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DETERMINING THE NOMINAL EXCHANGE RATE IN SRI LANKA: AN APPLICATION OF THE LAGRANGE MULTIPLIER STRUCTURAL BREAK UNIT ROOT TEST AND THE ARDL CO-INTEGRATION

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ABSTRACT

Bihari There is a vast literature on the impact of exchange rate on developing countries' economies. This paper studies the determinants of nominal exchange rate fluctuations in Sri Lanka. It employs recent secondary macroeconomics monthly time series data (2011:01-2018:07) and tests the ARDL co-integration approach with structural break LM unit root test, which was introduced by Lee and Strazicich in 2013. Results of the bound test show that the nominal exchange rate has a long-term relationship with its determinants. Further, our empirical findings suggest that a strong depreciating link exists between the nominal exchange rate and money supply in Sri Lanka during the sample period. Outcomes are signals that identify new lessons for policy-makers to implement consistent foreign exchange policies. Doing so must consider both monetary and fiscal policy simultaneously.

Keywords: Exchange rate determination, LM unit root test, ARDL approach, Sri Lanka, JEL classification: F31, B27.

INTRODUCTION

The Exchange Rate (ER) is one of the most significant fundamentals of a country's economic development, mainly involving international trade and foreign exchange market. The volatility of the ER causes uncertainty and a lack of investor confidence through capital flows and foreign trade. If the ER is moving based on the economic fundamentals and does not fluctuate unusually, then policy-makers can easily implement the correct policy decisions leading to benefits. This helps not only the foreign exchange market players but also the entire economy (Rajakaruna, 2017).

Due to the massive importance of the ER in an economy, the behavior of the ER is one of the unsolved policy issues noted in the empirical literature in developed and developing economies. Most of the ER literature has concentrated on the impacts on the economy rather than the determinants of ER (for instance, Kogid2012; Khondker et al., 2012; Korkmaz, 2013; Basirat et al., 2014; Jakob, 2016; Habib, 2016; Ashour and Yong, 2017; Razzaque et al., 2017; Selimi, 2017). Moreover, they have

examined currency market volatility (see Francis et al., 2003; Agrawal et al., 2010; Rekha and Mary 2017; Mitra 2017) and implications of ER for a few macroeconomic variables including trade balance and exports (see Ekanayake and Chatrna 2010; Kanchana and Ali, 2010; Wanaguru, 2015; Aslam 2016; Nawarathna Banda, 2016; Priyatharsiny, 2017). It has been argued, however, that the lack of studies only focused on the dynamics of the ER in developing countries.

The motivation of this study is that the dynamics of ER have both negative and positive impacts on the business cycle of the economy through the international investment portfolios, net exports, official reserves, external debt servicing, and tourist's industry. As well, the ER is one of the significant economic variables operating in the international financial markets (Krugman, 2008). Given these arguments, it is very important to analyze key factors which determine ER. The ER is a widely discussed topic in Sri Lanka in recent years because the country's USD/LKR exchange rate is steadily depreciating except for a few time periods. Further, research on the ER in Sri

Lanka seems to be limited when the country's dollar rupee ER is depreciating. Hence, the current study will shed more light on Sri Lanka's ER concerning the factors determining its fluctuations. The objective of this paper is two-fold: (1) to develop a dynamic model of Nominal Exchange Rate (NER); and (2) empirically estimate the determinants of NER for the Sri Lankan economy. The importance of this study is in the urgent need to analyze the determinants of NER since there are no recent studies with more independent variables which affect these determinants. Consequently, it is important to examine the response of official intervention, terms of trade, net foreign assets, foreign reserves, workers' remittance payments, money supply, inflation and interest rate to the Sri Lankan nominal exchange rate.

Our empirical results are in line with our theoretical discussion related to the exchange rate and some findings are different from previous studies. Based on the ARDL test results money supply is the most significant variable for determining NER in Sri Lanka in the selected period over the long-term. However, most other studies on the subject of exchange rate volatility concluded that the Central Bank's intervention in the foreign exchange market is an effective determinant of ER in Sri Lanka (Wanaguru, 2015; Rajakaruna, 2017). We also underline that short-run interest rates, foreign reserves, terms of trade and workers' remittances wield a positive significant impact on Sri Lanka's nominal exchange rate in the long-run. Supporting these outcomes, similar findings have been reported by Jayasuriya and Perera (2016).

The contribution of the study to the literature is three-fold. The current study analyses determinants of the ER utilizing the ARDL approach (Pesaran et al., 2001) with the structural break LM unit root test introduced by Lee and Strazicich in 2013. The ARDL approach is able to deal with both stationary and non-stationary variables. Considering monthly secondary time series data and utilizing the ARDL approach, the current study discovers the dynamics of nominal exchange fluctuations in Sri Lanka which a newly emerging market-based economy in the South Asian region. Secondly, this study departs from previous studies by extending the model with eight important and relevant exogenous macroeconomic variables. Many of these variables were not assessed in most prior studies that were done on the ER. Finally, this study tests recent secondary time series monthly data because older studies' findings were not based on recent

data. The most important conclusions of this investigation are the determination of NER adding new macroeconomic variables as well as estimating the ARDL model with structural breaks, in order to identify factors which, affect fluctuations in the ER. The major focus of this research is to indicate and validate a model for determining the true factors of NER fluctuations in Sri Lanka.

The remainder of the paper is structured as follows: the empirical literature and research gaps are described in section two. Section three discusses the validity of existing exchange rate theories and section four looks at the methodology including the definitions of variables; it also outlines the data sources. Empirical results of unit root tests, co-integration tests, and ARDL model estimates are presented in section five. Finally, section six concludes the paper with suggestions about policy implications.

