THE DYNAMICS OF EXCHANGE RATES, INFLATION, AND TRADE BALANCE IN A SMALL OPEN ECONOMY (CASE STUDY OF SIERRA LEONE)

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Abstract

Sierra Leone experiences a persistent trade deficit problem. Currently, there is a vacuum in the literature employing recent data and suitable approaches to address the issue of non-stationarity and dynamic interaction between macroeconomic variables in influencing the trade deficit in Sierra Leone. This study examines the relationship between Sierra Leone's trade balance, inflation, and exchange rate using quarterly data from 2005 Q1 to 2023 Q3. The focus is on understanding how the exchange rate and inflation impact Sierra Leone's trade balance in both the short and long term. To achieve this, the study utilizes the VAR/VECM model to depict the dynamic interaction between the trade balance, exchange rate, and inflation. It also employs Granger Causality analysis to determine the most appropriate ordering among the macroeconomic variables in the model and Impulse Response Function (IRF) analysis to test the hypotheses regarding the trade balance response to exchange rate shocks and inflation. The empirical results confirm the existence of cointegration, indicating a long-term balance between the trade balance, exchange rate, inflation, and other macroeconomic variables such as GDP growth and interest rate differentials. Moreover, the dynamic prediction analysis using the IRF method supports the J-curve hypothesis in Sierra Leone and suggests that inflation can reduce the performance of the trade balance. These findings highlight the need for Sierra Leone to implement a comprehensive strategy to adjust the exchange rate and curb inflation to improve the trade balance and enhance external economic stability.

Keywords: Trade Balance, Inflation, Real Effective Exchange Rate, VAR/VECM, Sierra Leone

1. INTRODUCTION

Sierra Leone's economic performance has been characterized by persistent trade deficits, limited export diversification, and vulnerability to external shocks, leading to periods of high inflation rates and economic instability. It is important to examine Sierra Leone's trade deficit and the factors determining it, even though it is not always bad for economic growth because a trade deficit can be a sign of strong domestic consumption and investment. If consumers and businesses are confident and willing to spend money, they may purchase more goods and services, including imported ones, which can drive economic growth.

A heavy dependence on imports while facing a trade deficit can be a source of external instability. Higher costs of imported goods due to weakening local currency can contribute to overall inflationary pressures. Severe and continuous imbalances between a country's exports and imports can lead to further issues. A country may become severely indebted if

the persistent trade imbalance causes it to borrow money or deplete its reserves to finance the imports. Accumulating external debt may result in increased debt-servicing costs, restricting government funding for other vital industries including infrastructure, healthcare, and education. The country's currency may experience negative pressure from a persistent trade deficit while the purchasing power of firms and individuals may also be impacted.

As a small open economy, Sierra Leone faces a great challenge to improve its trade balance and have a more conducive inflation and exchange rate. Unsuitable internal policies and outside influences made Sierra Leone perform poorly in the 1980s, but some forms of reforms adopted after the end of the civil war in 2001 helped the country to make improvements. Sierra Leone's economy performed better in terms of output and inflation rate between 2005 and 2023 than it did in the 1980s and 1990s. Despite the Ebola outbreak in 2014-2015 that resulted in a notable drop in GDP growth in 2014 and a contraction of 20.5% in 2015 (Stats SL, www.sttatistics.sl) and the COVID-19 pandemic in 2020 that significantly hit the country, the investment-to-GDP ratio grew from 8.55% in 1986–1990 to 9.86% in 2005–2023 thanks to the current period of structural adjustment and stable political climate.

The Ebola outbreak and COVID-19 pandemic severely affected the performance of the agriculture and services sectors of Sierra Leone. The Ebola outbreak hit the tourism industry with visitor arrival falling from 81,250 in 2013 to 25,104 in 2015. Tourism was again hit during the COVID-19 pandemic episode. All these also contribute to worsening the balance of payment. More recently the external shock in terms of increasing following the conflict between Russia and Ukraine put the country under inflationary pressures that have impeded the nation's economic recovery process brought by the economic stabilization efforts before these shocks. However, the shock also revealed the nation's reliance on extractive industries and mishandling of natural resource rents which can compromise the sustainability of the recovery efforts.

After the COVID-19 pandemic ended, Sierra Leone's GDP increased by 4.1% in 2021 but dropped to 3.5% in 2022 and was forecasted to grow by only 2.7% in 2023 amid various factors including depreciating currency rates, rising food, and energy costs, falling foreign donor support, increased geopolitical tensions, and weakening global demand. Inflation has been escalating from 12% in 2021 to 44.81% by June 2023, which is predicted to continue increasing until December 2023.

The paper explores the dynamic relationship between currency rates, inflation, and trade balance in Sierra Leone's small open economy. The country's economic environment is characterized by persistent trade deficits, limited export diversification, and vulnerability to external shocks, leading to high inflation rates and financial instability. Theories like the Traditional Mundell-Fleming Model assume perfect capital mobility and inflation rises as the money supply expands. Higher inflation reduces real money balances, leading to currency depreciation, making imports more expensive and exports more competitive (Farlian et al., 2019).

Since small-scale open economies are linked to inflation, trade balance, and exchange rates. Changes in exchange rates have an impact on a nation's ability to compete internationally, increasing export competitiveness and improving trade balance. Through its impact on the real exchange rate, inflation can also have an impact on the trade balance (Yiheyis & Musila, 2018), affecting import and export costs. The trade balance could

temporarily get worse due to the volume effect, while long-term changes to agreements and conduct may result in more complex partnerships. Inflation directly and indirectly impacts trade balance and exchange rate, and a fixed exchange rate system may make it less flexible in response to these changes.

Sierra Leone's trade deficit started because of the 1970s devaluation of its currency and may have contributed to high inflation and slow production growth. This deficit could increase the cost of imports, impacting the economy's overall pricing levels. A trade deficit also implies a higher reliance on imported goods and services, potentially leading to imported inflation. Structural problems with the trade balance, such as trade barriers, lack of competitiveness, or inadequate export diversification, can also contribute to the trade deficit.

A persistent trade imbalance can lead to a country becoming externally indebted, resulting in increased debt-servicing costs and restricted government funding for essential industries. The currency may also experience negative pressure, impacting the purchasing power of firms and individuals. Exchange rates and trade balance are closely related, with fluctuations in exchange rates affecting relative import and export costs. Overseas purchasers find exports more economical, but domestic consumers find imports more expensive. Enhancing a nation's pricing competitiveness in global markets can also impact the trade balance.

