Understanding SLL / US$exchange rate dynamics in Sierra Leone using Box-Jenkins ARIMA approach$

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Abstract

This study was carried out with the purpose of producing twelve out-of-sample forecast for a univariate exchange rate variable as a way of addressing challenges faced around dollarization issues in the domestic economy. In pursuit of this, the ARIMA model was utilised, with the best model [1,4,7] indicating that the Sierra Leone - Leone [SLL] currency will continue to depreciate against the United States Dollar [US$] throughout most part of the year 2020. This was done on the assumption of Ceteris Paribus condition, and most importantly on the view that past events of the univariate exchange rate variable is a determinant of future outcomes or performances. In a bid to moving forward, policy recommendations have suggested high level collaboration between relevant policy institutions like the Bank of Sierra Leone and the Ministry of Finance to address issues of concern, for example, a boost to the real sector and many more.

Keywords: *Box-Jenkins ARIMA, Exchange Rate, Forecast, Sierra Leone*
JEL Classification: *C52, C53, E47, F31, F47*

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1. Introduction

Foreign exchange dynamics is a highly topical concern in the stabilization of the world economy, particularly in some of the struggling economies around Sub-Saharan Africa (SSA), which are highly dependent on import transactions to support domestic consumption (Jackson, et al, forthcoming; Bangura et al, 2013). Exchange rate modelling is very important for policy decisions (Jabbie and Jackson, forthcoming), hence it is very important that the dynamics of such variable is accurately predicted on a regular basis in a bid to address on-going concerns around macroeconomic fundamentals in a country like Sierra Leone.

Exchange rate measures a country's currency worth in comparison with others, which is closely related to the purchasing power parity [PPP] – an area that was recently addressed in Jabbie and Jackson's (forthcoming) study. Where it is such that the domestic currency cannot be exchanged at the same rate in comparison with international currencies, there is likelihood that the domestic currency is being devalued, which to some extent may impact on citizens' welfare and also, prices that people pay in exchange for goods and services (Nyoni, 2019a; Jabbie and Jackson, forthcoming).

Exchange rate is very important in the international monetary market, particularly in areas concerned with offsetting payment on trade transactions, stabilisation of price dynamics and also, in support of basic structural development capacity in individual economies around the world (Jackson and Tamuke, 2018; Iyke and Odhiambo, 2017). Therefore, an intense study on exchange rate, and more so its prediction is very critical for macroeconomic stabilisation and planning. Fluctuations in exchange rate movement as witnessed in the Sierra Leone economy can stir up inertia of inflation expectations, which is not good for an economy (Jabbie and Jackson, forthcoming; Jackson and Tamuke, 2018; Bangura et al, 2012). This on many occasions can result in a build-up of dollarisation market, commonly used by people to hedge risks against collapse in investments connected with marketable securities and many more.

There is an expectation that with the continued devaluation of a country's currency, people will anticipate higher wages through collective bargaining agreements (Jackson, forthcoming). Higher level wage and salary settlements can also result in increased cost to employers, and the pass-through of this is normally felt through high cost of goods purchased and also, services delivered. There is also a higher chance for money supply to increase, which also exert intense pressure on central bank to utilise available policy instruments to address high risks of '*too much money chasing too few goods*' in the system. Unlike in inflation targeting regimes adopted by many of the developed economies where central banks are perceived as totally autonomous, decisions taken to address exchange rate concerns in politically-meddled system as witnessed in many of the small open economies around Africa can be a very hard thing to achieve (Warburton and Jackson, forthcoming; Bleaney, Morozumi and Mumuni, 2018). In the absence of economic diversification, it seem very certain that exchange rate will continue to threaten many of the small open economies around the world – a typical example is Sierra Leone, which is highly dependent on importation of essential goods and services to support domestic consumption.