EMPIRICAL LITERATURE AND RESEARCH GAPS

Although the empirical literature contains a wide range of studies on exchange rates and many economists suggested different theories on the ER, no one has yet attempted to identify the true factors of NER fluctuations in developing countries like Sri Lanka. This is the first analysis on this topic using the ARDL approach based on the Lagrange Multiplier structural break unit root test. Altogether, the economic and finance literature on the NER can be grouped into two classes based on their objectives: firstly, developed and/or advanced economics studies; and secondly, empirical research done on the economies of developing countries. In addition, these two groups of studies can be further divided into two groups based on their conclusions. Findings of these studies are varied. Some researchers contended that the official government intervention is the main determinant of ER fluctuations while other scholars indicated money supply or interest rate is the vital element of changing NER. Furthermore, empirical investigations have included global, regional, South Asian and Sri Lankan studies.

The empirical literature investigating the dynamics of ER is ambiguous and mainly focuses on the impacts of ER volatility on the economy rather than determinants. Ekanayake and Chatrna (2010) discussed the effects of ER volatility on Sri Lankan exports during the years 1980-2007 by testing GARCH models. Their findings suggested that the impact of ER volatility depends on the categories of goods (types of goods traded) and difficulty in

understanding specific relationships between them. However, Wanaguru (2015) identified the source of currency market volatility in Sri Lanka during the period 2002-2012. Her results indicated that the Central Bank's intervention in the foreign exchange market is an effective determinant of ER. Supporting this argument, Rajakaruna (2017) highlighted the fact that net official intervention is the most effective and significant determinant of the ER during the sample period from 2001 to 2010. Her study reveals the dynamics of ER by analyzing multiple linear regressions and the unrestricted VAR models. However, Jegajeevan (2015) examined the monetary model's validity by taking into account the behavior of the US dollar and Sri Lankan rupee ER using monthly data from 2001 to 2011. To check the empirical validity of the flexible price monetary model, her study tested co-integration and vector error correction methods. In contrast, this present study revealed that the Central Bank's official intervention in the foreign exchange market is not statistically significant.

A few studies have discovered determinants of ER in developing countries but led to controversial conclusions. Jayasuriya and Perera (2016) investigated the factors affecting the US dollar ER in Sri Lanka by analyzing co-integration tests and the VAR models for the period 2009 to 2015. Their findings indicated that previous month net foreign assets, trade balance and ER depreciation led to short-term ER appreciation. On the other hand, Uddin et al. (2013) studied ER determinants in Bangladesh by analyzing monetary and non-monetary variables (political instability) and found that an increase in debt service payment and money stock led to the depreciation of ER. Meanwhile an increase in foreign reserves resulted in an appreciation of the currency. They also highlighted there is a negative relationship between political instability and domestic currency. However, Raji et al. (2017) employ the ARDL model to examine determinants of real exchange rate (RER) in Malaysia. They find that real interest rate, real stock return, terms of trade and foreign reserves can affect the Malaysian RER in the long-term while real money supply is the smallest contributor. Similarly, Chowdhury and Ali (2012) analyzed determinants, dynamics and structural breaks in the RER of Libya a 37-year period utilizing the ARDL approach. Based on their findings the terms of trade led to a strongly appreciating RER, however, strong depreciation in line

with government expenditure contradicted the traditional Mundell-Fleming effect of fiscal policy.

Most studies have been conducted on developed or advanced economies while developing countries have received less attention. Ghalayini (2014) introduced an ARIMA (Auto-Regressive Integrated Moving Average) model for the examination of the sustainability of basic economic theories and modeling and forecasting of the US dollar/Euro ER. The main conclusion is that inflation is the most important variable to forecast the US dollar/Euro ER. Further, the article revealed some drawbacks of what appeared to be exciting theories on the subject of ER, by highlighting the unrealistic assumptions of the Purchasing Power Parity (PPP) and Interest Rate Parity (IRP) theories. Recently, Barbosa et al. (2018) investigated the dynamics of RER over the long-term for developing and emerging economies by adopting the non-conventional approach. Based on their findings of different panel data techniques the short-run financial variables (the stock of outstanding obligations, portfolio flows) are the main determinants of the long-run RER.

Several previous scholars focused on the impacts of ER on economic growth rather than dynamics of ER. Korkmaz (2013) investigated causal relationships between ER and economic growth of nine selected European countries, through the panel data analysis technique. The annual data covered the period 2002-2011. She concluded that there is a long-term causal relationship between ER and economic growth. Likewise, Kogid et al. (2012) examined the impacts of both nominal and real exchange rates on Malaysia's economic growth from 1971 to 2009 using both the ARDL bound and ECM tests. This study concluded that both ERs have positive effects on Malaysia's economic growth. In addition, Razzaque et al. (2017) evaluated the effects of ER movements on economic growth in Bangladesh, using the co-integration analysis technique and VAR models for both short- and long-term periods. Their findings suggested that the appreciation of the RER is associated with a decline in output. However, more recently, Ashour and Yong (2018) discovered the effects of ER regimes on economic growth for 16 developing countries from 1974 to 2006 utilizing panel data techniques. The results indicated there is a link between different exchange rate regimes and economic growth but the relationship functions better under fixed regimes than under flexible regimes.

Summarizing all of the gaps¹ (in table 1) in the ER empirical literature, we see that most of the studies were

either partial or comprehensive. Partial studies have only used one or two variables and their effects on the ER. Comprehensive studies were mostly related to exchange rate regimes or volatility. Further, when choosing the ER determinants, they have taken into account the limited macroeconomic variables. In addition, many of these empirical studies have not considered an accurate economic model or theory. In particular they have

neglected structural breaks. All of these identified gaps in our knowledge are answered in the current study and that is one of the major empirical contributions of this paper. To address them, this study analyses the dynamics of NER, incorporating more variables as exchange rate determinants, in an effort to introduce a new approach and structural breaks. These are the further justifications of this research.