Sierra Leone is facing trade deficits, causing currency depreciation, and affecting its trade balance. To address this, the country has implemented exchange rate policies like Fixed and Flexible. Governments can use these policies to stabilize or affect currency markets, while tariffs and trade agreements can also influence exchange rates. A persistent trade deficit increases reliance on imported goods and services, making a nation more vulnerable to fluctuations in import prices. Trade imbalances can also impact aggregate demand, with higher domestic consumption and import demand.

Exchange rates and inflation are interconnected, with fluctuations in one affecting the other. Exchange rates can make foreign raw materials and intermediate goods more expensive, leading to higher production costs for companies relying on imported materials. Currency depreciation can also affect exporters' pricing behavior, leading to higher prices for goods sold abroad. This can lead to demand-pull inflation as consumers and businesses anticipate rising costs.

The study aims to examine the dynamic relationship that exists in Sierra Leone, a small open economy that is experiencing growing inflation, depreciating currency, and a persistent trade imbalance. Previous literature suggests that higher inflation can negatively impact both the exchange rate and trade balance (Krouso et al., 2019). By examining the causal links between these variables in Sierra Leone, the research gap seeks to close the empirical evidence on the dynamics of inflation, exchange rates, and trade balances. The study utilizes the Vector Error Correction Model (VECM) to examine the short-term dynamics and long-term cointegration of trade balance, inflation, and exchange rates in Sierra Leone from 2005 Q1 to 2023 Q3. The objectives include determining the dynamics interactions among the trade balance, inflation, and exchange rates in Sierra Leone, investigating how exchange rates and inflation affect the trade balance in the short and long term, and exploring the relationships between these macroeconomic variables.

By employing the Johansen test approach to cointegration and addressing autocorrelation in estimation models, the study attempts to shed light on Sierra Leone's

economic dynamics and offer fixes to increase modeling accuracy. The primary hypothesis is that a dynamic relationship exists between inflation, trade balance, and exchange rates, with the J-curve theory predicting real devaluation of the exchange rate initially decreasing the trade balance before turning positive. The main goals of the study are to determine the correlations between these macroeconomic indicators and the effects of inflation and exchange rate swings on Sierra Leone's trade balance.

The study's scope covers data from 2005 Q1 to 2023 Q3, sourced from various institutions like the World Bank, IMF, Statistics Sierra Leone, Central Bank Bulletin, and the Ministry of Finance. The methodology involves using the VECM model to analyze the link between inflation, currency rates, and trade balance, with a focus on the shock these variables inflict on the trade balance. The research aims to contribute to the understanding of economic dynamics in small open economies like Sierra Leone and provide valuable insights for similar analyses in other emerging countries. The remaining sections of the study are arranged as follows: section 2 reviews relevant literature; section 3 discusses methodology; section 4 estimates result and discusses; section 5 concludes and offers recommendations.

2. LITERATURE REVIEW

There has been much empirical research about how currency depreciation affects inflation and trade balance, but little is known about the causal relationships or group dynamics of these factors in developing countries generally, and Sierra Leone specifically. The following discussion centers on the empirical study sample that examines the relationships among trade balance, prices, and the currency rate.

Research on macroeconomic factors that impact trade balance, such as foreign and domestic income, primarily focuses on the J-curve effect and Marshall-Lerner condition. The data, however, is contradicting; the trade balance increases when currency rates depreciate (Keho, 2021). Macroeconomic factors that influence trade balance dynamics include foreign direct investment, remittances, inflation, money supply, exchange rates, and both domestic and foreign income. These factors have been found through empirical investigations. Nonetheless, there is conflicting data regarding their impact on trade balance. For example, Lal & Lowinger (2002) found that foreign and local earnings, as well as real exchange rates, were significant influences.

Research shows that real devaluation in Nigeria initially leads to positive trade balances, but worsens in The Gambia and Ghana (Shuaibu & Isah, 2020) while (Keho, 2021; Shawa, 2013) trade liberalization, foreign income, foreign direct investment, human capital, and natural resources are beneficial in Tanzania. Igue & Ogunleye (2014) however, Nigeria's foreign and domestic incomes are negatively correlated. Real exchange rate declines and foreign direct investment help Kenya's trade balance (Kennedy, 2013).

Inflation and economic development in the West African Monetary Zone (WAMZ) countries in 2012 were heavily impacted by currency rates (Tarawalie, A. B., Sissoho, M., Conte, M., and Ahortor, 2012). Changes in consumer prices in Ghana, Nigeria, Sierra Leone, and The Gambia are on average, 26% due to the pass-through effect, according to Ndiaye (2021). With a small long-term impact but a large short-term impact, (Frimpong & Adam,

2012) this effect in Ghana. According to Ndiaye (2021), quarterly price hikes occurred in The Gambia, Nigeria, and Sierra Leone for every 1% devaluation of their national currencies.

Meniago & Eita (2017) study 39 Sub-Saharan African nations, the nominal rate of currency and trade balance were not found to be significantly correlated, most likely because of low-quality goods and undiversified export bases. Foreign income and domestic income were inversely correlated with the trade balance. Research on the WAEMU countries (Ousseini et al., 2017) demonstrated that although income, inflation, trade balance, and real exchange rate all had beneficial benefits, household consumption spending and the money supply did not.

Using annual data from 1980 to 2011, Bangura et al (2013) analysis demonstrates that the key variables influencing Sierra Leone's long-term trade balance performance are money availability and domestic revenue. This research also showed that real money supply and exchange rates in Sierra Leone may not keep pace with Marshall-Lerner requirements.

A 1% rise in Sierra Leone's money supply raises inflation by 1.3% over time, according to research Krouso et al (2019), and money growth and inflation expectations are two significant inflationary variables. Kalonji et al (2008) investigated domestic inflation using a structural VAR and discovered that it was connected to increased oil prices, a shrinking money supply, as well as a decrease in the indicated currency rate. Using a structural vector autoregressive approach in Nigeria, Chuku (2009) investigated Sierra Leone's exchange rate pass-through to inflation and found that monetary shocks have a more pronounced and short-lived impact on prices.

