Universidade do Estado do Rio Grande do Norte
Time Series - Final Exam
Due on 14/10/2021 by 2:30 pm. You are supposed to submit your R code as well as your answer file to lucasgodeiro@ufersa.edu.br. Only submissions to my email account will be graded. Do not place your files into my mail box.

1. **Downloading the data**. Using the Quandl Package You can download time series from FRED database to the R work space. Below are the instructions:

   i. In order to get data on exchange rate, you need to create an account in the Quandl website and set up an application program interface(API). The following link provides you with the information needed to set up an API in Quandl: Documentation API Quandl.

   ii. After setting You API, the Quandl will provide an API key that will be needed in the R package. Then, you will have to run the following command in R:

   ```
   Quandl.api_key('YOURAPIKEY')
   ```

   If you did not set the API in Quandl, then you can still use this key:

   ```
   Quandl.api_key('axEMFAuY9C53yizzzQw1')
   ```

   iii. After connecting R and Quandl API, download monthly data on British Pound(GBP) and Australian Dollar(AUD) exchange rates. You can carry out this task through the function "Quandl". The arguments needed in this function are the time series tickers, the frequency of the data, and the object class. To find out the time series ticker, you have to check the FRED website and find the links: GBP and AUD. You will learn that the tickers are "DEXUSUK" and "DEXUSAL" for GBP and AUD respectively. Then, you can run the commands below to get the data:

   ```
   gbp=Quandl("FRED/DEXUSUK",type='ts',collapse = "monthly",order="asc")

   aud=Quandl("FRED/DEXUSAL",type='ts',collapse = "monthly",order="asc")
   ```

   We choose type as time series (ts); monthly frequency; and ascending.

   After downloading the Exchange Rate data, we can compute the compounded returns by using the first difference of logs. Plot the graphs running these codes:

   ```
   #####Creating a New Matrix with both series#############
   data = cbind(gbp,aud)
   #########Computing the compounded return ###############
   data_er_ret=diff(log(data))
   ############ Excluding the first observation in the prices######
   data_er=ts(data[2:nrow(data),],start = c(1971,2),frequency=12)
   ##########Time series names #####################
   names_data_er=colnames(data_er)
   #########Time series date #######################
   date=seq(as.Date("1971-02-01"),by="month",along=data_er_ret[,1])
   ######Plot Exchange rate
   plot(data_er)
   #######Plot returns###########
   plot(data_er_ret)
   ```

   Question: After analyzing the graphs of the downloaded time series, comment on the covariance-stationarity properties of both prices and returns. Do prices look like a stationary process? Why? What about the returns? Why?

2. **Unit Root Testing.** Compute the ADF test for the downloaded time series by using the adf.test function from tseries package. Then, based on a 5% level test , can you conclude that prices are stationary processes? Are exchange rate returns stationary?

3. **Johansen's Cointegration Test**. Compute the Johansen Cointegration test for exchange rate prices according to the instructions below:

i. Select the number of lags in the VAR model by using the "VARselect" function from vars package. Set (type="const' , lag.max=12) to include a constant in the VAR equation and choose 12 as the maximum lag value (we are using monthly data, so 12 is a good guess).

ii. Estimate a VECM by using "VECM" function from tsDyn package. Choose this set (estim="ML",lag=K-1), where K is the number of lags found in the VARselect function used above (recall that if the VAR model has "K" lags then the VECM model will have "(K-1)" lags). We chose "ML" because the Johansen's test relies on the maximum likelihood estimator (why?). Would you choose a specification for the deterministic component other than an unrestricted constant? Why?

iii. Compute the cointegration test by using the rank function from tsDyn package. The function argument is only the VEC object fitted in the previous step(don't forget to name the object in the previous step to be able to store it in the R Workspace). Using the summary("cointegration test object name") you will find in the first column the number of cointegration vectors r to be tested. In the second and third columns the Trace statistic and its respective p-values are reported. In the fourth column you will find the p-value calculated using a small sample correction(see Johansen(2002) paper A Small Sample Correction for the Test of Cointegrating Rank in the Vector Autoregressive Model). In the fifth and sixth columns you will find the maximum eigenvalue statistic and its respective p-values.(Recall that the cointegrating test is a sequential test). At this point, I expect you to explain your findings about cointegration of exchange rate prices. What do you have to say about your choice of the deterministic components?

Question: Is there cointegration at the 5% level? Which test statistic has superior power in a small samples? and why ?(see paper Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process)

4. **Forecasting and Trading Models.** Let P_t^i be the time t price for exchange rate $i = \{gbp, aud\}$ and let $r_t^i = \ln(P_t^i/P_{t-1}^i)$ be its compounded return and w_{t+1}^i and a variable indicating a financial decision taken at time $t+1$ based on the forecast made at time t. Using the first 120 observations as your initial estimation sample, use your estimated VECM model to compute out-of-sample forecasts of $\hat{P}_{t+1,t}$ (use a recursive forecasting scheme). Follow these steps:

   i Compute the forecast for $h = 1$ $\hat{P}_{t+1,t}$ by using the function predict and the option (n.ahead=1).

   ii. Compute the values of w_{t+1}^i based on the forecasts made at 4.i, that is:

$$if(\hat{P}_{t+1,t} > P_t^i), \quad w_{t+1}^i = 1$$
$$if(\hat{P}_{t+1,t} < P_t^i), \quad w_{t+1}^i = -1$$
$$if(\hat{P}_{t+1,t} == P_t^i), \quad w_{t+1}^i = 0$$

   iii. Make financial decisions based on this rule:

$$if(w_{t+1}^i = 1), \quad decision = \ 'long\ position'$$
$$if(w_{t+1}^i = -1), \quad decision = \ 'short\ position'$$
$$if(w_{t+1}^i = 0), \quad decision = \ 'no\ position'$$

   iv. Compute the return for each exchange rate based on the selected decisions:

$$r_{t+1}^{*i} = w_{t+1}^i \times r_{t+1}^i$$

   where r_{t+1}^i is the compounded return at time $t+1$ for exchange rate i.

5. **Investment Value.** Compute the investment value on each exchange rate i at time t and plot it on a single chart where V_t is placed on the Y-axis and the dates are on the X-axis. Assume that the initial investment value is $V_t = U\$\$1.00$ which implies that $V_{t+1} = V_t(1 + r_{t+1}^{*i})$. Repeat this procedure recursively toward the end of the sample. Comment your results.

6. **Robot Design.** Change the decision rule in item (5) to improve the decision making process of your robot (I expect you to use your creativity to answer this question). Explain in details how artificial intelligence and time series econometrics are related to each other. I expect you to explain how the performance of your robot could be affected by a misspecified econometrics model or an inefficient decision rule. (30 points)