Table 1. Exchange Rate Literature: Sri Lanka.

Author	Data Sample	Methodology	Empirical Results
Ekanayake and Chatrna (2010)	1980-2007	GARCH model	The impact of ER volatility depends on the categories of goods
Wanaguru (2015)	2002-2012	GMM model	The Central Bank's intervention in the foreign exchange market is an effective determinant of ER
Rajakaruna (2017)	2001-2010	VAR model, MLR method	The net official intervention is the most effective and significant determinant of the ER
Jegajeevan (2015)	2001-2011	VECM model, Co-integration test	The Central Bank's official intervention in the foreign exchange market is not statistically significant
Jayasuriya and Perera (2016)	2009-2015	Co-integration test VAR model	Net foreign assets, trade balance led to short-term appreciation of the ER

Source: Made by the authors by using the data.

Theoretical Framework

This paper briefly discusses theories related to the ER: The Purchasing Power Parity theory (PPP), the Interest Rate Parity (IRP) and the Balance of Payments (BOP) theory of foreign exchange. These are discussed in more detail below.

Purchasing Power Parity Theory (PPP)

Gustav Cassel (1918) introduced the PPP theory to economic analysis. The PPP theory explains the long-run equilibrium between the ERs and price levels. Based on this theory, the ER between currencies of two countries should be equal to the ratio of price levels of two separate countries (Rajakaruna, 2017). According to the theory, changes in the price level are the main ER determinants. An increase in relative national (domestic) price requires a similarly relative national currency decrease. Consequently, there is a negative relationship between them.

Assume S_t to be the nominal dollar - rupee ER (in terms of dollar per rupee) and P_r is the price level in t-country. The PPP indicates that the exchange between the Sri Lankan rupee and US dollar should be:

$$S_t = \frac{P_r}{P_{\text{dollar}}}$$

Further, equation (1) can be written as follows:

$$P_r = S_t * P_{\text{dollar}}$$

This equation states that the Dollar price of the commodity basket in Sri Lanka, i.e. 'Pr', must be the same as the Sri Lanka rupee value of the commodity basket in USA. Therefore, PPP states that the price of the standard commodity basket be the same across countries when measured in a common currency.

That condition explains the absolute value of the PPP and the relative version of the theory can be shown as follows:

$$\epsilon = U_r - U_d$$

where, ϵ is the rate of change in the exchange rate and U_r and U_d are the Sri Lankan and American inflation rates, respectively. However, it is important to examine the validity of the PPP theory for international given that there are some limitations to the assumptions (constant dollar-rupee exchange rate).

The Interest Rate Parity (IRP)

The IRP theory is concerned with explaining the relationship between the interest rate and ER. If there is a discrepancy in the interest rates of two currencies, this will lead to a potential arbitrage. To avoid the balance of the interest rate differentials, some adjustment of the ER is required. However, the IRP theory assumed no-arbitrage condition in an equilibrium stage (Ghalayini, 2014). Nevertheless, the impossible assumptions of the PPP and the IRP theories undermine their reliability. The above two theories explain only part of the variation in the US dollar-

rupee ER but some monetary aggregates and business cycle fundamentals do affect fluctuating NER.

Balance of Payment Theory (BOP) of Foreign Exchange

Based on the BOP theory of foreign exchange (FE) introduced by Johnson in 1992, the value of one currency in terms of another currency depends on demand for and supply of the FE. An increase in the Sri Lankan rupee per dollar ER implies that Sri Lankan goods are cheaper than in terms of dollars to foreigners. This will encourage Sri Lanka to export more because foreigners are demanding more. In addition, foreigners will be aware that investment is now more profitable. Therefore, a high exchange rate leads to more capital inflows and exchange

rate appreciation. Conversely, a low exchange rate ensures the depreciation of the national currency.

METHODOLOGY

In this section, we explain data sources, dependent and independent variables and both analytical models briefly, i.e. the ARDL model and LM unit root tests.

Data Sources and Variables

Secondary monthly time series data for the period from 2011 January to 2018 July were used for estimation purposes. The data sources and variables of the study are summarized in table 2 below.

Table 2. Data Sources and Variables.

Variable	Description	Unit of measurement	Source
Nominal Exchange Rate (NER)	USD/LKR exchange rate	Rate	www.cbsl.gov.lk
Net official Intervention(NOI)	Purchases and sales of foreign exchange by the Central Bank	USD Mn	CBSL annual reports 2011:2017
Worker Remittances (REM)	Money transfers by Sri Lankan migrants	USD Mn	Statistics tables –CBSL websites
Terms of Trade (TOT)	$TOT = PX / PM$, PX – price of Sri Lanka’s exports; PM – price of Sri Lanka’s imports	USD Mn	Data library - CBSL
Net Foreign Assets (NFA)	The value of overseas assets owned by a nation, minus the value of its domestic assets that are owned by foreigners	USD Mn	CBSL annual reports 2011-2017
Foreign Reserve (FR)	Sri Lankan international official reserve assets at current price	USD Mn	Data library - CBSL
Inflation Rate (CPI)	Sri Lanka Consumer Price Index	Index	Department of Census and statistics
Interest rate (IR)	Short Term T-Bills rate (3 Months)	Rate	Monthly monetary policy review - CBSL
Money Supply (MS)	Currency held by the public + demand deposits held by the public	USD Mn	Data library - CBSL

Source: Made by the authors by using the data.