The impact of global commodity prices on the dynamics of inflation in Sierra Leone has been the subject of numerous studies. The ARDL model was developed by Swaray & Kabba (2023) discovering that real GDP, money growth, and exchange rate depreciation all influence inflation. In the near term, cocoa lowers the persistence of inflation, but its long-term effects are substantial. Yiheyis & Musila (2018) examine the effects of currency rate variations and inflation, both in the near and distant future, on Uganda's trade balance between Q3 of 1993 and Q4 of 2014. They used the limits testing method to co-integrate the quarterly data. Real devaluation, on the other hand, eventually results in higher inflation, and neither inflation nor real depreciation is predicted to significantly impact the balance of trade. It has also been discovered that changes in the international sector might affect inflation. When both short- and long-run multipliers are combined, the S-curve impact is not supported, but they occasionally seem to support the J-curve influence.

Tarawalie & Kpana (2022) apply yearly time series information from 1980 and 2020 to evaluate distributed autoregressive lag (ARDL) bound methodology and how Sierra Leone's trade balance is affected by the currency rate system. Results supporting co-integration include the bound test, unit root test, and a long-term relationship integrating the I(0) and I(1) series. Long-term study indicates that the three main variables that determine Sierra Leone's trade balance consist of the quantity of money in use, the actual effective exchange rate, and the actual GDP.

The real rate of exchange, the currency supply, and the actual GDP are the three parameters that have the least long-term consequences on trade volume, based on beta coefficients' findings. Thus, the short-term Auto-Regressive Distributed Lag error correction model's findings also suggest that foreign investment, public spending, and actual GDP are the main factors influencing Sierra Leone's trade balance.

When trying to clarify how fluctuations in exchange rates and inflation over time affect and impact the trade balance, scientific investigation has yielded conflicting and unclear findings. The trade balance and currency rate were found to be positively correlated Tarawalie & Kpana (2022) other researchers; they were found to be negatively correlated (Iqbal et al., 2019). A few studies found no connection between currency rates and the total trade balance (Alhanom, 2016). Although only a few studies Yassin et al (2016) demonstrated a negative relationship between these two variables, some studies Nwagu et al (2022) discovered a strong link between the balance of trade and money supply.

Some trade balance factors are highly correlated with actual exchange rates, whereas others are not, as the review demonstrates. The structural distinctions between developed and developing nations could account for this variation. Compared to developing nations that rely on manufactured goods, many of them rely on a small number of fundamental commodities, which causes persistent trade imbalances. This is consistent with the Prebisch-Singer Hypothesis. Though their trading patterns differ, Sub-Saharan African nations export primary goods. Some have varying prices, such as crude oil and uranium, while others export cotton, cocoa, and coffee. Furthermore, exchange rates fluctuate significantly since some nations have fixed exchange rates and others have floating regimes.

There seems no definitive proof regarding this type and magnitude of the correlations among the important factors based on the contradictory and inconclusive data. This study's goal is to advance the empirical discussion on (i.e., the trade balance effects of the temporal interplay between changes in inflation and exchange rates) involves analyzing the shifting trends in actual exchange rates, the inflation, and the balance of trade of Sierra Leone, an open-ended economy characterized by a lingering trade deficit, severe exchange rate fluctuations, and disinflation. This inquiry makes use of the VECM framework.

Recognizing the foreseeable connections between trade balance, currency value, and inflation is crucial for developing and implementing policies in developing countries. In trying to understand the relationship we develop econometric models that explicitly incorporate the relationships between inflation, currency value, and trade balance. Structural models, such as simultaneous equations models, can be employed. Thus, econometric models allow for a comprehensive analysis of the relationships, considering both immediate and lasting consequences. This enables policymakers to simulate the impact of different policy measures.

Lastly, we utilize the cointegration technique to investigate the enduring relationships among trade balance, currency value, and inflation. Since time series analysis allows for the identification of historical trends and the examination of how changes in one variable impact others over time. It provides insights into the dynamics of the relationships.

3. RESEARCH METHODS

3.1. Data source

This study examines the long-term association between the estimated variables using secondary data. There are data gaps in Sierra Leone, hence the World Bank database on global development indicators, Statistics Sierra Leone, and the Central Bank of Sierra Leone served as the main sources of data for this study. This study's empirical research was created using a multiple regression analysis. We have utilized the information on the trade balance

(TB), Inflation (INF), Real Effective Exchange Rate ($REER$), Real Gross Domestic Product ($RGDP$), and Interest Rate Differential (IRD) for the period of 2005 q1 to 2023 q3.

3.2. Methodology and Model Specification

Examining the link between inflation and the currency rate, how it affects Sierra Leone's trade balance, and the shock these variables inflict on the balance of trade is the primary focus of this research. Based on economic theory, a multitude of factors significantly influence the balance of trade, imports, and exports. Based on the critical assessment from our literature review analysis we end up using the VECM model, which is a linear model that is quite simple to use in both theory and practice. The VAR models are simple to apply in economic analysis as well as forecasting.

Since the VAR models focus on short- to medium-term dynamics and do not account for long-run equilibrium relationships explicitly. The VECM models extend VAR models by incorporating cointegration among variables, capturing both the dynamics of the immediate and the relations of long-term equilibrium. The inclusion of error correction elements in the VECM models enables the adjustment towards equilibrium following a shock, which is not present in VAR models. Also, VECM models are suitable when the variables in the system are found to be cointegrated, while VAR models can be applied more generally.

The study of economic variables has evolved significantly due to the discovery of stochastic trends and cointegration analysis by Johansen, Granger, and Engle. It is beneficial to remove short-term dynamics from long-term interactions when constructing variables. Vector error correction (VECMs) helps differentiate between immediate and distant future components of data. A stochastic process with discrete random walk features is considered a nonstationary stochastic component. All variables are assumed to be either I(0) or I(1) in the Johansen (1995) formal framework. A fundamental relationship is described below:

$$TB_t = \beta_0 + \beta_1 logREER_t + \beta_2 logINF_t + \beta_3 logRGDP_t + \beta_4 logIRD_t + \mu_t (1)$$

Where:

TB	= Trade Balance
INF	= Rate of Inflation
REER	= Real Effective Exchange Rate
RGDP	= Real Gross Domestic Product
IRD	= Interest Rate Differential

And it is presumed that the error term μ_t holds an independent, equal distribution with a zero mean and constant variance i.e. μ_t~iid(0,σ), the time dimension is denoted by the subscript t, β_0is the intercept and β_i (i = 1, 2,.., 4) are the parameters to be calculated?

