**Lab Assignment-1**

**Note: Write a concise report that shows that you have done the assignments and reflected over the results obtained.** **Deadline to submit report and assignment code is 15/05/2022. Submit a zip file containing datasets, codes, and the report. The file name must be in the following format: *Name\_Rollno\_Assignment1*.**

**Q1.** Consider an AR(2)-process



normally distributed with mean zero and variance one. Such a process is stationary if the parameters *ϕ*1 and *ϕ*2 satisfy the following conditions

*ϕ*2+*ϕ*1<1,

*ϕ*2-*ϕ*1<1,

-1<*ϕ*2<1.

Furthermore, it is easy to show that these conditions are satisfied if the point (*ϕ*1 , *ϕ*2) is inside the triangle defined by the straight lines *ϕ2*+*ϕ*1=1, *ϕ*2-*ϕ*1=1, and *ϕ*2=-1.

Select a pair (*ϕ*1, *ϕ*2) of parameter values that is inside the triangle defined above and not close to any of its sides. Generate 100 observations of the selected AR(2)-process. Make a time series plot of the generated data.

Select a new pair of parameter values that is inside the triangle defined above but close to its boundary. Generate and plot 100 observations of the selected AR(2)-process. In what respect does the temporal variation of the second curve differ from that of the first curve?

Select a third pair of parameters that correspond to a point outside the cited triangle. Generate and plot 100 observations of the selected AR(2)-process. In what respects does the third curve differ from the other curves?

Make sure that you, by visual inspection, you can identify time series plots corresponding to

1. a clearly stationary process,
2. a stationary but almost non-stationary process, and
3. a non-stationary process.

Plot the sample autocorrelation function for time lags 1-20 for above three AR(2) process samples. In what respect are the three autocorrelation functions different? Note especially how the autocorrelation tails off with increasing time lags.

**Q2.** Generate 100 observations according to the AR(1)-process



where *Var*(*et*)=1. Form a new process



by adding independent normally distributed measurement errors *ηt* with mean 0 and variance 1 to the original observations. Plot sample autocorrelation and partial autocorrelation functions of *Zt*. Identify a suitable ARMA-process for the data set under consideration and estimate the parameters of the model. Plot the residuals to check whether the selected model is a suitable model.

**Q3.** Make a time series plot for ***Average population age*** dataset

Carry out appropriate differencing operations and make time series plots of each of the differenced series. What differencing operations are needed to make the series stationary?

Compute sample autocorrelation functions for the original series as well as each of the differenced series. Do the estimated autocorrelations indicate that you have obtained a stationary series after the last differencing? If not, carry out additional differencing.

Fit a suitable ARMA-model to the twice differenced population series and compute forecasts for the next five years.

Convert the forecasts of the twice differenced series into forecasts of the original population series for the next five years.

**Q4.** Make a time series plot of the number of cars in use by using ***Passenger cars*** dataset.

Carry out additional differencing and make time series plots of the differenced series.

What differencing operations are needed to make the series stationary?

Compute sample autocorrelation functions for the original series as well as each of the differenced series. Do the estimated autocorrelations indicate that you have obtained a stationary series after the last differencing? If not, try another type of differencing.

Fit a suitable ARMA-model to a suitable differenced series of registered cars and compute forecasts for the next twelve months. Convert forecasts of the differenced series into forecasts of the original series.

**Q5.** For ***electricity.csv*** dataset do the following:

Make time series plots of:

1. the original time series of data
2. the differenced series of data
3. the seasonally differenced series of data
4. the differenced and seasonally differenced series of data

What kind of differencing is needed to make the time series stationary?

Examine plots of sample autocorrelation functions and partial autocorrelation functions for a seasonally differenced (and possibly further differenced) and fit the following types of ARIMA- and Seasonal ARIMA models to the time series of electricity consumption:

1. an ordinary ARMA-model of a seasonally differenced (and possibly further differenced) series;
2. a seasonal ARMA-model of a seasonally differenced (and possibly further differenced) series.

Compute forecasts of the electricity consumption for a period of 12 months and plot observed and forecasted values. Examine, by visual inspection, in what respect the two model classes above produce different forecasts.