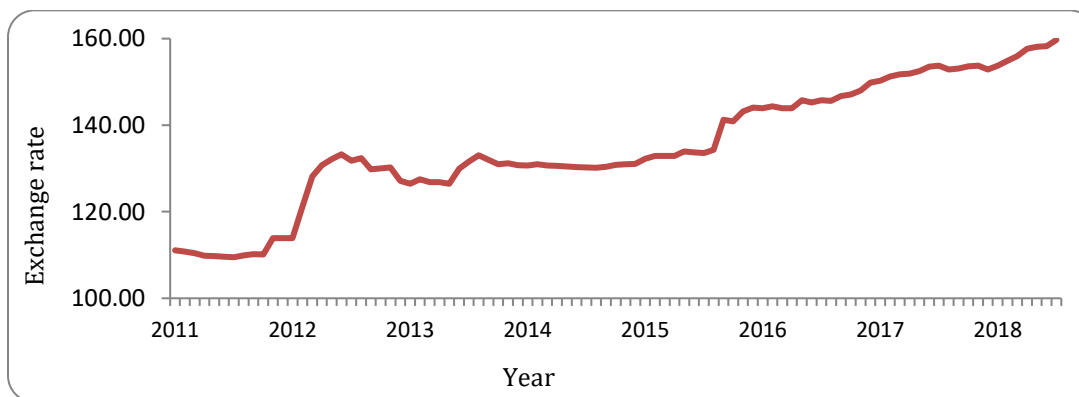


Figure no. 1 above illustrates the variations in the nominal exchange rate in Sri Lanka from 2011:01 - 2018:07. Source: this figure is made after the data analysis.

Figure 1. Nominal Exchange Rate.

ANALYTICAL MODELS

ARDL Model

In order to investigate the relationship between dependent (NER) and independent variables (NOI, REM, TOT, NFA, FR, CPI, IR, MS) we apply the ARDL model. Further, we can estimate both short-run and long-run dynamics simultaneously using the ARDL approach. When compared with other methods of co-integration (Engle and Granger causality tests, Johansen and Juselius co-integration tests) the ARDL approach is able to deal with variables with various orders of integration (Pesaran et al. 1999, Perasan et al. 2001). The ARDL approach creates is flexible enough to contain optimal lag lengths that are essential to describe the dynamic behaviour of the dependent variables to completely capture the effect of dependent and independent variables. Further, this approach presents relationship between dependant and independent variables well even do have a small sample size when compared to the other co-integration techniques (Raji et al. 2017).

The following equation shows the unrestricted error correction model (UECM) of the ARDL approach:

The following equation shows the unrestricted error correction model (UECM) of the ARDL approach:

$$\begin{aligned} \Delta \ln NER_t &= \gamma_0 \\ &+ \sum_{i=1}^k \gamma_1 \Delta \ln NER_{t-i} \\ &+ \sum_{i=0}^k \gamma_2 \Delta \ln NOI_{t-i} + \sum_{i=0}^k \gamma_3 \Delta \ln REM_{t-i} \\ &+ \sum_{i=1}^k \gamma_4 \Delta \ln TOT_{t-i} + \sum_{i=0}^k \gamma_5 \Delta \ln NFA_{t-i} \\ &+ \sum_{i=0}^k \gamma_6 \Delta \ln FR_{t-i} \\ &+ \sum_{i=1}^k \gamma_7 \Delta \ln CPI_{t-i} \\ &+ \sum_{i=1}^k \gamma_8 \Delta \ln IR_{t-i} \\ &+ \sum_{i=1}^k \gamma_9 \Delta \ln MS_{t-i} + \lambda_1 \ln NER_{t-1} + \lambda_2 \ln NOI_{t-1} \\ &+ \lambda_3 \ln REM_{t-1} + \lambda_4 \ln TOT_{t-1} + \lambda_5 \ln NFR_{t-1} \\ &+ \lambda_6 \ln FR_{t-1} + \lambda_7 \ln CPI_{t-1} + \lambda_8 \ln IR_{t-1} + \lambda_9 \ln MS_{t-1} \\ &+ \mu_t \end{aligned}$$

where, $\Delta \ln$, and k represent the first difference natural logarithm, and optimum lag, respectively. *The μ_t* is the error term.

The advantages of the ARDL approach are as follows. Firstly, it does not require the pre-testing of the variables included in the model for unit root tests. Secondly, the ARDL procedure is relatively unbiased and hence is a more statistically significant approach to determining the co-integration relationship for a small sample size as utilized in this study. Thirdly, the ARDL approach avoids the difficulties experienced by the Johansen co-integration technique such as deciding on the number of exogenous and endogenous variables to be included, the treatment of deterministic components, and the order of VAR and the optimal number of lags to be identified. The estimation procedures are very sensitive to such choices and decisions (Pesaran et al., 1999). Finally, the ARDL method is able to differentiate between the dependent and independent variables when co-integration exists.

LM Unit Root Tests

The problem of the ADF test results is that they do not allow for the possibility of a structural break. The power to reject a unit root decreases when the stationary alternative is true, and a structural break is ignored (Perron 1989). Particularly, when we analyse macroeconomic data, it is necessary to consider structure breaks to avoid bias and inconsistent results. Hence, we allow structural breaks for the time series data. Moreover, the LM unit root test has the advantage that it is unaffected by breaks under the null, in contrast to the ADF test. Additionally, it would provide valuable information for analyzing whether a structural break on a certain variable is associated with a particular government policy, economic crises, war, regime shifts or other factors.

The main strengths of the LM unit root test suggested by Lee and Strazicich are as follows: (1) the breakpoints are considered endogenously from the data; (2) the structural breaks are allowed under null and alternative hypotheses; (3) it avoids the problem of bias and spurious rejections associated with previous tests; and (4) The LM test assists accurate breakpoint estimation. Furthermore, Lee and Strazicich (2003) presented the model C (exogenous structural break) with a change in both level and trend. In addition, Lee and Strazicich's (2003)² model allows for two endogenous breaks both under the null and alternative hypotheses. They indicated

that the two-break LM unit root test statistic which is estimated by the regression according to the LM principle, will not spuriously reject the null hypothesis of a unit root.

