Bocconi UNiversity - 20236 Time Series Analysis: Assignment 1

Introduction to time series analysis with R.
Time series decomposition. Exponential smoothing.

Due by March 2, 2023

NOTE: You will use **Rmarkdown** for your final project; therefore, we encourage you to start using RMarkdown (see LAB1 on BBoard) since now.

You can find many **tutorials** on the web, such as these:

https://www.youtube.com/watch?v=EmZqlcKkJMM

https://www.youtube.com/watch?v=orjLGFmx6l4

on R: https://www.youtube.com/watch?v=s3FozVfd7q4

on R markdown: https://www.youtube.com/watch?v=DNS7i2m4sB0

on ggplot2: https://www.youtube.com/watch?v=49fADBfcDD4

1. **Exercise 1** (*This exercise is solved in LAB 1 – look at the LAB1 files provided on BBoard!*)

Consider the time series **co2**, monthly observations of atmospheric concentrations of co2 at Mauna Loa, from 1959 to 1997; this series is available in R.

```
? co2
?decompose
```

- Plot the data.
- The series clearly shows a trend and a seasonal behavior. Describe such components using classical time series decomposition methods (**R** function: **decompose**).

2. **Exercise 2**.

Consider another classical data set, **UKgas**, available in **R**. This time series provides the quarterly UK gas consumption from the first quarter of 1960 to the forth quarter of 1986, in millions of therms.

```
? UKgas
```

- First, plot the data.
- Describe the structural components of the UKgas time series: decompose the series, and plot the results.

Would you use an additive or multiplicative time series decomposition? Or, you could take the log of the series: why?

- Comment briefly: are you satisfied with your results? Is there anything that you would like to improve, or any assumption you would like to relax?
- Compare the previous results with those obtained by using Holt & Winters exponential smoothing with trend and seasonality.

Comment briefly (we still see a time-varying seasonal component, that changes around 1973. On the contrary, classical time series decomposition assumes **constant** seasonal factors!)

```
decUK = decompose(log(UKgas), type="additive")
```

In fact, we would like to allow for **time varying** seasonal factors. Holt & Winters exponential smoothing is a first step in that direction.

Remark: *Later in the course, we will study dynamic linear models for trend and seasonality, that can account for time-varying seasonal factors, in a rigorous probabilistic framework.*

3. **Exercise 3**.

The dataset **Nile**, available in **R**, provides the measurements of the annual flow of the river Nile at Ashwan, for the period 1871-1970.

```
? Nile
```

This is a very popular dataset, used as a classical example of a time series that shows a change point.

- Plot the data, together with the online one-step-ahead forecasts obtained by simple exponential smoothing. Use the R default choice of the smoothing parameter α (what value of α is chosen)?
- Then, compare the results obtained for different choices of the smoothing parameter α, namely: $\alpha = 0.1$, $\alpha = 0.9$, and the default choice of α. Comment on the effect of α on the forecasts.
- Compare the results above, using the MAPE as a simple measure of the predictive performance of the model. Comment briefly.

```
# hint:
mape = function(y, yhat){ mean(abs(y - yhat)/y) }
```

4. **Coronavirus data**

With the horrible pandemic, we also experienced the relevance of reliable data and forecasts as support of decisions under uncertainty.

I provide on BBoard a dataset of daily data on the evolution of the covid epidemic in Italy, since February 20, 2020.

Import the data in RStudio and provide meaningful plots.

You could also make some first analysis of these data, with the first tools we learned, but this is **not** part of the assignment. A question for you to keep in mind for reflection: can you make forecasts and express the uncertainty about your forecasts?