

MODELING USD/LKR EXCHANGE RATE USING TIME  
SERIES TECHNIQUES

Ponnam Hettiarachchilage Thamindu Santharaka Hettiarachchi

179078F

Degree of Master of Science

Department of Mathematics

University of Moratuwa

Sri Lanka

March 2023

MODELING USD/LKR EXCHANGE RATE USING TIME  
SERIES TECHNIQUES

Ponnam Hettiarachchilage Thamindu Santharaka Hettiarachchi

179078F

Thesis submitted in partial fulfillment of the requirements for the degree Master of  
Business Statistics

Degree of Master of Science

Department of Mathematics

University of Moratuwa

Sri Lanka

March 2023

## **DECLARATION**

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgment any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Also, I hereby grant to the University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The above candidate has carried out research for the Masters thesis under my supervision.

Name of the supervisor (1): Dr H A S G. Dharmarathne

Signature of the supervisor:

Date:

## **ABSTRACT**

Modeling Exchange Rate is one of the most vital and essential parts of financial econometrics. This study aimed to formulate time series models using both univariate and multivariate time series techniques. The macro-economic factors of Inflation Rate, Trade balance, Net Foreign Assets, and Foreign Remittances have been used in this study which were chosen by an extensive literature survey. Data from January 2015 to October 2022 was used in this study. A univariate model was formulated using ARIMA and ARCH/GARCH modeling techniques. The GARCH model with the mean equation which is estimated by an ARIMA (1,1,1) Model along with a dummy variable and the variance equation which is estimated by GARCH (1,0) Model was selected as the best-fitted univariate model with a R-square value 81.8%. Using ARDL modeling technique associated with ARDL bound tests for cointegration was used to formulate the multivariate model. The ARDL (3,4,3,0,0) was selected as the best-fitted model which satisfied all the assumptions along with model specifications. It was identified that there exists significant co-integration among the exchange rate and the selected macro-economic factors. Error correction model was formulated based on the selected ARDL model and according to the results, the speed of adjustment is -5.78% which means that the short-run model will be converged to the long-run equilibrium by 5.78% for each period moving forward. Among the two models selected from univariate and multivariate analysis, ARDL (3,4,3,0,0) model was selected as the final best fitted model.

**Key Words:** Exchange Rate, Advanced Time Series Analysis, ARIMA, ARCH/GARCH, ARDL, Cointegration

## **DEDICATION**

This Thesis is dedicated to all the lecturers, family members and friends who encouraged and supported me through out!

## **ACKNOWLEDGMENT**

I would like to take this opportunity to thank my supervisor Senior Lecturer in Statistics, Department of Statistics, University of Colombo, Dr. H A S G. Dharmarathne and the joint Coordinators of the MSc/PGD in BS Program, Department of Mathematics, Faculty of Engineering, University of Moratuwa, Ms. D R T Jayasundara & Dr J A B U Jayasinghe.

Also, my family and friends who have been always with me!

# TABLE OF CONTENTS

ABSTRACT.....	iv
TABLE OF CONTENTS.....	vii
LIST OF FIGURES .....	ix
LIST OF TABLES .....	x
1. Introduction.....	1
1.1 Overview .....	1
1.2 Background of the Study .....	1
1.2.1 Exchange Rate Regimes.....	1
1.2.2 Evolution of Sri Lankan Monetary and Exchange Rate Policy .....	2
1.3 Significance of the Study .....	3
1.4 Common Factors Affecting Exchange Rates .....	4
1.4.1 Inflation Rate.....	4
1.4.2 Trade balance .....	4
1.4.3 Foreign Remittances.....	5
1.5 Objectives .....	5
1.6 Chapter Outline .....	5
2. Literature Review .....	6
3. Data and Methodology.....	9
3.1 Introduction .....	9
3.2 Data Sources .....	9
3.3 Descriptive Analysis.....	9
3.4 Theoretical Aspects of a Univariate time series model.....	10
3.4.1 Stationarity of a Stochastic Process .....	10
3.4.2 White Noise.....	10
3.4.3 Moving Average Process .....	10
3.4.4 Auto-Regressive (AR) Process .....	10
3.4.5 Mixed ARMA Models .....	11
3.4.6 Mixed ARIMA (p, d, q) Models (Auto Regressive Integral Moving Average Process) .....	11

3.4.7	ARCH/GARCH Models (Autoregressive Conditionally Heteroscedastic/ Generalized Autoregressive Conditionally Heteroscedastic)..	11
3.5	Theoretical Aspects of Multivariate time series models .....	13
3.5.1	Model selection framework.....	13
3.5.2	ARDL – Co-integration Approach.....	13
3.5.3	Causality Test.....	14
3.6	Residual diagnostic tests .....	14
3.7	Dummy variables .....	15
4.	Data Analysis.....	16
4.1	Univariate Analysis of monthly average USD/LKR Exchange Rate.....	16
4.1.1	Graphical illustration of monthly average USD/LKR Exchange Rate along with summary statistics.....	16
4.1.2	Stationarity of the Time Series.....	17
4.1.3	Identification of The ARCH Effect Using ARIMA Model with OLS Method	20
4.1.4	ARCH/GARCH Model Estimation.....	23
4.1.5	Model Adequacy of the Selected GARCH Model.....	25
4.2	Multivariate Analysis of monthly average USD/LKR Exchange Rate.....	27
4.2.1	Descriptive statistics.....	27
4.2.2	Stationarity of the variables .....	32
4.2.3	Traditional ARDL Model Estimation .....	34
4.2.4	ARDL Bound test – Cointegration Approach.....	35
4.2.5	Short run Causality among the variables .....	38
4.2.6	Residual Diagnostic Tests .....	39
4.3	Comparison of Univariate and Multivariate Models.....	41
5.	Discussion, Conclusions and Future Research .....	43
5.1	Discussion and Conclusions .....	43
5.2	Future Studies .....	48
	Bibliography.....	49