1. Rational for the Study and Emerging Knowledge Exploration

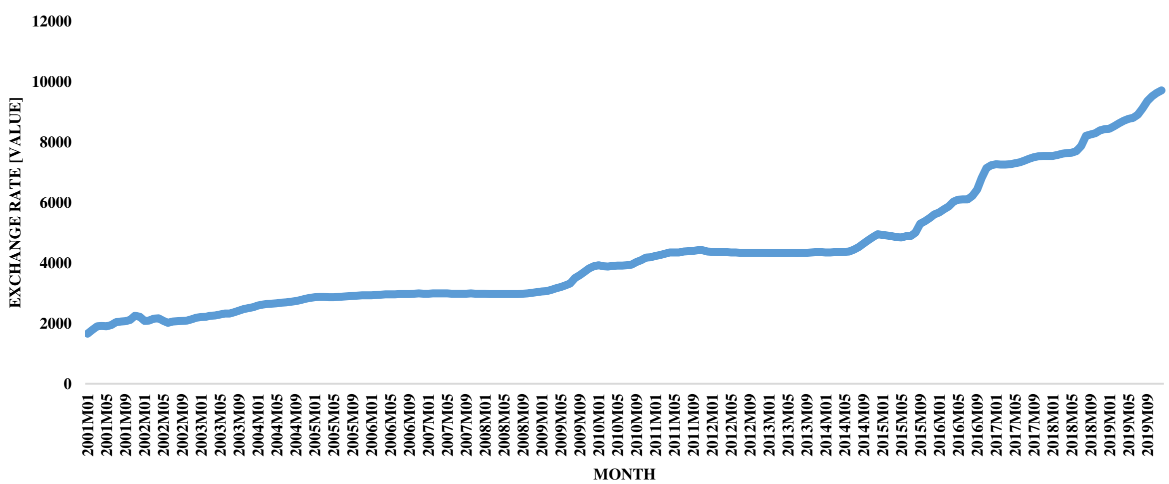
Exchange rate dynamics in Sierra Leone is a topical concern for economic prosperity - people's expectations about the economy, particularly prices of goods and services consumed have always being hinged on dynamic events in the exchange rate market, also highly influenced by parallel market street traders. Added to the highlighted expectations, the current state of low productivity in the real sector is also an attestation of the on-going crisis, with essential and basic consumable items like Rice and Onion continued to be the dominant imports, which also increase pressure on institutions like the central bank to settle high demand for foreign currencies to settle import bills.

On this note, this study has taken as its rationale by utilising data on Exchange Rate variable within the period 2001-2012 in observance of how past events of the series will impact on out-of-sample forecast for a twelve months duration. It is a general expectation that such outcome will induce exchange rate depreciation, on the backdrop of the country's low capacity to absorb shocks, attributable to an almost inactive real sector to support the production of basic goods and services needed for consumption in the domestic economy. The proposed methodology [ARIMA] will generate automated iteration of (likely) best models suitable for predicting out-of-sample forecast of exchange rate dynamics in the country.

Despite the wide usage of ARIMA model to address exchange rate predictions, the uniqueness of this study is its automated approach to data utilisation (as shown in Appendix 1). It is hoped the outcome will be useful for addressing knowledge exploration connected with the formulation of robust policy measures to address short-term concerns pertaining to exchange rate depreciation and scarcity in Sierra Leone. It is also import to note that, assumption built in this model is based on past events of the series, in which out-of-sample forecast is to be produced. Policy recommendations from the study will seek to address pressures in the exchange rate market and its pass-through effects to economic agents in the domestic economy.

1.2. Stylised facts on Exchange Rate Dynamics in Sierra Leone

Figure 1: Exchange Rate Stylised Facts [2001M01 - 2019M12]



Source: *BSL data warehouse*

As already mentioned, exchange rate is an on-going challenge in the economy, attributable to an unproductive real sector, which has been heavily reliant on imports to support economic activities in the domestic economy. Figure 1 shows a steady increase in exchange rate in SLL/US$ over the period, which makes it very difficult for growth to be achieved in the economy. The country's susceptibility to shocks on account of its weak real sector is partly to be blamed for the situation as depicted in the steep rise in exchange rate between the SSL and the US$.

In addition to the weak real sector operation in the country, Sierra Leone has gone through series of traumas, some of which are man-made disasters, while others are occurrences attributable to natural disasters and events in the global economy (supply-side driven). The occupation of the country by rebel intruders is something that cannot be forgotten by people in the country – the legacy of this is still resonating in the fabrics of structural problems the country is still faced with, for example, destructive towns / villages and some urban towns, which were once utilized as means for activities relating to agriculture, mineral exploration, etc. The data as provided for exchange rate is indicative of recurring problems, which is making it easy for the SLL to be regularly devalued against international currencies like the US$. Equally, the experience of the twin shocks around 2014-15 is also an added trauma for a small open economy like Sierra Leone to absorb.

The lack of prudence on the part of people during the boom time of Iron Ore exploration also exposed the country's vulnerability to shocks (see Jackson, 2016). It was quite evident from the twin shock of Iron Ore price slump and the Ebola epidemic that proceeds from the boom time of mineral exploration were not utilised judiciously to cushion uncertainties revolving around natural disaster and supply-side driven shocks (Jackson and Jabbie, forthcoming; Jackson, 2016a).

1.3. Objectives and Organisation of the study

In view of the above discussion, the main objectives of the paper are hereby stated as follows:

- Utilise automated ARIMA codes to produce the best model.
- Produce out-of-sample forecast covering twelve months period for the year 2020.
- Provide suggested policy recommendation[s] in addressing exchange rate concerns.

In view of the above discourse, the remaining sections of the paper are divided as follows: Section two addresses the literature review, which is further sub-sectioned into theoretical and empirical literatures. Section three addresses the econometric model, which in this case is Autoregressive Integrated Moving Averages [ARIMA] and the data range, which is typically based on a univariate monthly usage of exchange rate variable sourced from the Bank of Sierra Leone data archive system. Section four covers the analysis of data and the model evaluation, which is based on an automated system produced from EVIEWS application. Section five covers the conclusion and relevant policy recommendations.