The LM unit root test can be obtained from the following regression:

$$y_t = \delta' Z_t + e_t, \quad e_t = \alpha y_{t-1} + \varepsilon_t$$

where, Z_t consists of exogenous variables and ε_t is an error term. Lee and Strazicich (2003) develop a LM unit root test to accommodate for two endogenous structural breaks with two shifts in the intercept and the slope is described as:

$$[1, t, D_{1t}, D_{2t}]$$

where $DT_{jt} = t - T_{Bj}$, for $t \geq T_{Bj} + 1$, $j = 1, 2$ and 0 otherwise. Here, T_{Bj} represents the break date. The term D_{jt} is an indicator dummy variable for a mean shift occurring at time T_{Bj} , while T is the corresponding trend shift variable.

EMPIRICAL RESULTS AND DISCUSSION

Data Stationary

Initially, we conducted two-unit root tests - the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests for each independent and dependent variable - to avoid spurious outcomes. Based on those results, our variables are combinations of both stationary and non-stationary variables. A summary of ADF and PP test results are presented in table 3. However, when we

analyze macroeconomic data, it is necessary to consider structure breaks to avoid bias and inconsistent results. Specifically, when structural breaks exist above the traditional unit root tests results are ineffective. Therefore, we applied the Lee and Strazicich (2001, 2003) (LS) unitroot tests which can identify structural breaks endogenously. Model C (break model: break in both intercept and slope) picks up the gradual change while model A (crash model) captures the rapid change. A summary of the LM unitroot test results is shown in table 4. Except for the IR, the variables NFA, NER and MS and others are stationary at the level under model C.

Empirical Results and Stability Tests

ARDL Bound Test: This research examines whether the long-term relationship exists between NER and independent variables utilizing the ARDL bound test. For the null (H0) and alternative (H1) hypotheses, we can write them as follows:

H0 = $\lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = \lambda_1 = 0$
 (There is no long-run relationship existing between the dependent variable and its determinants)

H1 = $\lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq \lambda_1 \neq 0$
 (There is a long-run relationship existing between the dependent variable and its determinants)

To get a decision, F-statistics are compared with the critical values from Perasan et al.'s (2001). The results of the bound test for co-integration are shown in table 5.

Table 3. Unit Root Test Results.

Variable	ADF Test		PP Test	
	Test statistics ¹	Results	Test statistics	Results
NER	-0.7690	NS	-0.6845	NS
TOT	-0.7726	NS	-8.2494	S ² ***
OI	-3.8759	S***	-3.8675	S***
REM	-3.8826	S***	-4.7064	S***
INF	-2.5657	NS	-2.2989	NS
IR	-2.0906	NS	-1.8901	NS
NFA	-2.2177	NS	-2.2174	NS
FR	-3.1006	S**	-2.8943	S**
MS	-1.0041	NS	-0.9053	NS

Sources: Authors' estimates S = stationary, NS = non-station;

¹ - 3.5047, -2.8940 and -2.5841 are the critical values of I(0) at the 1 percent, 5 percent and 10 percent levels.

² ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 4. One or Two-Break Minimum LM Unit Root Tests.

Variable	Lags	T _{B1} , T _{B2}	Test statistic	Result
NER	4	2013:08	-3.72	Unit root with one break in trend
TOT	4	2017:11	-8.89 (-4.24)***	Stationary with one break in level
OI	4	2012:05,2016:04	-4.61(-4.55)***	Stationary with two breaks in level
REM	4	2014:08,2017:11	-10.28(-5.82)***	Stationary with two breaks in trend and level
INF	4	2016:04	3.85(-3.57)**	Stationary with one break in level
IR	4	2013:03,2015:12	-4.36	Unit root with two breaks in trend and level
NFA	4	2017:04	-3.29	Unit root with one break in trend and level
FR	1	ADF	-3.10 (-2.89)**	Stationary without breaks
MS	4	2014:06	-2.90	Unit root with one break in trend and level

Sources: Authors' estimates that Critical values (CVs) are presented in Lee and Strazicich (2001, table 1). CVs at the 1%, 5%, and 10% levels for the CC model are -5.823, -5.286 and -4.989, respectively. For models with one break, the CVs are as tabulated in Lee and Strazicich (2003, table 2). The CVs for model C, depending on the location of the break, change from -5.05 to -5.11, -4.45 to -4.51, and -4.17 to -4.20; TB1 and TB2 are the break months. Correspondent critical values (CVs) are -4.545, -3.842 and -3.504 for the AA model, respectively (Lee and Strazicich, 2001). The model A, CVs are 4.239, -3.566, and -3.211, respectively (Lee and Strazicich 2003). ADF test critical values the significance levels of 1 percent, 5 percent and 10 percent are -3.50, -2.89 and -2.58, respectively.

Table 5. Bound Test Results.

F-Statistics	Bound CV 10%		Bound CV 5%		Bound CV 2.5%		Bound CV 1%	
F-NER (TOT, FR, NFA, OI,MS,IR, REM and INF)= 7.0138***	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	1.85	2.85	2.11	3.15	2.33	3.42	2.62	3.77

Sources: Authors' estimates.

Based on the above results, F-statistics is significant at the 1 percent level so we can accept H1: long-run relationship between NER and independent variables (co-integration exists between nominal exchange rate (NER) and terms of trade (TOT), foreign reserves (FR), net foreign assets (NFA), official intervention (OI), money supply (MS), short-term interest rate (IR), remittances (REM) and inflation (INF)).

Long-run Coefficients

For the next step, involving a long-run relationship, we used the ARDL co-integration method to evaluate the parameters of equation. The estimated long-run coefficients and short-run error correction model (ECM) for the nominal exchange rate are presented in table 6. The lag in the ARDL model is chosen by the Akaike Info Criterion (AIC).