The coefficients of every parameter are read as elasticities, and they are all given in the natural log except the trade balance. Since natural log transformation is often applied to variables that have a skewed distribution or exhibit exponential growth which can help linearize the correlation between the variable and the result, enhance the understanding of coefficients, or satisfy the regression model's presumptions. However, when it comes to the

trade balance, it is more common to use these variables in their original form without taking the natural log. The trade balance is typically measured as a monetary value.

4. RESULTS AND DISCUSSION

4.1. Research Results

The research process involves collecting and organizing time series data for variables such as trade balance, real effective exchange rate, inflation, real gross domestic product, and interest rate differential. Statistical tests (ADF) are used to check stationarity and determine if variables are non-stationary. If cointegration is detected, the VECM model is estimated, capturing the adjustment process toward long-term equilibrium. The Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) are two examples of information metrics used to determine the lag length of the VAR model.

The model is calculated using methods like Ordinary Least Squares (OLS) by fitting equations relating to the variables' lagged values. Diagnostic and goodness of fit tests are performed on the VECM model, checking for autocorrelation, heteroscedasticity, and normality of residuals. The findings are analyzed using economic theory and conclude dynamic relationships among the variables. Three regressions with distinct dependent variables and similar explanatory factors are generated, with each equation's ordinary least squares (OLS) estimator calculated separately.

The VAR model can be created by integrating the I(1) and stationary variables after the initial difference; otherwise, we build both the short-run VAR and log-run VEC models. It is assumed that a time series $y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + \mu_t$ and given a sample size of $T, y_1, \ldots, y_T$ pre-sample values $y_{-p+1}, \ldots, y_0$ is assumed to be available. We can derive our VAR model use for this study down below:

$$TB_t = \alpha + \sum_{i=1}^{k} \beta_i TB_{t-i} + \sum_{i=1}^{k} \phi_i logREER_{t-i} + \sum_{i=1}^{k} \varphi_i logINF_{t-i} + \sum_{i=1}^{k} \psi_i logRGDP_{t-i} + \sum_{i=1}^{k} \varpi_i logIRD_{t-i} + \mu_{1t} \quad \ldots\ldots (2)$$

$$\log REER_t = \vartheta + \sum_{i=1}^{k} \beta_i TB_{t-i} + \sum_{i=1}^{k} \phi_i logREER_{t-i} + \sum_{i=1}^{k} \varphi_i logINF_{t-i} + \sum_{i=1}^{k} \psi_i logRGDP_{t-i} + \sum_{i=1}^{k} \varpi_i logIRD_{t-i} + \mu_{2t} \quad \ldots\ldots (3)$$

$$logINF_t = \theta_0 + \sum_{i=1}^{k} \beta_i TB_{t-i} + \sum_{i=1}^{k} \phi_i logREER_{t-i} + \sum_{i=1}^{k} \varphi_i logINF_{t-i} + \sum_{i=1}^{k} \psi_i logRGDP_{t-i} + \sum_{i=1}^{k} \varpi_i logIRD_{t-i} + \mu_{3t} \quad \ldots\ldots (4)$$

$$LogRGDP_t = \delta + \sum_{i=1}^{k} \beta_i TB_{t-i} + \sum_{i=1}^{k} \phi_i logREER_{t-i} + \sum_{i=1}^{k} \varphi_i logINF_{t-i} + \sum_{i=1}^{k} \psi_i logRGDP_{t-i} + \sum_{i=1}^{k} \varpi_i logIRD_{t-i} + \mu_{4t} \quad \ldots\ldots (5)$$

$$LogIRD_t = \sigma \sum_{i=1}^{k} \beta_i TB_{t-i} + \sum_{i=1}^{k} \phi_i logREER_{t-i} + \sum_{i=1}^{k} \phi_i logINF_{t-i} + \sum_{i=1}^{k} \psi_i logRGDP_{t-i} + \sum_{i=1}^{k} \varpi_i logIRD_{t-i} + \mu_{5t} \quad \ldots\ldots (6)$$

The equations show that every model's dependent variable is a function of both the other variables and their lagged values, and therefore the VAR needs to be given in levels. The stochastic error terms denoted by $\mu's$ are frequently referred to as impulses, innovations, or shocks. The information criteria of the AIC, SC, and HQIC determine the maximum lag length (k), and the VAR model is calculated using OLS.

The research discloses short-run causal links between inflation, trade balance, and exchange rates in Sierra Leone. A shock that raises the real effective exchange rate will first deterioration in the trade balance because of price effects, but with time, as quantity effects set in, the trade balance improves, thus supporting the J-curve hypothesis. Permanent high inflation negatively influences the trade balance by affecting export competitiveness. It showed resilience in that after all kinds of shocks, it could stabilize very fast, including the deadly Ebola epidemic, through effective government interventions like proportional income tax rates and investment in public health.

Such findings have key policy implications. Policymakers have to be directed at stabilizing the exchange rate through foreign exchange market interventions and competitive exchange rate policies, among others. This would be supplemented by low and stable inflation through effective monetary policy, appropriately setting interest rates that help attract foreign investment but do not affect domestic economic activities. The study also notes the need to stimulate export growth and import substitution, as well as economic diversification in order to reduce the impact of these external shocks.

Some of the avenues that this study would therefore open for future research include: detailed sectoral analyses to see how different industries respond to macroeconomic shocks; extent of the time series with more recent data; Sierra Leone's experience in comparison with that of other Sub-Saharan African nations; and incorporation of more variables, including fiscal policy indicators, political stability, and external debt. Such further studies could provide a wider understanding of the determinant factors of the trade balance and overall economic performance in Sierra Leone and similar economies.

4.1.1. Empirical result

This section examines the variables' time series properties in addition to presenting and interpreting the results of the estimated regression. These consist of the Augmented Dickey-Fuller (ADF) and the Phillips Peron test unit root test, and the stationarity of the estimated variables at first difference tests. To ascertain if the endogenous and exogenous factors are related throughout the long run, use Johansen's Cointegration test; for a short-term relationship, use the Error Correction Mechanism test.

a. Unit Root Test

The study examines the long-term link between time series variables using recent econometric developments in time series analysis. To avoid inaccurate results, the data's time series qualities are ascertained through the utilization of Unit root Tests for ADF and PP. The ADF's null hypothesis test is against stable trends (Al-Gasaymeh et al., 2015). To

determine whether the variables are stationarity, the ADF and PP unit root tests are performed without dummies, as Table 1 below shows.