2. Literature Review

2.1.Theoretical

In order to address concerns around exchange rate dynamics and its forecast outcome, it is very important that attention is drawn to the theoretical connections of exchange rate determination – in this study, the researcher has identified three connections as explained below:

Purchasing Power Parity [PPP] – this typically suggest concerns relating to cause and effect between change in price level (which is the main cause) and exchange rate (which in this case, is the effect). As explained by Jabbie and Jackson (forthcoming), a simple mathematical expression can be used as outlined below in equation 1.

$$e = {}^{P}/_{P*} = \frac{\text{Leprice of standard market prices of goods}}{\$\, price\ of\ the\ same\ standard\ basket} \ldots\ldots\ldots\ldots\ldots \quad 1$$

As explained by Nyoni (2019b), the theory of PPP is based on the simple '*law of one price*'. With reference to equation 1, PPP explains exchange rate movement between currency in two different countries, for example, Sierra Leone (SLL) and the United States of America (US$). Under a typical goods-market arbitrage condition, it is possible that such situation will make it possible for exchange rate to equalize prices in the two countries – in this case, where US imported goods are considered more expensive in the Sierra Leonean market, it is possible for economic agents in Sierra Leone to purchase more of what is produced in the domestic economy, which may eventually result in the appreciation of Sierra Leonean manufactured goods on account of high demand over that of US traded goods in the local market.

Mint parity theory – this is based on the simple idea of two or more countries utilising the same metallic standard of either gold or silver currency as medium of exchange for transaction. In this case, countries that uses gold for instance will be inclined to exchange based on the gold standard value in the respective countries. This essentially will make it possible for there to be a standard differential in prices of goods and services purchased in one country as against the other, given the exchange value of metallic currencies that are being utilised in the different countries. As pointed out by Aahana (Online) in an economics discussion portal, the mint parity of foreign exchange rate have highlighted two main concerns – the first is based on the actual rate of exchange, which can differ from the equilibrium rate of exchange. Secondly, under the gold standard, there is a limit specified beyond which fluctuations of exchange rate cannot take place. This thereby add pressure in the determination of exchange rate parity, and thus price dynamics in the country in which the gold standard may not be of worthwhile value.

Uncovered Interest Rate Parity (UIP) – this is based on movement in exchange rate, which is hinged on holdings of assets in two different currencies, for example SLL and US$. The theory of UIP gives premium to arbitrage mechanism without much emphasis on transaction costs and liquidity constraints. On the condition that UIP is to hold, the resulting arbitrage relationship will produce the following (Nyoni, 2019b; detailed reference is also addressed to Warburton, 2018):

$$E_{t(Ine_{t+h}\text{ - }Ine_t)} = i_{t\,-\,i_t^*} \quad \cdots\cdots\cdots \quad 2$$

Market expectation of exchange rate return is defined on the basis of the left hand side of the equation from time t to time t+h, and i_t and i_t^* while i_t are the interest rate of the domestic and foreign currencies respectively.

2.2.Empirical

The relevance of forecasting exchange rate dynamics have been demonstrated lately in several studies produced by Nyoni (2019a; 2019b) – such studies captures forecast outcomes of Naira / US$ and the Indian Rupee / US$ exchange rate in India respectively. Each of the models made use of ARIMA with the best model outcomes indicating full robustness of the system in the underpinning policy recommendations. In the case with the Indian Rupee / US$ outcomes, there is an indication that the Rupee will appreciate, but also indicating a devaluation of the Rupee, while also encouraging local productivity and promoting capital inflows.

The practicality of ARIMA to forecast outcome has become very popular, given its rigor in providing high level of certainty; evidence of this in the area of forecasting inflation dynamics has been done more lately to address going forward situation with price stability and even the influence of exchange rate as an exogenous determinant of inflation dynamics in the Sierra Leone economy to be more specific (Jackson, Tamuke and Jabbie, 2019; Jackson, 2018; Jackson and Tamuke 20108; Jackson, Tamuke and Sillah, 2018; Jackson, Tamuke, Jackson and Sillah, 2018).

Babu and Reddy (2015) made an attempt to forecast exchange rate using ARIMA, Neutral Network and Fuzzy Neuron. The results proved contradictory, on the ground that ARIMA proved to be a better model in predicting exchange rate market in India than the other two counterpart models.

Olakorede et al (2018) utilised univariate time series ARIMA model to determine exchange rate movement between Nigeria Naira and US$, with monthly data ranging from 1980M01 to 2015M12. The best fitted model (0,1,1) with minimal AIC and BIC indicated that the Naira will continue to depreciate against the US$ during the periods under investigation (2016M01 to 2018M12).

