

Forecasting CAD/USD Exchange Rate

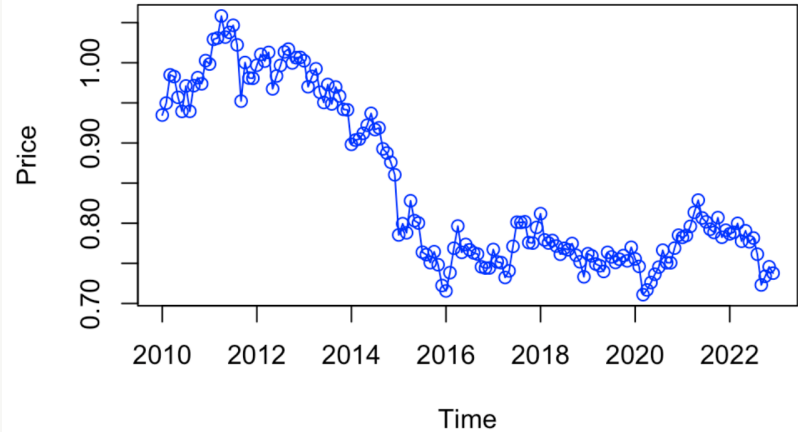
STAT 370 Time Series
By Joyce Wu



Introduction

- 01 The exchange rate of Canadian dollars was closely bound up with the US dollars for the past decades.
- 02 The last time that the Canadian dollar was worth more than the US dollar was in July 2011.
- 03 Fast decline in modern-day history as commodity prices rapidly deteriorated.

CAD / USD Exchange Rate 2010-2022



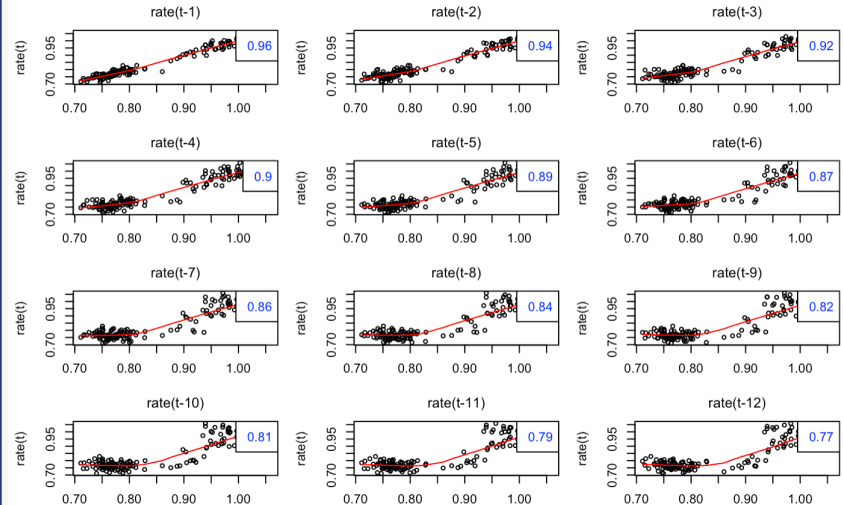
Data Description

01 The data is collected from
<https://ca.investing.com/currencies/cad-usd-historical-data>

02 Training set : monthly data from
Jan 2010 - Feb 2022

03 Prediction : Mar 2022 - Dec 2022

Lag Plots



Detrend the Data

Box Cox Transformation

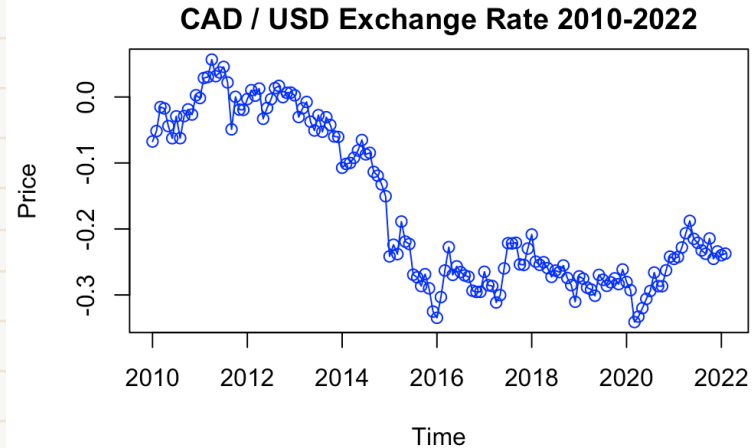
- to determine if transformation is needed