Table 1. The Unit Root Test of Stationarity

Variable	ADF		Phillips-Peron (PP)	
	T-Stats	Prob	T-Stats	Prob
Trade Balance				
Level (TB)	-4.2472	0.0603	-4.4269	0.0037
First Difference (ΔTB)	-8.7532	0.0000	-10.1140	0.0001
Real Exchange Rate				
Level (Log REER)	-0.5905	0.9765	0.1730	0.9974
First Difference (ΔLog REER)	-4.0934	0.0018	-4.0491	0.0021
Inflation				
Level (Log INF)	-1.8399	0.6750	-1.3879	0.8566
First Difference (ΔLog INF)	-6.2741	0.0000	-6.1351	0.0000
Real GDP				
Level (Log RGDP)	-2.7774	0.2104	-18.2075	0.0001
First Difference (ΔLog RGDP)	-17.9909	0.0001	-31.0292	0.0001
Interest Rates Differential				
Level (Log IRD)	-2.4296	0.3616	-2.0113	0.5854
First Difference (ΔLog IRD)	-3.7739	0.0048	-6.2836	0.0000

Source: Own Calculation, (processed using E-Views 12)

Based on data spanning 2005 Quarter 1 to 2023 Quarter 3, Table 1 displays the ADF unit root test results. The maximum latency of four is automatically computed by applying the Schwarz information criteria. First differences (FD) unit-root test regressions contain intercepts, whereas levels unit-root test regressions contain trend terms and intercepts as exogenous variables. Following the initial differencing, the result shows that every variable is stationary.

We also conducted the PP unit root test which incorporates both intercept and trend for levels and intercept for first difference and the Bandwidth is chosen automatically by the Bartlett-Kernel approach (Newey-West automated), except for trade balance and real gross domestic product, which exhibits stationary behavior at a level as well as at first difference, the findings show that every variable at the initial difference remains stationary. Consequently, for the series integrated at the same order's first difference, a co-integration test needs to be run.

b. Johansen Cointegration Test

A cointegration test would follow an empirical investigation to ascertain the variables' long-term relationship since at their initial difference they are combined in the same sequence I(1). This necessitates long-term stationary error terms. Using the cointegration approach developed by Johansen and Juselius (1990), this study ensures that the variables in the cointegration relationship are integrated in the same order.

With a lag interval of 1 to 2, for both Trace and Maximum Eigenvalue, Johansen's cointegration rank test was performed. The cointegrating series are TB, LogREER LogINF, LogRGDP, and LogIRD. The table below displays the outcomes:

Table 2. The Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Null Hypothesis	Eigenvalue	Max-Eigen Statistic	5% Critical Values	Prob**
None*	0.477606	46.75203	33.87687	0.0009
At Most 1	0.261103	21.78696	27.58434	0.2315
At Most 2	0.166059	13.07466	21.13162	0.4454
At Most 3	0.064057	4.766488	14.26460	0.7710
At Most 4	0.000136	0.009772	3.841465	0.9210

Source: Own Calculation, (processed using E-Views 12)

*Denotes rejection of the hypothesis at the 0.05 level and **MacKinnon-Haug-Michelis (1999) p-values

Table 2 shows the results of the maximum eigenvalue unconstrained cointegration rank test. The results of the following tables demonstrate that, at the 5% significant level, the null hypothesis for either no cointegrating relationship at all or at least no link between the variables was rejected, indicating that there might only be one cointegrating relationship.

4.1.2. Analysis of Regression Result

a. The VAR Model

Economic models often use factors to determine a dependent variable and serve as explanatory variables, which has been criticized for not distinguishing between endogenous and exogenous factors. Once this distinction is removed, all variables are considered endogenous. The VAR models, which include Equation 1, represent the variables used in this study. The variables are stationary following the initial difference and cointegrated, as demonstrated by the Johansen cointegration test result. We therefore estimate the VEC models.

Table 3. The Choice of Var Lag Order Selection

The Choice Criteria of Var Lag Order Selection						
LAG	**LOGL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-957.0737	NA	277865.6	26.72427	26.88237	26.78721
1	-643.3698	575.1238	91.58511	18.700427	19.65333*	19.08236
2	-606.5693	62.35635*	66.65945*	18.37693*	20.116050	19.06927*
3	-585.4932	32.78517	76.266910	18.48592	21.01555	19.49297
*Indicate lag order selection by criterion						

Source: Own Calculation, (processed using E-Views 12)

In other to carry out the VECM, we need to determine the lag length criteria to ascertain which lag to use, and Table 3 above depicts the appropriate lag order selection which is lag 2 and has been adopted by the VECM. The VECM estimation analysis results then follow.

b. The VECM Model

To specify the VECM model, one needs to ensure that the variables are stationary. In the previous chapter, we suggest that all variables of interest are I (1). Hence, in the

specification of VECM, we use the first difference of all variables. Denote a vector $y = \{TB, LogREER, LogINF, LogRGDP, LogIRD\}$ we can write our general VECM model as:

$$\Delta y_{t=\alpha\beta' y_{t-1}} + \sum_{i=1}^{p-1} \tau_i \Delta y_{t-i} + \varepsilon_t$$

Where $\Delta y_t = y_t - y_{t-1}$, y_{t-1}, is the vector of lagged endogenous ε_t is the vector of residuals, τ_i is a matrix with order k×k of the coefficient of the lagged endogenous variables, α is the vector of adjustment parameters and β' is the vector of parameters in the cointegration equations. In the error correction model, α is suggested to be negative with an absolute value between 0 and 1.

$$\Delta TB_t = \sigma + \sum_{i=1}^{k-1} \Delta TB_{t-i} + \sum_{j=1}^{k-1} \Delta LOGREER_{t-i} + \sum_{j=1}^{k-1} \Delta LOGINF_{t-i} + \sum_{j=1}^{k-1} \Delta LOGRGDP_{t-i} + \sum_{j=1}^{k-1} \Delta LOGIRD_{t-i} + \sum_{m=1}^{k-1} \xi_m \Delta ECT_{t-1} + \mu_t$$

Literature suggests several cases of cointegration, and one needs to ascertain which scenario is most suitable. We suggest that the Unrestricted constant case is the most suitable because this specification allows for a linear trend whereas the cointegrating connection is stationary at the initial levels of the variables around some constants mean. However, for an illustration, we provide below the resulting error correction equation for trade balance (TB) using three cointegration cases, namely the unrestricted, the restricted trend, and the restricted constant, and only one lag term.