Driss and Fatima (2018) utilises Box-Jenkins ARIMA and Vasicek Stochastic Models to predict exchange rates in Morocco. Comparisons were then made from the two model outputs for the month of March 2018. The exchange rate outcome then made it possible for the best ARIMA (2,1,2) to be retained for EUR/MAD, while the Vasicek best model (3,1,2) was retained for the US$/MAD.

In pursuit of exploring means of forecast accuracy, Trafalis and Ince (2006) utilised hybrid model approach for predicting exchange rate performances. In this study, they proposed two stage forecasting that incorporated parametric techniques such as autoregressive integrated moving average (ARIMA), Vector Autoregression (VAR) and co-integration techniques, and nonparametric techniques such as support vector regression (SVR) and Artificial Neutral Networks (ANN). It was particularly noted that input selection in the model estimation was very important in the final forecast output – in short, the SVR technique outperformed the ANN for two input selection models.

In pursuit of exploring the best model approach of forecasting exchange rate dynamics, Leung et al (2000) made an attempt by utilising the General Regression Neutral Network (GRNN) – this study was intended to explore opportunities for international firms that are engaged in conducting substantial currency transfers in the course of business transactions, and the GRNN model was seen to be able to be a good approach in improving their overall prospects for profitability. The monthly data used was able to predict exchange rate for three currencies namely, the British Pound, Canadian Dollar and Japanese Yen. The overall outcome from the study proved that GRNN is better than other neutral network and econometrics techniques utilised in the study (namely, the Multi-Layered Feed-forward Neutral Network [MLFN]), which is a better means of solving financial forecasting problems.

West and Cho (1994) compared out-of-sample forecasting performance of univariate homoscedastic, GARCH, Autoregressive and Non-Parametric Models for conditional variances, using five bilateral weekly exchange rates for the dollar during the period 1973-1989. GARCH models were seen to demonstrate high level of forecast accuracy during a one week horizon period. In the case of longer horizon, it was a difficult task of selecting the best model for forecasting out-of-sample performances. More confusing, none of the models were seen to perform better in a conventional test of forecast efficiency.

Canova (1993) also utilizes the Bayesian Time-Varying Coefficients (TVC) approach to model and forecast exchange rate data. In this, it was shown that leptokurtic behaviour disappears under condition of time aggregation. Overall, it was proved that the Bayesian TVC model improves over a random walk and such improvements are robust enough to effect changes in the forecasting environment.

Despite the relevance of the methodologies utilised in the aforementioned empirical reviews produced by researchers from selected countries, the uniqueness of this study is its ease in utilising ARIMA automated system to model exchange rate for twelve months out-of-sample forecast period in Sierra Leone – as opposed to manual iteration, the automated system will generate easy means of diagnostically iterating model choices, while also selecting the best model for utilisation in out-of-sample forecast for a specified period. It is hoped that such outcome will remain very important in adding to empirical literatures, while also serving as a means for supporting executive decision(s) that requires urgent attention in addressing exchange rate issues in the Sierra Leone economy.

3. Econometric Model and Data Usage

3.1.Autoregressive (AR) Models

$$SLL_t = \emptyset_1 SLL_{t-1} + \emptyset_2 SLL_{t-2} + \cdots + \emptyset_p SLL_{t-p} + \uparrow \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3$$

The above series (SLL_t) as expressed in equation 3, epitomize as the Sierra Leone (Leone) currency (SLL) is assumed to be an autoregressive process of the order p, expressively denoted as AR(p). The above equation signify that the SLL exchange rate is explained by previous values of the SSL/US$ series (see Jackson, 2018; Nyoni, 2019a). US$ is the United States Dollar currency notation.

Operationalization of equation 3 makes it possible for ε_t to be made the subject, as shown in equation 4 below.

$$SLL_t \left(1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right) = \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4$$

Where:

- B in equation 4 is a backshift operator;
- $\emptyset_1$ ... $\emptyset_p$ are the parameters of the model;
- ε_t is a normally distributed random process with mean 0 and a constant variance σ_ε^2 which is assumed to be independent of all process values;
- SLL_{t-1}, SLL_{t-2}, are AR models, with stationary data, which means the data should be stationary prior to being fitted into the model (See Appendix 1 for automated codes, reflecting properties for satisfying stationary conditions).

3.2.Moving Average (MA) Models

White noise series properties with mean 0 and variance σ_ε^2 are normally referred to as moving average, with order q, normally expressed as MA(q). This can be expressed as a weighted linear sum of previous forecast errors:

$$SLL_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 5$$

Equation 5 implies that SLL/US$ exchange can be explained in terms of current and past period disturbances (in this case the random errors, or attributed to shocks, which is categorised on the basis of natural disasters or man-made events ……… (see Jackson, 2018a).

The backshift operator process of equation 5 can be rearranged to produce a new expression as indicated in equation 6 below.