## LIST OF FIGURES

Figure 3.1: Methodological Framework to select the Time Series Model.....	13
Figure 4.1: Time Series plot of monthly average USD/LKR Exchange Rate from January 2015 to October 2022 .....	16
Figure 4.2: Time Series plot of Log transformed monthly average USD/LKR Exchange Rate from January 2015 to October 2022 .....	17
Figure 4.3.: Time Series plot of first Differenced Log transformed monthly average USD/LKR Exchange Rate from January 2015 to October 2022 .....	19
Figure 4.4: Time Series plot of Monthly Inflation from January 2015 to October 2022.....	27
Figure 4.5: Time Series plot of Monthly Net Foreign Assets from Jan 2015 to Oct 2022.....	28
Figure 4.6: Time Series plot of Monthly Trade balance from Jan 2015 to Oct 2022 .....	29
Figure 4.7: Time Series plot of Monthly Foreign Remittance (USD Mn) from January 2015 to October 2022 .....	30
Figure 4.8: Histogram – Normality test .....	39
Figure 4.9: Forecast summary for GARCH (1,0) Model.....	41
Figure 4.10: Forecast summary for ARDL (3,4,3,0,0) Model .....	41

## LIST OF TABLES

Table 4.1: Dickey-Fuller Test Results for Log transformed monthly average USD/LKR Exchange Rate.....	18
Table 4.2: Dickey-Fuller Test Results for the first difference of Logarithmic series of monthly average USD/LKR Exchange Rate.....	20
Table 4.3: Estimation Output of ARIMA (1,1,1) Model .....	21
Table 4.4: Correlogram of Residuals .....	21
Table 4.5.: Test results for Heteroskedasticity Test: ARCH LM.....	22
Table 4.6: Summary of GARCH Models.....	23
Table 4.7: Estimation output of GARCH (1,0) model.....	24
Table 4.8.: Correlogram of the Residuals and Squared Residuals.....	25
Table 4.9: Test results for Heteroskedasticity Test: ARCH LM.....	26
Table 4.10: Summary Statistics of the variables .....	27
Table 4.11: Correlation Analysis of the Variables.....	31
Table 4.12.: ADF Test at Level.....	32
Table 4.13.: ADF Test at First Difference .....	33
Table 4.14.: ARDL Model Estimation Output.....	34
Table 4.15.: F Bound Test Output.....	35
Table 4.16.: Level Equation Output.....	36
Table 4.17.: Error Correction Model Output .....	37
Table 4.18.: Pairwise Granger Causality Tests Output .....	38
Table 4.19.: Serial Correlation LM Test Output .....	39
Table 4.20.: Heteroskedasticity Test Output.....	40

## LIST OF EQUATIONS

Equation 3.1: MA Process .....	10
Equation 3.2: AR Process .....	10
Equation 3.3: ARIMA Models .....	11
Equation 3.4: ARCH Models .....	12
Equation 3.5: GARCH Models .....	12

## LIST OF ABBREVIATIONS

ACF	Auto Correlation Function
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
AR	Auto Regressive
ARCH	Autoregressive Conditionally Heteroscedastic
ARDL	Auto Regressive Distributed Lag
ARIMA	Auto Regressive Integrated Moving Average
ARMA	Auto Regressive Moving Average
CPI	Consumer Price Index
CBSL	Central Bank of Sri Lanka
D(Exchange Rates (-n))	First difference of the nth lagged Exchange Rate series
D(Inflation (-n))	First difference of the nth lagged Inflation series
D(LOG_EXCHANGE_RATES)	Differenced series of log transformed exchange rates
D(NET_FOREIGN_ASSETS__LKR_BN(-n))	First difference of the nth lagged Net Foreign Assets series
DW	Durbin Watson
ECM	Error Correction Model
Exchange Rates (-n)	nth lagged series of Exchange Rates
GARCH	Generalized Autoregressive Conditionally Heteroscedastic
GDP	Gross Domestic Product
HQC	Hannan Quinn criterion
Inflation (-n)	nth lagged series of Inflation
FIT	Flexible Inflation Targeting
LKR	Sri Lankan Rupee

MA	Moving Average
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MSE	Mean Square Error
NET_FOREIGN_ASSETS__LKR__ BN_(-n)	nth lagged series of Net Foreign Assets
PACF	Partial Auto Correlation Function
RMSE	Root Mean Square Error
SBC	Schwartz Bayesian Criterion
USD	United States Dollar
VAR	Vector Auto Regressive