Based on the findings of the ARDL co-integration and long-run form, the MS leads to a long-term depreciation of the Sri Lankan rupee. Money supply is the most significant variable for determining NER in Sri Lanka in the selected period for the long-term. The co-efficient is -33.9 and highly significant at 1 percent. This outcome agrees with the flexible price model proposed by Frenkel (1976), where an increase in domestic money supply should increase the domestic price level and as a result,

domestic currency will depreciate. Further, when an increase in money supply occurs, this will lead to reducing domestic interest rate and capital inflows. Therefore, the supply of dollars declines, and domestic currency will subsequently depreciate (Krugman, 2008). Supporting these outcomes, similar findings have been reported for developing countries (Islam and Hasan, 2006; Jegajeevan, 2015; Uddin et al., 2013).

However, short-term interest rates, foreign reserves, terms of trade and workers' remittances have a positive and significant impact on Sri Lanka's nominal exchange rate in the long run. A positive relationship exists between terms of trade and NER, when a one percent increase in TOT will lead to an increase in Sri Lankan NER by 6 percent which is highly significant. In addition, a 1 percent increase in short-term interest rate appreciates the NER by nearly 0.55 percent in the long-run to a 5 percent significance level. Based on Chowdhury and Ali's (2012) findings, the terms of trade were the main factor that led to Libya's RER appreciating. Further, an increase in the short-term interest rate and terms of trade will lead to a rising supply of foreign currency due to the capital inflows and appreciation of domestic currency. Similar results which were presented by Jayasuriya and Perera (2016) related to their Sri Lankan ER study.

Table 6. Estimated Long-run Coefficients and Short-run Error Correction Method (ECM).

The long-run coefficients estimates based on ARDL (1, 1, 3, 3, 1, 1, 4, 3, 3, 0, 0) selected lag based on AIC				The short-run coefficients estimates based on ARDL (3, 4, 3, 3, 1, 2, 4, 2, 3, 0, 0, 0) selected lag based on AIC			
Variable	Coefficient	t-statistics	Probability	Variable	Coefficient	t-statistics	Probability
INF	0.1444	0.9051	0.3693	ΔINF	0.4229	2.2102	0.0318**
LFR	5.9439	4.0746	0.0001***	ΔFR	-4.8175	-2.5205	0.0150**
LMS	-33.9455	-8.0484	0.0000***	ΔMS	-38.0410	-7.0450	0.0000***
LNFA	-0.0096	-0.1957	0.8456	ΔNFA	0.1579	2.6943	0.0096***
LOI	0.0035	0.1173	0.9070	ΔOI	-0.0875	-2.2012	0.0325**
LTOT	5.5463	5.7659	0.0000***	ΔTOT	2.2099	1.7109	0.0934*
IR	0.5494	2.0946	0.0407**	ΔIR	1.0577	3.1259	0.0030***
LREM	4.0060	2.7504	0.0080***	ΔREM	5.0042	2.7667	0.0080***
Constant	-0.1012	-9.6525	0.0000***	ECM (-1)	-0.7809	-3.6315	0.0007***
DV_1 2013: 08	-1.8606	-1.9095	0.0613*	$\Delta DV_{12013} :08$	-2.4867	-3.0631	0.0036***
DV_22014: 06	-1.2286	-1.2841	0.2044	$DV_{22014} :06$	-1.3253	-1.7241	0.0910*
R² = 99	DW = 2.001						

Sources: Authors' estimate

Table 7. Estimated Long-run Coefficients and Short-run Error Correction Method (ECM) (without dummy variables).

The long-run coefficients estimates based on ARDL (1, 3, 0, 0, 0, 0, 1, 2,4) selected lag based on AIC				The short-run coefficients estimates based on ARDL (1, 3, 0, 0, 0, 0, 1, 2,4) selected lag based on AIC			
Variable	Coefficient	t-statistics	Probability	Variable	Coefficient	t-statistics	Probability
INF	-0.2045	-1.6940	0.0949*	ΔINF	-0.2185	-1.8440	0.0318**
LFR	-0.0001	-0.5123	0.6101	ΔFR	-0.0011	-0.5248	0.6589
LMS	-29.4700	-2.7492	0.0077**	ΔMS	-21.1800	-1.4306	0.0088**
LNFA	0.0001	0.7680	0.4452	ΔNFA	0.0022	0.6103	0.5437
LOI	0.0001	0.0009	0.8846	ΔOI	0.0020	0.1504	0.8808
LTOT	-0.0523	-3.3729	0.0012***	ΔTOT	-1.0159	-0.9856	0.3279
IR	1.1967	3.4290	0.0010***	ΔIR	2.9337	1.6273	0.1084
LREM	0.0091	2.3670	0.0208**	ΔREM	0.0089	1.7853	0.0787*
Constant	5.6215	1.3257	0.1894	ECM (-1)	-0.6850	-4.0118	0.0002***
R² = 51	DW = 2.07						

Sources: Authors' estimate.

Furthermore, FR and REMled to the Sri Lankan rupee appreciating over the long-term. A 1 percent increase in foreign reserves and remittances will lead to an appreciation of the NER by 6 percent and 4 percent, respectively. Uddin et al. (2013) documented similar findings for the dynamics of ER in Bangladesh. However, their results indicated Central Bank official intervention, net foreign assets and inflation are insignificant when determining NER in the long run for a selected period of time. This supports the findings of Jegajeevan (2015). Additionally, we tested the long-run coefficients and short-run error correction model without considering the structural dummy variables. The results are shown in table 6. However, when compared with estimated results of long-run coefficients and short-run error correction model with the dummy variables, some variables are statistically insignificant: i.e. foreign reserves. Therefore, we could conclude that the exclusion of these dummies does qualitatively change the nature of the results. Hence, we included breaks in our model to examine the determinants of the nominal exchange rate in Sri Lanka. Both structural dummy variables presented negative sign of the coefficient, but one of them (second structural dummy variable) is statistically insignificant. In the long run the first structural break (DV_1) in 2013:08 had a depreciating effect on the long-term NER of Sri Lanka mainly due to an increase in import demand. Additionally, the expectation of loosening by foreign investors from the government securities market in anticipation of the possible tapering of the US bond-

buying programme (CBSL 2013). In addition, the $R^2 = 99$ indicates the overall goodness of fit of the estimated ARDL model. This is high and all the regressors indicate statistical significance at the 1 percent level.

