PSTAT274 Time Series

Lab Worksheet - Week 4

John Inston

This lab is due at 11:59pm on Wednesday, February 7th, 2024 and should be submitted as a pdf document via Gradescope.

For this week's lab report you will require the `astsa` and `forecast` packages which can be loaded into your Rstudio using the code chunk below.

```
# load library
library(astsa)
library(forecast)
```

In last weeks lab we looked at several ways of obtaining stationary data, such as using the `diff()` function to difference the time series by lag 1 (to remove linear trends) or lag 12 (to remove seasonal trends of period 12); and using transformations to obtain normality such as Box-Cox using the function `boxcox()` from the `MASS` library.

This week we will be looking at the procedure and steps for fitting ARIMA(p,d,q) models to time series data.

Question 1 - Modelling GNP

We consider the `gnp` data from the `astsa` package. This is pre-loaded into R when you loaded the package.

a. Produce a time series plot of the `gnp` data. Is the data stationary? Is there evidence of any trends or seasonality? Propose steps to obtain stationary data.

b. Take the log differences of the data and produce a second time series plot. What impact has this particular transformation had on the time series? Does the time series now appear stationary?

c. Produce both an ACF plot and a PACF plot of the transformed data. What are your observations?

Hint: The function `acf2()` from the `astsa` package helpfully plots both at once.

d. First, fit an MA(2) model using the `Arima()` function below from the `forecast` package and name it `ma.model`. Obtain a summary of our model using the `summary` function. What are the values of the coefficients θ_1 and θ_2?

e. Evaluate the fit of your model by producing a plot of the residuals as well as an ACF plot. From this cursory inspection does our model appear to be a good fit? Why?

Hint: Obtain the residuals by using the code `ma.model$residuals`.

f. Repeat (d) and (e) but this time fit an AR(1) model, naming it `ar.model` and stating the value of coefficient ϕ_1.

g. Produce a plot of the original transformed data series with both fitted model values overlayed in different colors. The fitted model values can be obtained using `ma.model$fitted` and `ar.model$fitted`.

Question 2 - Modelling Global Temperature

We consider the `xglobtemp` data from the `astsa` package. Our aim is to fit an appropriate ARIMA(p,d,q) model and to evaluate our model's performance using residual diagnostics before constructing a 10 year ahead forecast.

a. Load the data and produce a time series plot. Is the data stationary? Comment on any possible linear or seasonal trends and how best to remove them.

b. Difference the data lag 1 and produce a new time series plot. Does the data now appear stationary?

c. Produce both an ACF and a PACF of the log-differenced data and comment on your observations. What potential ARIMA(p,d,q) models do they suggest?

Hint: The `acf2()` function in the `astsa` package helpfully produces both simultaneously.

Hint: Recall that the d parameter just indicates how many times we needed to difference the data to obtain stationarity.

d. This time use the `sarima()` function from the `astsa` package to fit your selected ARIMA model. Use the residual analysis plots it produces to determine the goodness-of-fit of our model.

e. Using our final model produce a 10 year ahead forecast for global temperature using the `sarima.for()` function from the `astsa` package. Comment on your forecast.