Lambda lower bound value	Lambda upper bound value	Lambda MLE
-1.1	0.9	-0.1

1. MLE close to 0 $\rightarrow$ log transformation

2. Upper bound close to 1 $\rightarrow$ no transformation

Log transformed data



Detrend the Data (con't)

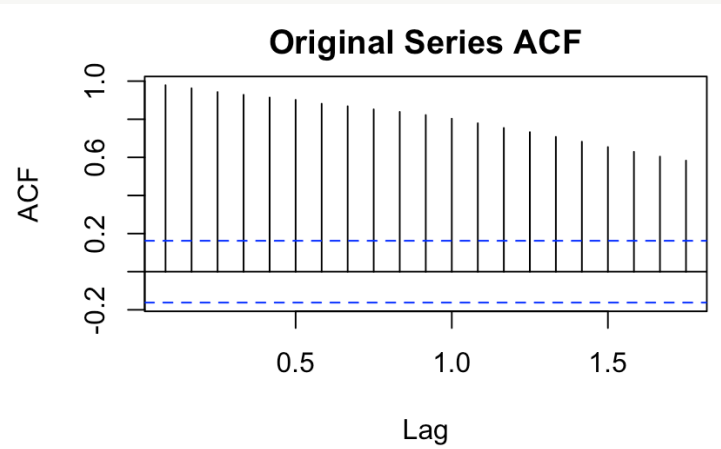
ACF of the original data

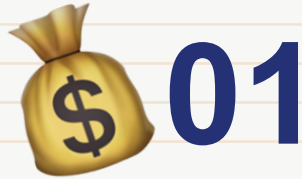
- check the correlation between a time series with a lagged version of itself

- **Lag decrease slowly**

- Non-ststionary

- Differencing is needed





Log transformed Series

With tsoutliers function

- tsoutliers

A function helps to detect outliers and the fitting model

- Outliers

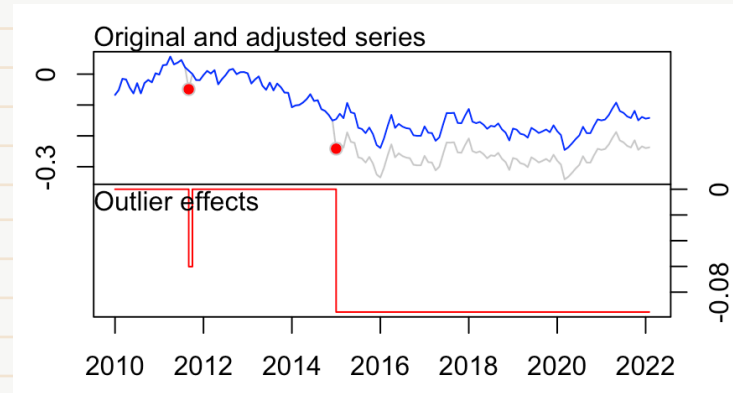
Somewhere in the end of 2011 and 2015

- AIC, AICc, BIC

Indicies help model selection later

- Model → Auto Regressive $AR(1)$

$$Z_t = -0.0602 I_t^{(21)} - 0.0955 I_t^{(61)} + \frac{1}{(1-0.9871 B)} a_t, \sigma^2 = 0.0004303$$



Outliers



2011 - Bank of Canada rise the overnight rate to 1% → higher interest rate
→ reduce money supply → lower foreign exchange rate

2015 - The speed of the decline is in part due to the swift collapse in oil prices.

Residuals Check

Check if AR(1) model with log transformation is a good fit

- **Residuals ACF, PACF plots**

Ideal plot : all lags falls in the white noise band (blue dotted lines)