With the unrestricted trend cointegration case, the error correction model for TB is the following:

$$\Delta TB_t = -0.14 ECT_{t-1} - 0.10 \Delta TB_{t-1} - 312661.1 \Delta LOGREER_{t-1} + 10221.4 \Delta LOGINF_{t-1} + 62673.2 \Delta LOGRGDP_{t-1} - 145915.7 \Delta LOGIRD_{t-1} + 3085.3$$

Meanwhile, the case for restricted trend takes the following form:

$$\Delta TB_t = -0.56 ECT_{t-1} + 0.04 \Delta TB_{t-1} - 180467.4 \Delta LOGREER_{t-1} - 4574.0 \Delta LOGINF_{t-1} + 24355.7 \Delta LOGRGDP_{t-1} - 550097.3 \Delta LOGIRD_{t-1}$$

Lastly, for restricted constant the result shows the following:

$$\Delta TB_t = -0.53 ECT_{t-1} - 0.01 \Delta TB_{t-1} - 18597.3 \Delta LOGREER_{t-1} + 39097.9 \Delta LOGINF_{t-1} + 71498.5 \Delta LOGRGDP_{t-1} - 366799.4 \Delta LOGIRD_{t-1}$$

Where the ECT terms in the three error correction models are derived from the cointegration equation by normalizing the coefficient of TB into one. The speed of adjustment coefficients in the three error correction models for TB are all negative (-0.14, -0.56, and -0.53), confirming our expectation that the short-run movement of TB is not only

influenced by the value of the other variables. It also maintains its long-run equilibrium with the other variables, indicating a tendency for TB to return to the equilibrium.

The preferred cointegration equation is shown in the upper panel of Table 4, which can be written as:

$$ECT_{t-1} = [1.000000TB_{t-1} + 49898.8LOGREER_{t-1} + 68203.5LOGINF_{t-1} - 462590.2LOGRGDP_{t-1} + 142348.0LOGIRD_{t-1} - 4530292.0]$$

Incorporating this ECT into the VAR model for TB results in the following error correction model:

$$\Delta TB_t = -0.5366ECT_{t-1} + 0.1165\Delta TB_{t-1} - 0.0187\Delta TB_{t-2} + 496603.8\Delta LOGREER_{t-1} - 0.1978\Delta LOGREER_{t-2} + 6294.4\Delta LOGINF_{t-1} - 0.39564\Delta LOGINF_{t-2} + 161848.9\Delta LOGRGDP_{t-1} + 0.71655\Delta LOGRGDP_{t-2} + 96730\Delta LOGIRD_{t-1} - 0.37373\Delta LOGIRD_{t-2} + 10550.3$$

This is the error correction equation for TB. The speed of adjustment parameter is -0.53 and it is statistically significant meaning that the deviation from the equilibrium in the prior quarter is corrected at a rate of 0.53%. It should be noted that no direct interpretation can be made on the coefficients of the other variables in the equation because the error correction model for TB is only one equation in the VECM system, so we need to rely on the innovation accounting to know the impact of one variable, e.g., exchange rate or inflation, on the trade balance.

Given that the coefficient of $LOGINF_{t-1}$ in the cointegration vector is positive (68203.5), the speed of adjustment in this equation is $-0.00000003 \times 68203.5 = -0.00205$ and it is statistically significant. This means that there is an error correction mechanism in the LogINF series toward the long-run equilibrium following a short-run disequilibrium, even though at a lower speed than that of the TB series.

Similarly, we can derive the error correction terms for LogREER $-0.00000006 \times 49898.8 = -0.003$, LogRGDP $0.000001 \times -462590.2 = -0.463$ and LogIRD $-0.00000004 \times 142348.0 = -0.006$. Only the RGDP and REER are statistically significant while IRD are statistically insignificant. We conclude that all variables in the system by themselves exhibit an error correction mechanism.

Table 4. The Vector Error Correction Model (VECM)

VECM						
Cointegrating EQ:	**Cointeq1**					
TB (-1)	1.000000					
Logreer (-1)	49898.80					
Loginf (-1)	68203.56					
Logrgdp (-1)	-462590.20					
Logird (-1)	142348.00					
C	-4530292.00					

Error Correction		D(Tb)	D(Logreer)	D(Loginf)	D(Logrgdp)	D(Logird)
Cointeq1	coefficient	-0.5366	-0.00000006	-0.00000003	0.000001	-0.00000004
	t-statistics	-4.3265	-0.5955	-0.1164	3.5285	-0.7955
D(Tb (-1))	coefficient	0.1165	0.0000001	-0.00000005	0.0000003	-0.00000006
	t-statistics	0.9990	1.5211	-0.2157	0.7777	-1.3220
D(Tb (-2))	coefficient	-0.0187	-0.00000005	-0.0000003	0.000000004	0.00000005
	t-statistics	-0.1619	-0.5480	-1.1725	0.0087	1.1993
D(Logreer (-1))	coefficient	496603.8	0.51204	0.18871	0.6805	-0.0514
	t-statistics	3.5520	4.0447	0.5954	1.1846	-0.8923
D(Logreer (-2))	coefficient	-19780.04	0.2272	0.03938	0.8241	0.0625
	t-statistics	-0.1265	1.6055	0.1111	1.2833	0.9718
D(Loginf (-1))	coefficient	6294.404	0.0554	0.3172	0.4769	-0.0365
	t-statistics	0.1208	1.1757	2.6879	2.2290	-1.7013
D(Loginf (-2))	coefficient	-39564.82	0.0611	-0.1771	-0.1567	-0.0520
	t-statistics	-3.6993	1.1936	-1.3811	-0.6741	-2.2337
D(Logrgdp (-1))	coefficient	161848.9	-0.0139	-0.0518	-0.1010	0.0186
	t-statistics	3.6647	-0.3498	-0.5178	-0.5568	1.0254
D(Logrgdp (-2))	coefficient	71655.31	-0.0151	-0.0439	-0.0733	0.0234
	t-statistics	2.3382	-0.5461	-0.6326	-0.5828	1.8600
D(Logird (-1))	coefficient	96730.02	0.3519	-0.3224	-2.1743	0.1380
	t-statistics	0.3434	1.3797	-0.5050	-1.8786	1.1895
D(Logird (-2))	coefficient	-373731.2	0.3871	-0.8476	0.5565	0.2882
	t-statistics	-1.3061	1.4943	-1.3068	0.4733	2.4443
C	coefficient	10550.39	0.0036	0.0085	-0.0074	-0.0022
	t-statistics	1.1774	0.4505	0.4189	-0.2033	-0.6131

Source: Own calculation (processed using EViews 12)

c. Diagnostic Test

Residual diagnostics are crucial in assessing the validity of statistical or econometric models. These tests evaluate discrepancies between the model's predictions and observed data, ensuring they adhere to key assumptions like linearity, independence, and homoscedasticity. Violations of these assumptions can compromise the reliability of statistical inferences. Diagnostic tests provide insights into potential issues, enabling researchers to address problems and improve the model.