$SLL_t = \varepsilon_t(1 + \theta_1 B^1 + \theta_2 B^2 + \cdots + \theta_q B^q)$ ………………………… 6

Where:

- $\theta_1, \theta_2, \ldots.\ \theta_q$, are said to be coefficients, with lagged error terms;
- B is backshift operator;
- ε_t is normally distributed random process.

3.3. Autoregressive Moving Average (ARMA) Models

This is a combination of both the AR and MA models, which is also expressed as [ARMA(p,q)]. It is expressed thus:

$SLL_t = \emptyset_1 SLL_{t-1} + \emptyset_2 SLL_{t-2} +..+ \emptyset_p SLL_{t-p} + \varepsilon_t + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \cdots + \theta_q\varepsilon_{t-q}$ …7

A rearrangement of equation 7 will then produce a new expression as shown in equation 8 below:

$SLL_t - \emptyset_1 SLL_{t-1} + \emptyset_2 SLL_{t-2} +..+ \emptyset_p SLL_{t-p} + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \cdots + \theta_q\varepsilon_{t-q}$ ……..8

The backshift operator expression then result in a new equation as expressed in equation 9 below:

$SLL_t\left(1 - \emptyset_1 B^1 - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right) = \varepsilon_t(1 + \emptyset_1 B^1 + \emptyset_2 B^2 + \cdots + \emptyset_q B^q)$ …………....9

Simplifying equation 9 produces a new expression as shown below:

$\emptyset(B) SLL_t = \emptyset(B)\varepsilon_t$ ……… 10

This is a simple case of parsimony ARMA(p,q), which gives a better representation of the data used.

3.4. Autoregressive Integrated Moving Average (ARIMA) Models

This is applicable to data that is representative of stationary series, which are thereby differenced on several occasions to make sure the date at use is fit-for-purpose. In this case, series can be differenced once or twice, depending on the properties of the series as shown in the equation below.

$(1 - B)^d SLL_t$ …………….. 11

Where d = is the number of times the process is differenced to ensure stationarity is achieved.

Hence, drawing on from equation 9, the expression with differencing can be written as shown in equation 12 below:

$SLL_t\left(1 - \emptyset_1 B^1 - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right)(1 - B)^d = \varepsilon_t(1 + \emptyset_1 B^1 + \emptyset_2 B^2 + \cdots + \emptyset_q B^q)$
……… 12

This can now be simplified to form equation 13 as indicated below:

$\emptyset(B)(1 - B)^d SLL_t = \emptyset(B)\varepsilon_t$ ………………… 13

Equation 12 in particular is referred to as the ARIMA process, with the following characteristics:

- White noise [ARIMA(0,0,0)]
- Random walk [ARIMA(0,1,0)]
- Autoregressive process [ARIMA(0,0,q)]
- Autoregressive moving average [ARIMA(p,0,q)]

Random Walk process as mentioned above can be expressed as indicated in equation 14 below:

$SLL_t = SLL_{t-1} + \varepsilon_t$ …………………….. 14

The first difference of the expression in equation 14 will now result in a stationary series as expressed here; $SLL_t - SLL_{t-1}$

3.5.Data and Application Usage

Data utilised ranged between 2001M01-2019M12 and this was sourced from the Bank of Sierra Leone data warehouse system, with a total of 227 data points. The automated coding system developed in EVIEWS application made it such that all data were seasonally adjusted in a bid to smoothen their pattern (See Appendix 1). Relevant diagnostic checks are also incorporated in the automated coding system to enable quick outcome of results, and more so with precision in the iteration process compared to manual iteration.

4. The Box Jenkins ARIMA Process, Analysis and Evaluation

In this section, the process of model analysis and evaluation can be determined by applying the Box-Jenkins ARIMA methodology. This is outlined in Appendix 1, with relevant codes to illustrate each stage of the process – the model selection process commenced by differencing the series in a bid to achieve stationarity. The model selection as specified in the codes have been given maximum AR and MA properties of 11, and then seasonally adjusted to smoothen the series. Identification of the ARMA is done by assigning optimal AR and MA orders, which is based on the AIC, SIC and Hannan-Quinn criterion. This will also help to generate set of residuals, while also performing automated diagnostic tests to ascertain conformity with the characteristics of a white noise property (Nyoni, 2019). The process can be repeated, which addresses the order of integration until the best models are sourced out for use in forecasting out-of-sample exchange rate (See Appendix 1).

