Introduction to Financial Engineering (HW1)

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- Please follow the guidelines for assignments given in the Module Handbook.
- All programs should be written in R (compilable without errors or warnings).
- You should submit a write-up (.pdf) of the program as well as the source code (.r).
- File names should be as `yoursurname_yourname_HW1.extension`
- You should submit via moddle.
- Deadline: 13th October 2023 at 10am.

Datasets are available by **quantmod**.

1. Run the following code corresponding three quarterly time series data and answer the questions below.
   (a) Describe the signs of nonstationarity seen in the time series and ACF plots.
   (b) Use the augmented Dickey-Fuller tests to decide which of the series are nonstationary (search on R help for the definition of the test and what conclusions shows). Do the tests corroborate the conclusions of the time series ACF plots?
   (c) Do the difference series appear stationary according to the augmented Dickey-Fuller test?
   (d) Do you see evidence of autocorrelation in the differenced series? If so, describe these correlations.
   (e) What order of differencing is chosen in `auto.arima`? Does this result agree with your previous conclusions?
   (f) What model was chosen by AIC?
   (g) Which goodness-of-fit criterion is being used here?
   (h) Change the criterion to BIC. Does the best-fitting model then change?
   (i) Do you think that there is residual autocorrelation? If so, describe this autocorrelation and suggest a mode appropriate model for the T-bill series.

```r
data(Tbrate,package="Ecdat")
library(tseries)
#   r = the 91-day treasury bill rate
#   y = the log of real GDP
#   pi = the inflation rate

# Questions a) and b)
plot(Tbrate)
acf(Tbrate)
#Consider only the diagonal plots which correspond to the ACF plots of r, y an
    pi
adf.test(Tbrate[,1])
adf.test(Tbrate[,2])
adf.test(Tbrate[,3])

# Qeustions c) and d)
diff_rate=diff(Tbrate)
adf.test(diff_rate[,1])
adf.test(diff_rate[,2])
```

```
adf.test(diff_rate[,3])
plot(diff_rate)
acf(diff_rate)

# Questions e), f), g) and h)
library(forecast)
auto.arima(Tbrate[,1],max.P=0,max.Q=0,ic="aic")

# Questions i)
fit1=arima(Tbrate[,1],order=c(?,?,?))
acf(residuals(fit1))
Box.test(residuals(fit1),lag=10,type="Ljung")
```

2. Consider the AR model

$$Y_t = 5 - 0.55Y_{t-1} + \varepsilon_t$$

and assume $\sigma_\varepsilon^2 = 1.2$.

(a) Is the process stationary? Why?

(b) What is the mean of this process?

(c) What is the variance of this process?

(d) What is the covariance function of this process?

3. An AR(3) model has been fit to a time series. The estimates are

- $\hat{\mu} = 104$
- $\hat{\phi}_1 = 0.4$, $\hat{\phi}_2 = 0.25$ and $\hat{\phi}_3 = 0.1$

The last four observations were $Y_{n-3} = 105$, $Y_{n-2} = 102$, $Y_{n-1} = 103$ and $Y_n = 99$. Forecast Y_{n+1} and Y_{n+2}.

4. Run the following code

```
library(Ecdat)
data(Mishkin)
tb1=log(Mishkin[,3])
```

(a) Use the time series and ACF plots to determine the amount of differencing needed to obtain a stationary series.

(b) Next use `auto.arima` to determine the best-fitting nonseasonal ARIMA models. Use both AIC and BIC and compare results.

(c) Examine the ACF of the residuals for the model you selected. Do you see any problems?