Short-run Error Correction Model (ECM)

Table 6 reveals long-run coefficients and the short-run dynamics for the estimated ARDL models separately. The ECM (-1) indicates the short-run adjustment process. Furthermore, the ECM (-1) specifies how quickly determinants adjust and return to the initial equilibrium level. The coefficient of ECM should be a negative sign and is statistically significant. As expected, the ECM is the correct sign, and is statistically significant. The coefficient of the ECM (-1) is equal to -0.7809 and is highly significant, confirming the existence of the co-integration relationship between the dependent and independent variables. The deviation from the long-run equilibrium path is corrected by nearly 78 percent of disequilibrium in the previous year, and then it is corrected in the current year.

Diagnostic Tests

To assess accuracy of the ARDL models, we conducted three diagnostic tests for serial correlation, heteroscedasticity, and Ramsey RESET which is reported in table 8 below. Based on these test results, there is no autocorrelation or heteroscedasticity problem, and so the model is well defined.

Table 8. Results of Diagnostic Tests.

Tests	Obs*R-squared	P-value	Lag Order
Serial correlation LM test	1.0664	0.7347	4
Heteroscedasticity	29.5435	0.7694	4
Ramsey RESET	0.9970	0.1291	4

Sources: Authors' estimates.

The stability of long-run coefficients of Sri Lankan NER was estimated by conducting CUSUM (Figure 2) and CUSUMSQ (Figure 3) tests introduced by Brown et al. (1975). These two graphs do not exceed the 5 percent

critical values which are depicted by two straight broken lines. Consequently, we can conclude that long-run estimated parameters of the NER function are stable.

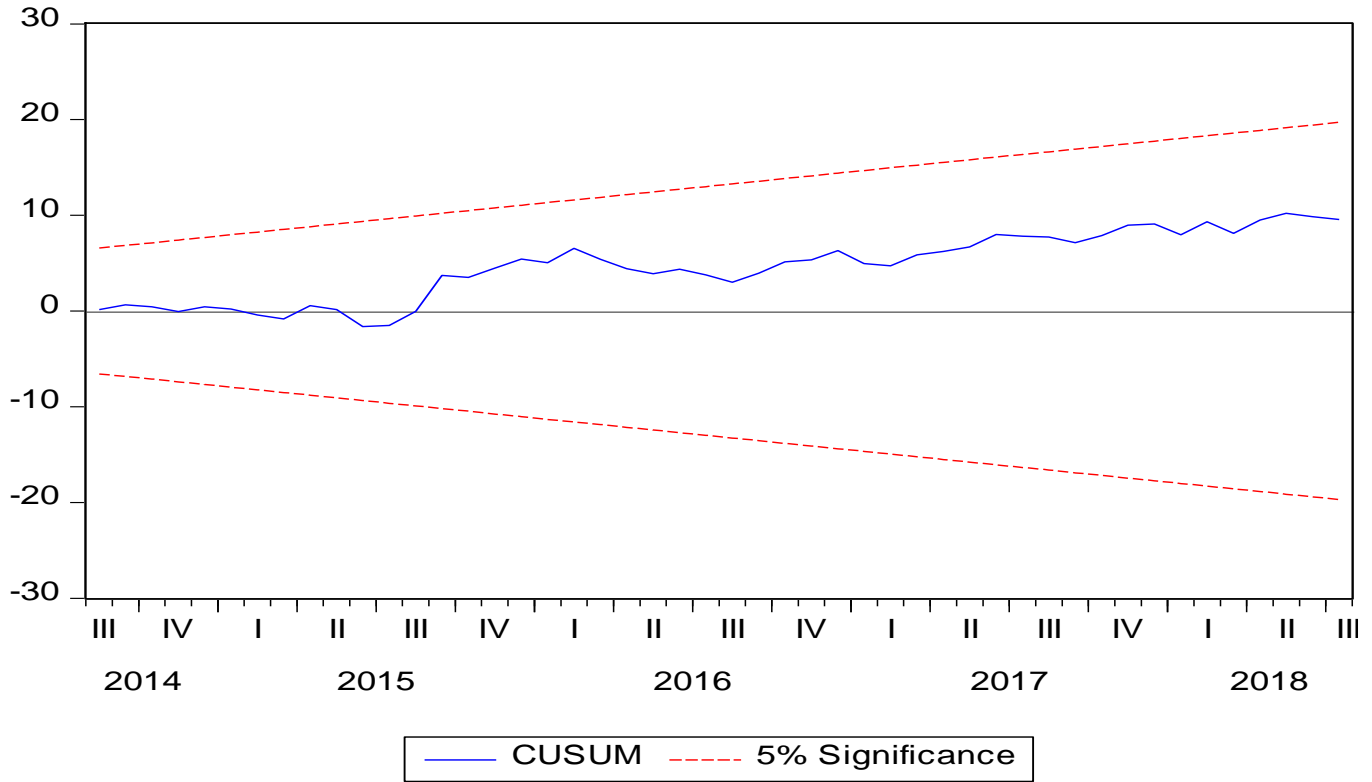


Figure 2. Plot of Cumulative Sum of Recursive Residuals.
Sources: Authors' estimates