ACF - 3 rd and the last lag are out

PACF - 3rd lag is out

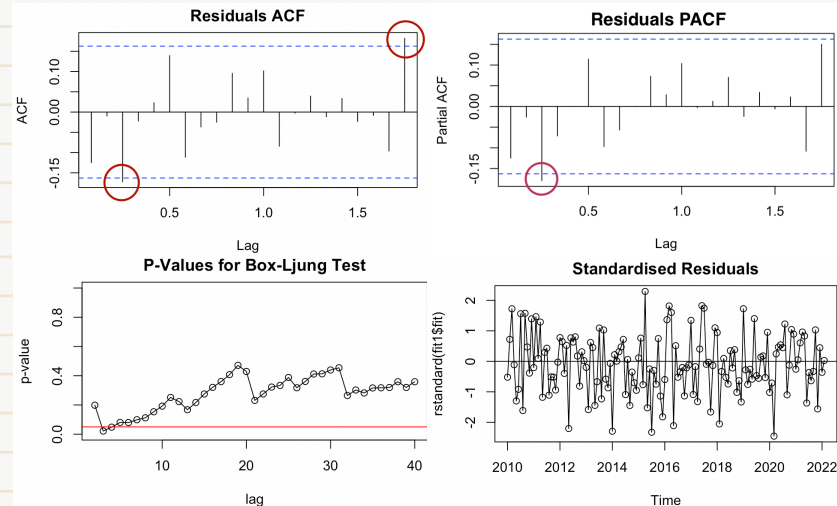
- **P-value for Box-Ljung Test**

Most lags have a p-value **greater than 0.2**

→ **good fit**

- **Residuals plot**

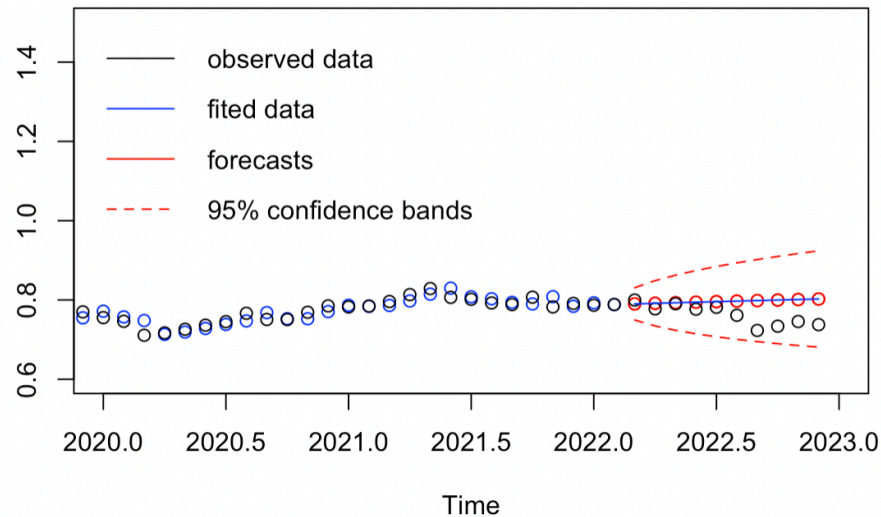
All residuals within (-3,3) → **good fit**



Good fit ? Maybe?

Forecasting

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Predicted rate	0.7901	0.7915	0.7929	0.7943	0.7957	0.7971	0.7984	0.7997	0.8011	0.8024
Actual rate	0.7998	0.7776	0.7906	0.7768	0.7816	0.7614	0.7231	0.7339	0.7457	0.7378





02

Original Series

With tsoutliers function

- tsoutliers

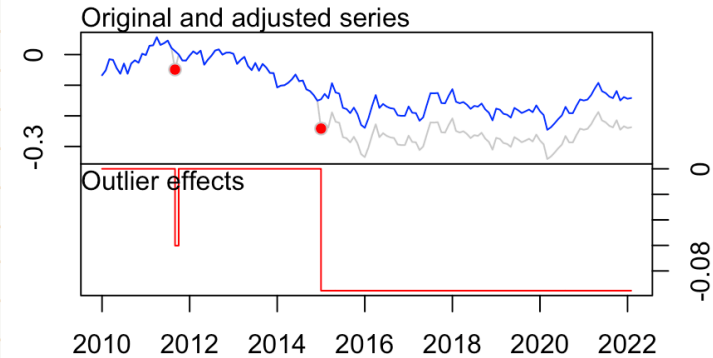
A function helps to detect outliers and the fitting model

- Outliers

Somewhere in the end of 2011 and 2015

- Model → Auto Regressive $AR(1)$

$$Z_t = 0.9002 - 0.0590I_t^{(21)} - 0.0822I_t^{(61)} + \frac{1}{(1-0.9629B)}a_t, \sigma^2 = 0.0003103$$



Residuals Check

Check if AR(1) model with the original series is a good fit

- **Residuals ACF, PACF plots**

Ideal plot : all lags falls in the white noise band (blue dotted lines)

ACF - the last lag is out (reject)