Table 5. The VEC Residual Serial Correlation LM Test

Lag	Lre*Stat	Df	Prob	Rao F-Stat	Df	Prob
1	66.61938	25	0.0000	2.976281	(25, 191.0)	0.0000
2	32.39928	25	0.1468	1.325597	(25, 191.0)	0.1480
Note: Null hypothesis: No serial correlation at lag h						

Source: Own calculation (processed using E-Views 12)

The (p-value) for the LM test at lag 2 in Table 5 above indicates that there is not enough data to rule out the possibility of not being serially associated with the residuals. An analysis of the residuals reveals no systematic pattern of correlation, indicating that the selected model appropriately reflects the temporal dependence in the data (a non-significant LM test). The absence of significance suggests that there is no discernible pattern of connection in the residuals that goes beyond what would be predicted by chance.

Table 6. The VEC Residual Heteroskedasticity Test: Levels and Squares (No Cross-Term)

Joint Test		
Chi-Sq	Df	Prob
404.0705	330	0.3030

Source: Own calculation (processed using E-Views 12)

Given that the probability linked to the heteroskedasticity test is not significant, Table 6 above shows not enough information available to rule out the homoskedasticity null hypothesis. Put differently, the residuals' variance is taken to be constant at every level of the independent variables. A non-significant result shows that there is no violation of the homoskedasticity assumption, and the variability of the residuals does not exhibit a systematic pattern that is different from what would be expected by chance. The standard errors of the regression coefficients are reliable and unbiased when heteroskedasticity is absent.

Finally, given the estimated VECM in Table 4, the subsequent analysis is to simulate the trade balance response when there is a shock in the other variable. This will be obtained via innovative accounting. However, before that, one must impose limiting assumptions on the exogeneity of the innovations in the system. One needs to determine which innovation is the most exogenous and then order the variables in the system according to the relative exogeneity of their innovation.

We will use the Granger Causality test to help determine such ordering Table 7 below displays the results of Granger Causality tests on 5 pairs of variables, namely (1) LogRGDP and TB, (2) LogIRD and TB, (3) LogRGDP and LogREER, (4) LogRGDP and LogINF, and (5) LogIRD and LogINF. Each test examines whether the causation runs from the first variable to the second variable in the Granger sense, runs the other way around, or runs both ways, or there is no symptom of Granger causation in any direction.

The rejection of the null hypothesis (H0) occurs if the p-value is less than the significance level (α=0.05), in which we suggest that the variables are demonstrated to have Granger-cause. The null hypothesis is not rejected if the p-value is higher than the significance level. In this case, we say there is no evidence of Granger causation between the variables.

Table 7. The Granger Causality

The Null Hypothesis	OBS	F-Statistics	Prob
1a) LOGRGDP does not granger cause TB	73	4.15136	0.0199**
1b) TB does not granger cause LOGRGDP		2.97546	0.0577
2a) LOGIRD does not granger cause TB	73	4.36933	0.0164**

2b) TB does not granger cause LOGIRD		0.76553	0.4691
3a) LOGRGDP does not granger cause LOGREER	73	0.72901	0.4861
3b) LOGREER does not granger cause LOGRGDP		3.58640	0.0331**
4a) LOGRGDP does not granger cause LOGINF	73	0.54622	0.5817
4b) LOGINF does not granger cause LOGRGDP		4.86476	0.0106**
5a) LOGIRD does not granger cause LOGINF	73	0.87040	0.4234
5b) LOGINF does not granger cause LOGIRD		5.17248	0.0081**
Note: Significant at 5% **			

Source: Own calculation (processed using EViews 12)

The results show that we can reject hypothesis 1a but not hypothesis 1b, suggesting a one-way causation from LogRGDP to TB. This means that knowledge from past values of LogRGDP can be used to forecast TB values in the present or the future. We can also reject hypothesis 2a but not 2b, meaning that LogIRD does granger cause TB. Comparing the results of testing hypotheses 3a and 3b, we conclude that LogREER does granger cause LogRGDP and not vice versa. The results for hypotheses 4a and 4b indicate a one-way causation from LogINF to LogRGDP, while the results for hypotheses 5a and 5b suggest a one-way causation from LogINF to LogIRD.

The trade balance, inflation, and exchange rate's Granger Causality test results do not only provide information on the dynamic relation between the pair of variables. The results can complement economic theory to determine how the Cholesky decomposition or the VEC model's variable ordering should be determined. Considering the context of this study, we argue that exchange rates may be influenced by external factors or policy decisions while inflation is often influenced by monetary policy, output, and interest rates, which are determined by monetary policy decisions. The standard ordering places the variables in the decreasing order of exogeneity. Hence, in this study, we propose the following ordering of variables: the trade balance, exchange rate, inflation, real gross domestic product, and interest rate differential.