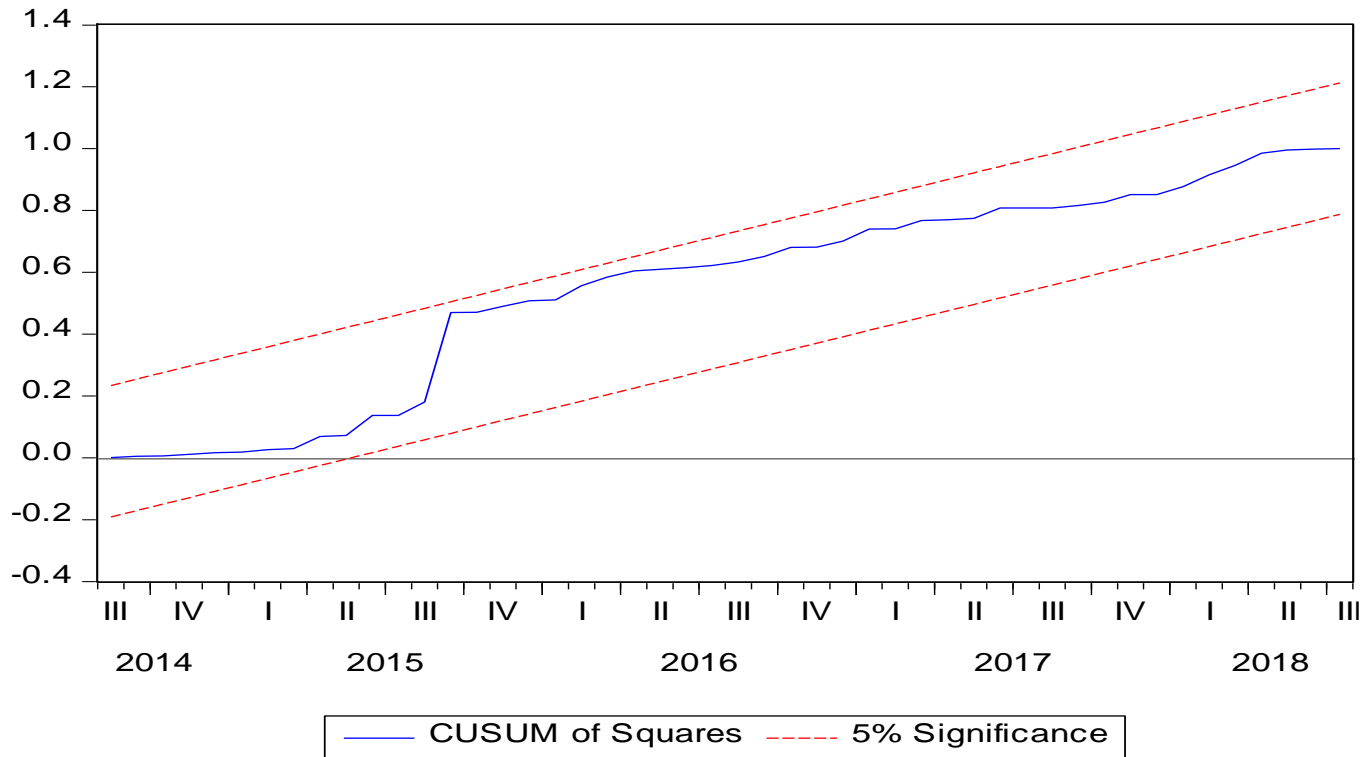


Figure 3. Plot of Cumulative Sum of Squares Recursive Residuals.
Sources: Authors' estimates

SUMMARY AND CONCLUSION

In this study, we create new insights into the dynamics of NER in Sri Lanka. The current paper is important in three ways. Firstly, we conducted Lee and Strazicich's LM unit root test to identify two endogenous structural breaks and this paper is the first to use this third generation unitroot test procedure. Secondly, this study analyses the NER in Sri Lanka by employing the ARDL technique which is flexible for both stationary and non-stationary variables, estimating long-run and short-run relationships between dependent and independent variables. Thirdly and finally, this study used a wider range of variables as NER determinant based on recent monthly data.

The bound test results indicate that there exists a cointegration relationship between NER and its determinants after allowing for structural breaks. Our empirical findings suggest that a strong depreciating link exists between the NER and money supply in Sri Lanka during the sample period of 2011:01 to 2018:07. We have found that MS, FR, TOT, REM and IR were the significant factors determining NER for Sri Lanka in the long-run. A 1 percent increase in MS will lead to a 34 percent depreciation of the Sri Lankan rupee and this is consistent with exchange rate theory. In addition, short-term interest rate, foreign reserves, terms of trade and workers' remittances leads to an appreciation of the Sri Lankan NER. A 1 percent rise in TOT, FR, IR and REM appreciate the NER by 5.5 percent, 6 percent, 0.55 percent, and 4 percent in the long-run, respectively. The first dummy variable was negative, and statistically significant. The error correction term (speed of adjustment towards equilibrium) was reasonable by approximately 78 percent per year. Our model and estimation methods are reliable and robust in both the short- and long-term (CUSUM and CUSUMSQ tests and results of diagnostic tests showed stability).

Above outcomes are signals to identify new lessons for policy-makers to implement correct and corrective policy management tools in the future. Findings could be useful for applying combined and organized monetary, fiscal and exchange rate policies for the current situation (depreciation of the Sri Lankan currency). Any depreciation in a national currency will seriously compromise stock in terms of Sri Lankan rupee and increasing domestic price of imported goods and services. In this context, developing countries like Sri Lanka need to consider more sustainable foreign currency inflows

(earnings from export goods and services and foreign direct investment) to maintain a reliable exchange rate. Consequently, Central Banks or monetary authorities are responsible for determining consistent foreign exchange policies which consider both monetary and financial policy frameworks.

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¹ A survey of the recent literature related to exchange rate in Sri Lanka is shown in Table 2.1

² If only one break is significant, we recommend running the one-break LM unit root test as proposed by Lee and Strazicich (2004).

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