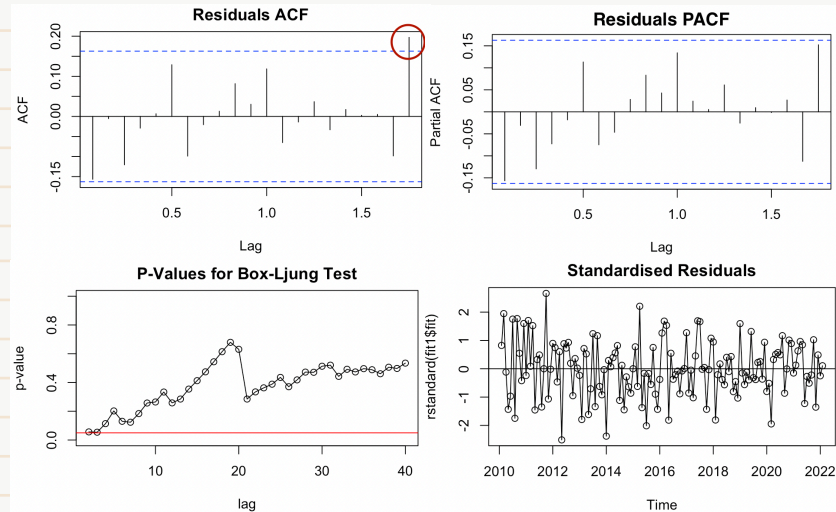
PACF - all lags are in

- **P-value for Box-Ljung Test**

Most lags have a p-value **greater than 0.2**
→ good fit

- **Residuals plot**

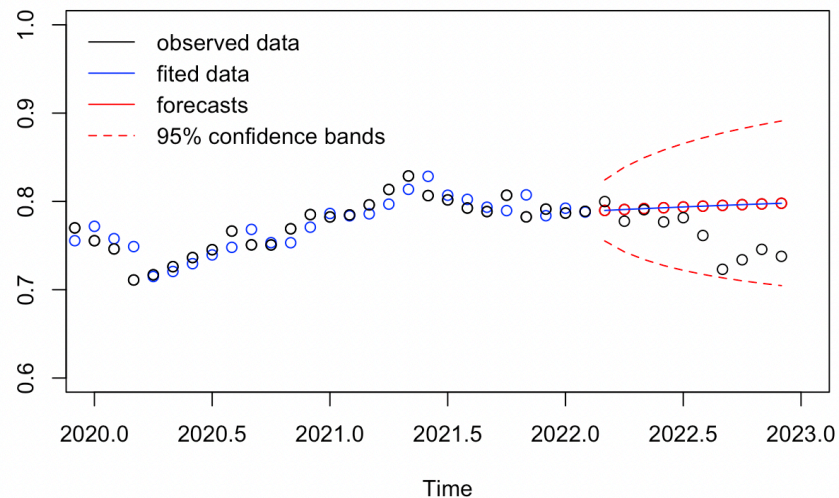
All residuals within $(-3,3)$ → *good fit*



Good fit ? Maybe?

Forecasting

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Predicted rate	0.7897	0.7908	0.7918	0.7928	0.7937	0.7946	0.7954	0.7963	0.7971	0.7978
Actual rate	0.7998	0.7776	0.7906	0.7768	0.7816	0.7614	0.7231	0.7339	0.7457	0.7378



Model Comparision

- **AR(1) with log transformation**

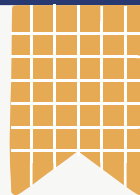
- **Residuals plot**

ACF - 2 lags out , **PACF** - 1 lag out

- **AIC, AICc, BIC (Indices help model selection)**

AIC	AICc	BIC
-708.68	-708.39	-696.74

→ **Higher** indicies



- **AR(1) with the original series**

- **Residuals plot**

ACF - 1 lag out (rejected) , **PACF** - **NO** lag out 👍

- **AIC, AICc, BIC**

AIC	AICc	BIC
-756.47	-756.04	-741.55

→ **Lower** indicies (fewer parameters) 👍

Model Comparison

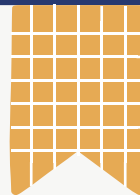
- AR(1) with log transformation

- MPE, MSE, MAE, MAPE

Error between predicted values and real values

MPE	MSE	MAE	MAPE
-0.0452	0.0019	0.0354	0.0476

(con't)



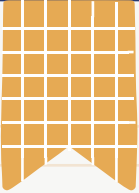
- AR(1) with the original series

- MPE, MSE, MAE, MAPE

MPE	MSE	MAE	MAPE
-0.0421	0.0017	0.0332	0.0446

→ Lower error 👍

→ AR(1) with the original series is the best fit



Conclusion

- Log transformation **DOSE NOT** improve the fit and prediction
 - This may due to the unstable exchange rate during Covid-19
- **Improvement** : try weekly data and intervention
- Prediction indicadtes the echange rate increase
 - **Yet**, the exchange rate is actually **decreasing**
 - One reason might be due to the increase interest rate in the US makes USD is more valuable compare to CAD
- **Future work** : corss-correlation anlysis with Alberta oil price



THANK YOU !
Q&A