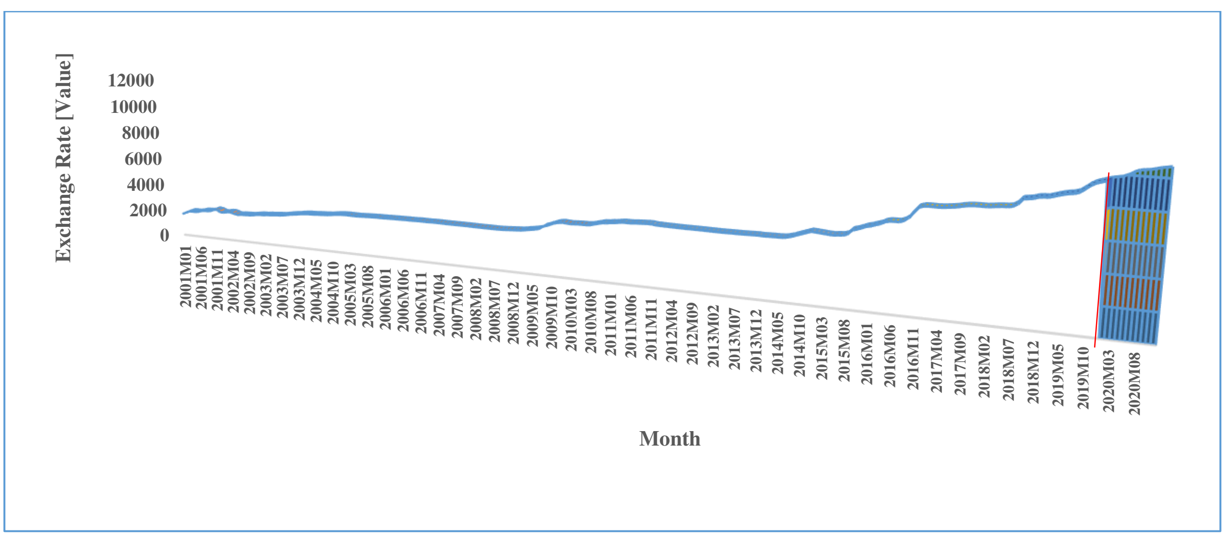
The automated system for this study produced 426, with 227 observed data, which is more than sufficient to run the model. In order to minimise repetition of all the model iterations, the best two model properties are illustrated in Appendix 2 and 3 ([1,4,7] and [1,9,9] respectively) to enable effective evaluation of the best model, which can be used to forecast out-of-sample values for exchange rate in the identified period of 2020M01 to 2020M12.

Table 3: Summary of Two Best Model Selected out of 426 Iterations						
Component	**Best Model**	**R-square**	**AIC**	**Durbin Watson**	**Root [AR and MA]**	**Prob (F-Stat)**
Exchange Rate	(1,4,7)	52.7%	-6.39	1.94	AR <1 MA<1	0.00
	(1,9,9)	51.9%	-6.25	1.96	AR<1 MA=1	0.00
	Source: *EVIEWS Output*					

Out of the 426 iterated models, the two models specified in Table 3 above were judged to be the best for forecasting exchange rate. Amongst the two as shown above in Table 3, Model [1,4,7] is the preferred choice given its R^2 value, which is slightly higher than that of model [1,9,9]. Equally, values relating to AIC, Durbin Watson and both the AR and MA roots, which addresses stability condition for forecasting are also comparatively smaller.

As shown in Table 2, the automated model [1,4,7] was selected to generate out-of-sample forecast for Exchange rate, and it shows that exchange rate dynamics will continue to move above Le10,000 (Ten thousand Leone mark, which is approximately equivalent to $1) as shown in Figure 2 below in the shaded portion – this is an indication that the SLL will continue to depreciate against the US$ throughout most part of the year 2020 (Reference to Figure 2 and Appendix 3). The model being univariate in nature only took into consideration past events of the series, which commenced from 2001M01 to 2019M12.

Figure 2: Exchange Rate Actual and Forecast



Source: *EVIEWS generated Out-of-Sample Forecast*

If the condition of ceteris paribus is to be held constant, that is, with no policy intervention, then SLL / US$ exchange rate will certainly become a concern in the domestic economy. This will have wide scale implications, for example, goods in the domestic economy will become expensive to purchase using the SSL currency in comparison to the same item sold in the USA. In this regard, purchasing power will reduce on account of continued devaluation to the SSL currency against the US$. Given the fact that the country is highly dependent on imports to support domestic consumption, this will likely result into serious problems in areas relating to some of the undermentioned points:

- Prices of basic goods and services will continue rise due to the inertia of expectations manifested by citizens in relation to issues concerned with exchange rate problems.
- There is also a chance for unscrupulous individuals, particularly parallel market street traders to continue their habit of hoarding the dollar currency, which eventually will make it difficult for the central bank to meet requests submitted by importers in settlement of import bills.
- There is also a chance that citizens, particularly those in employment would channel request for collective bargaining agreements with employers in a bid to negotiate wage / salary increase, given the fact that inflation would have undermine the value of consumers' purchasing power, and in particular their sustained means of livelihoods (Jackson, forthcoming1; Jackson, forthcoming).
- Equally, there is a chance for money supply to increase due to possible devaluation of the SLL currency, with citizens also being inclined to hoard money due to expectations of occurrences pertaining to price increase with domestically consumed items.