4.1.3. Simulating the Dynamic Response of The Variables in The VECM

The impulse response analysis is a popular econometrics method for examining the dynamic impacts of shocks in a system of equations, like those in a VAR model. An individual shock's reaction to the model's variables is depicted by the IRF. The IRF shows how one variable—the trade balance in this example—responds to a change in another variable—the actual exchange rate. It shows how the variable evolves after the shock. An innovation shock refers to an unexpected and exogenous change in a variable. Using the IRF method, this study first investigates how the trade balance would react over time following the shocks of other variables in the system including the exchange rate and inflation. To complete the analysis, the study also sees how the exchange rate and inflation would evolve following the shocks of other variables in the system. To apply the IRF, the study determines the ordering of the variables based on the insights given by the previous Granger Causality analysis, namely the trade balance, the exchange rate, inflation, the real GDP, and the interest rate.

a. The response to the trade balance

Figure 1 shows the results of the trade balance's IRF. The upper-left panel illustrates how the trade balance would react following one standard deviation positive shock of the

real effective exchange rate (LOGREER). The upper-left panel shows that following this shock (an increase of REER), the trade balance may improve in the short term but then, after quarter 2, deteriorates and remains at a level lower than the initial state. Thus, different effects on the trade balance appear in the short term and the long term, with a permanent effect occurring in the long run. We can deduce whether the results are consistent with the J-curve hypothesis. Assuming that the IRF is symmetrical, the results indicate that if the REER innovation is negative, the trade balance would initially become worse before it improves and stays at a level superior to the initial state. Hence, we have support, albeit indirectly, to say that the J-curve prediction, which predicts that after a real devaluation of the exchange rate, the trade balance could initially worsen before turning positive, applies to the dynamic of the trade balance in Sierra Leone.

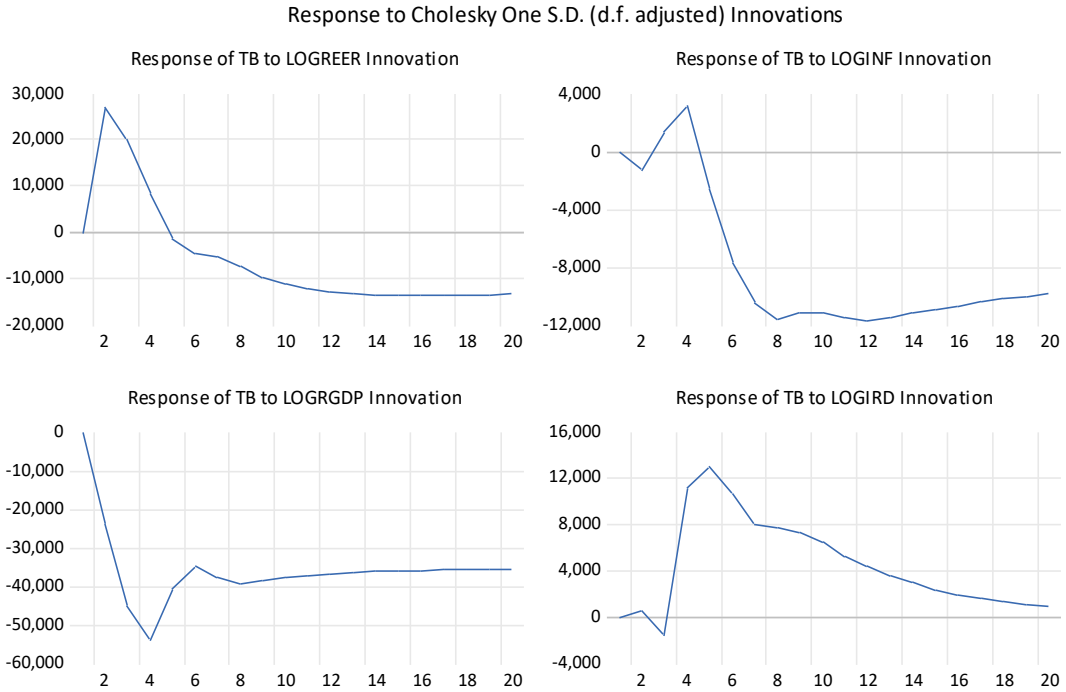

Figure 1. The response of trade balance to innovations of the trade balance, real exchange rate, real gross domestic product, and interest rate differential

The upper-right panel shows the trade balance's reaction to an inflation shock. The panel demonstrates that after quarter 4, the trade balance continues to decline up to quarter 8 and remains at a lower level afterward, indicating a permanent negative effect on the trade balance in the long run. This result is consistent with the hypothesis that an increase in domestic inflation can compromise Sierra Leone's export competitiveness, making imports more expensive and hence weakening the trade balance.

The other panels in Figure 1 capture the trade balance's reaction to innovations in the real GDP and interest rates differential. In the lower-left panel, innovation in real GDP is shown to permanently affect the trade balance, implying a negative link between real GDP and trade balance. As previously addressed, Sierra Leone is highly dependent on imports of raw food commodities and intermediate goods, so as the country grows, demand for

imported food and intermediate goods tends to increase as well, and this adversely affects the trade balance.

The last panel in Figure 1, the lower-right one, shows how the trade balance would react following a positive innovation in the interest rates differential, namely when the gap between Sierra Leone's domestic interest rate and the US interest rate widened. The figure shows that the trade balance starts to improve between quarters 3 and 4 and continues to increase up to quarter 6 before the improvement effect subsides. Thus, the result suggests that when Sierra Leone's Central Bank increases the interest rate, it can improve the trade balance for a while, during the first two years after the shock. However, the effect is not permanent in the long run and the trade balance would go back to its initial condition before the shock.

5. CONCLUSION

This paper evaluates the relationship between the trade balance, inflation, and exchange rates of Sierra Leone through vector autoregressive models and impulse response function analysis using quarterly data from 2005 Q1 to 2023 Q3. The research ascertains short-run causal relationships among these variables and establishes that the shocks to the exchange rate do have asymmetric impacts on the trade balance in the short and long run, thus validating the J-curve hypothesis. The study also finds that inflation has a negative persistent impact on the trade balance, while both trade-balance and inflation shocks are found to influence the exchange rate in the short term.

The findings bring out intricate dynamics of the Sierra Leonean macroeconomy with significant implications for informed policy making. The results suggest that attempts at improving the trade balance should not be limited to currency adjustments, but rather they should involve actions geared toward export competitiveness, import reduction, and structural matters. The study has stressed the need for control of inflation and exchange rate stability as a means of ensuring general economic stability and strengthening the resilience of the external sector.

Based on the foregoing findings, the researchers propose to Sierra Leone policymakers a package of comprehensive long-run policies that incorporate structural adjustments and competitiveness. They should frame policy options with a sense of the complex linkages between exchange rates, inflation, and trade balance. Future research, the paper proposes, shall further engage an extended time series analysis, sectoral analysis, and comparative studies so as to deepen understanding of the macroeconomics of Sierra Leone and similar economies.

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