show()
```

## Part B: Correlation and Regression in Python

1. Calculate the mean and the st. Deviation of BTC and Apple stocks for monthly returns. How do you comment on them? What is the correlation between these two stocks?
2. Find the correlation between BTC returns and other US stock return series. Comment on your findings on looking at my other notes (Risk Return Calculations). (find the correlation using Python libraries)

3. Sharpe Ratio =  $\frac{\mu}{\sigma}$  is a very popular performance ratio indicating how much return is expected for a given risk. The higher the Sharpe ratio the better the risk adjusted expected return. Calculate the daily, weekly, monthly sharpe ratio for US stocks. What do we find? How would you manage your portfolio after your findings. What is the Sharpe ratio of Bitcoin? (Note that we simplified Sharpe Ratio by assuming interest rates

are zero.  $sharpe = \frac{\mu - r}{\sigma}$  where  $r$  is the interest rates.)

4. Markowitz Frontier: Please first read the risk-return calculations before attempting to solve this question. Suppose your wealth is 100 \$. First you invest all your wealth in BTC i.e  $w_1=100\%$ . Then you do divide your portfolio 50% BTC, 50% Apple. Then 1/3 BTC, 1/3 Google, 1/3 Apple. Finally you divide your wealth equally for all the stocks you have i.e  $w_1=w_2=w_3=w_4=25\%$  for each four stocks including Amazon.
  - a. Calculate your expected return and st. Deviation of your portfolio for each of these 4 cases.
  - b. Plot the expected return of portfolio 1,2,3,4 against number of stocks. Plot the standard deviation of each portfolio against the number of stocks in your portfolio
  - c. What do you observe in terms of your standard deviation of your portfolio
  - d. What do you expect your results if you add more stocks into your portfolio
  - e. Can you generalize the saying “don’t put all of your eggs into a basket” with this exercise.

## 5. Stock Beta

Please focus on your monthly Turkish and US stocks and their stock indices XU100 and NASDAQ. Choose one stock say Apple. Estimate the regression equation below.

$$R_{i,t} = \alpha + \beta R_{m,t}$$

$R_{i,t}$ : i th stock arithmetic return for stock i say: APPLE for month t.

$R_{m,t}$ : is the return of a stock index (i.e NASDAQ’s monthly stock returns), m is the market index

6. Estimate the beta's for each stocks. (Turkish and US stocks separately use BIST100  $R_{m,t}$  for the for Turkish Stocks . 2 betas for Turkey (AKB, Tupras) and 4 for US (APPLE, GOOGLE,NVDIA, AMAZON.)
7. How do you compare the beta's in US and Turkey separately? Which stock seemed to have highest beta? Which stocks would you buy if you expect a sharp drop in growth in US economy.
8. Do a statistical t test whether beta is significant or not? How does the model fit look at their R-square?