5. Conclusion and Policy Recommendation(s)

Exchange rate dynamics is quite a topical concern for the global economy, particularly those in the global south that seem to be struggling with limited scope of improving their productive capacity in addressing citizens' basic needs. Equally as in the case with inflation forecasting, exchange rate forecasting is also a growing interest to policy makers and particularly for those in the business community. Given the volatility of events in the global economy, it is always such that exchange rates can be intrinsically noisy, non-stationary and produces level of confusion for those who are policy makers (Nyoni, 2019a, 2019b and Box and Jenkins, 1994).

Out-of-sample forecast from this study shows that exchange rate is set to rise in the year 2020 (reference to Figure 2 and Appendix 3) on the back drop of expectation inertia, attributable to the country's unproductive real sector in addressing consumption needs of essential food and non-food items. Outcome from this study is critical for policy makers, whose decisions are considered very important in addressing exchange rate concerns in the domestic economy. In reality, the situation in Sierra Leone is worrying, given the high level of unproductive capacity in the real sector and also, the inertia of expectations from economic agents in the country, which is generally connected with price increase and continued devaluation of the SSL currency against the dollar in this case. Regardless of authorities' decisions (in the case, the Central Bank and Ministry of Finance) to affirmatively address issues, people's mindsets have been attuned to thinking in a negative way that makes it harder for the situation to normalize in the country.

The way forward in this difficult condition is for both the monetary and fiscal authorities to work collaboratively in addressing issues of practical concern. In this situation, investments can be selectively diverted in the short-run to address basic commodity needs in the country – this could involve '*hand-picking*' of trustworthy importers earmarked to receive foreign exchange from the central bank in support of its core mandate in stabilising prices, while also monitoring dynamics in the exchange rate market.

The prevalence of corruption that has gone unchecked for decades in the country is also making it very difficult for institutions like the central bank to meet its core objective of stabilising prices (see Jackson, 2018a; Jackson, 2017). Medium to long term strategies should be directed at addressing ways by which the country's real sector can be strengthened through diversion of investments in core areas connected with food and other essential non-food production, which seem to be the most influential in the country's Consumer Price Index [CPI] basket (see recent studies produced by Jackson, Tamuke and Jabbie, 2019).

In view of the empirical output and analysis of the study done so far, it seem more reasonable for authorities to develop affirmative measures in a bid to address issues around exchange rate dynamics, which is crippling the fabrics of developmental and growth prospects in the country. Continued depreciation of the SLL against the US$ is a deterrent to economic prosperity, particularly when the real sector is not productively capable to support domestic activities and also, the lack of prudence on the part of citizens in supporting sustained developmental agendas (Jackson and Jabbie, 2019; Jackson, 2016).

In recommendation of the way forward on things, particularly in the short term, measures should be set in place to monitor revenue generating sources, particularly earnings from overseas trade (e.g., proceeds or royalties from mining companies, etc.). In addition, there should be transparent means of ensuring that those in receipt of foreign currencies to settle payments for goods imported in the country are monitored to avoid abuse of potential reserves that can be utilised by the central bank for judicious purposes, and also in ensuring minimum international requirements relating to three months of import cover is regularly maintained.

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APPENDICES

Appendix 1: 'EVIEWS ARMA selection of optimal lag lengths'

```
smpl @all 'Set sample period
scalar n1=@obs(nexr) 'Number of observations of NEXR data
scalar components = 1 'Number of NEXR components, including aggregate index
scalar maxar = 11
scalar maxma = 11

'Rename series
series nexr_1 = nexr

'Seasonally adjust data
for !i = 1 to components
nexr_!i.x12(mode=m) nexr_!i
next

'For each component produce ARMA(a,m) with varying orders
for !i = 1 to components
   for !a = 1 to maxar '12
      for !m = 1 to maxma '12

      smpl 2001m1 2001m1+n1-1
      equation arma_!i_!a_!m.ls d(nexr_!i_sa) c ar(1 to !a) ma(1 to !m)

      next
   next
next

'Identify the ARMA for each component with the optimal AR and MA orders according to the Akaike Information Criterion.  Change to @schwarz or @hq for Schwarz and Hannan-Quinn criteria.
for !i = 1 to components
!mininfocrit = 9999
   for !a = 1 to  maxar '12
      for !m = 1 to maxma '12

      if arma_!i_!a_!m.@aic<!mininfocrit then
      !besta = !a
      !bestm = !m
      !mininfocrit = arma_!i_!a_!m.@aic
      endif
      next
   next

'Save the equation with the best order structure
```

```
smpl 2001m1 2007m1+n1-1
equation arma_best_!i.ls d(nexr_!i) c ar(1 to !besta) ma(1 to !bestm)

smpl 2001m1+n1 2020
arma_best_!i.forecast nexr_forecast_!i
next

'Show best ARMA models for selected components
for !i = 1 to 1
show arma_best_!i
next

show exp(nexr_forecast_1)/exp(nexr_forecast_1(-12))*100-100
'*
```

Source: *EVIEWS Output*

Appendix 2: Best Model

Dependent Variable: D(NEXR_1_SA) – [1,4,7]
Method: ARMA Maximum Likelihood (BFGS)
Date: 12/27/19 Time: 23:37
Sample: 2001M02 2019M12
Included observations: 227
Convergence achieved after 320 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008223	0.002687	3.060118	0.0025
AR(1)	2.130098	0.209186	10.18282	0.0000
AR(2)	-2.045876	0.435270	-4.700246	0.0000
AR(3)	0.351086	0.580099	0.605217	0.5457
AR(4)	1.187092	0.608753	1.950037	0.0525
AR(5)	-1.139257	0.524579	-2.171755	0.0310
AR(6)	-0.442927	0.457537	-0.968068	0.3341
AR(7)	1.698625	0.426458	3.983103	0.0001
AR(8)	-1.510659	0.317392	-4.759602	0.0000
AR(9)	0.517494	0.139128	3.719545	0.0003
MA(1)	-1.570731	47.38617	-0.033147	0.9736
MA(2)	0.927326	56.39745	0.016443	0.9869
MA(3)	0.784794	74.75416	0.010498	0.9916
MA(4)	-1.234469	154.8589	-0.007972	0.9936
MA(5)	0.509392	78.66760	0.006475	0.9948
MA(6)	0.867417	164.2629	0.005281	0.9958
MA(7)	-0.980542	216.3296	-0.004533	0.9964
MA(8)	0.520619	130.5464	0.003988	0.9968
MA(9)	0.032411	9.146762	0.003543	0.9972
SIGMASQ	7.90E-05	0.000239	0.330926	0.7410

R-squared	0.527244	Mean dependent var	0.007770
Adjusted R-squared	0.483851	S.D. dependent var	0.012956
S.E. of regression	0.009308	Akaike info criterion	-6.395626
Sum squared resid	0.017935	Schwarz criterion	-6.093869
Log likelihood	745.9036	Hannan-Quinn criter.	-6.273863
F-statistic	12.15042	Durbin-Watson stat	1.945309
Prob(F-statistic)	0.000000		

Inverted AR Roots	.82-.45i	.82+.45i	.75	.59+.74i
	.59-.74i	.15+.97i	.15-.97i	-.87-.39i
	-.87+.39i			
Inverted MA Roots	.87-.50i	.87+.50i	.59-.66i	.59+.66i
	.22-.89i	.22+.89i	-.06	-.87-.35i
	-.87+.35i			

Source: *EVIEWS Output*

Appendix 3: *Alternative Best Model Selected*

Dependent Variable: D(NEXR_1)
Method: ARMA Maximum Likelihood (BFGS)
Date: 12/27/19 Time: 23:37
Sample: 2001M02 2019M12
Included observations: 227
Convergence achieved after 426 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007970	0.002302	3.462829	0.0006
AR(1)	1.684868	0.063894	26.36983	0.0000
AR(2)	-2.177746	0.081889	-26.59390	0.0000
AR(3)	1.580565	0.083919	18.83440	0.0000
AR(4)	-0.807957	0.064109	-12.60278	0.0000
MA(1)	-1.002605	4.439207	-0.225852	0.8215
MA(2)	1.207362	2.537261	0.475853	0.6347
MA(3)	-0.221457	0.539772	-0.410279	0.6820
MA(4)	0.151773	1.730492	0.087705	0.9302
MA(5)	0.446037	2.341793	0.190468	0.8491
MA(6)	0.027203	1.932681	0.014075	0.9888
MA(7)	0.280735	3.922650	0.071568	0.9430
SIGMASQ	9.76E-05	0.000983	0.099234	0.9210

R-squared	0.518713	Mean dependent var	0.007797
Adjusted R-squared	0.491725	S.D. dependent var	0.014269
S.E. of regression	0.010173	Akaike info criterion	-6.248394
Sum squared resid	0.022146	Schwarz criterion	-6.052252
Log likelihood	722.1927	Hannan-Quinn criter.	-6.169248
F-statistic	19.22011	Durbin-Watson stat	1.964563
Prob(F-statistic)	0.000000		

Inverted AR Roots	.71-.58i	.71+.58i	.13+.97i	.13-.97i
Inverted MA Roots	.78-.63i	.78+.63i	.25-.90i	.25+.90i
	-.18+.66i	-.18-.66i	-.69	

Source: *EVIEWS Output*

Appendix 3: Actual Forecast of SLL/US$ Exchange Rate in 2020

Month	**Out-of-Sample Forecast [SSL]**
2020M01	9804.666
2020M02	9860.084
2020M03	9917.775
2020M04	10044.49
2020M05	10222.86
2020M06	10355.31
2020M07	10402.77
2020M08	10433.78
2020M09	10506.23
2020M10	10587.92
2020M11	10638.13
2020M12	10695.46
Source: *EVIEWS Empirical Output*	