AN ASYMMETRIC MODEL INVESTIGATION OF THE EXCHANGE RATE PASS-THROUGH TO DOMESTIC PRICES IN SIERRA LEONE

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An Asymmetric Model Investigation of the Exchange Rate Pass-Through to Domestic Prices in Sierra Leone

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Abstract

The objective of the study is to investigate exchange rate pass-through to domestic prices in Sierra Leone by explicitly distinguishing the effect of an appreciation of the exchange rate from the effect of a depreciation. An autoregressive distributed lag inflation model for Sierra Leone is estimated using the Ordinary Least Squares with data from 1980 to 2020. The results show that increase in appreciation of the Leone reduces inflation rate, while increase in depreciation increases inflation rate. Moreover, the impact of a depreciation lasts longer than that of an appreciation. However, the impact of a depreciation was found to last longer than an appreciation. A major policy implication is the need for domestic policies that can constrain exchange rate depreciation, which requires the joint effort of a number of stakeholders in Sierra Leone, including all actors in economic transformation.

Keywords: Asymmetry, Exchange Rate, Domestic Price, ARDL

JEL Classification : E58, E52, C33, C52

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1. Introduction

Central Banks around the world are almost in consensus on price stability as the core objective of monetary policy. However, in an open economy, exchange rate changes can militate against the chances of delivering on this objective, depending on the structure of the economy. This has brought to light interest in academics and policymakers studying the role of exchange rate in the inflationary dynamics of countries. In addition, understanding the transmission mechanism of exchange rate pass-through to domestic prices in developed, emerging markets and developing economies has been obscured during the past three decades. Hence, the need to understand how exchange rate changes affect domestic prices and their implications on monetary policy cannot be overemphasized (Kassi et al., 2019). Simply defined as the extent to which changes in the exchange rate are transmitted to prices in a given country, the channel of transmission of exchange rate pass-through to domestic prices and its attendant effect on monetary policy has not been clearly identified (Kassi et al., 2019). Several studies have attempted to explain the effect of exchange rate pass-through to domestic prices by paying attention to either the independence of the central bank in its monetary policy implementation (Ho & Hafrad, 2020) or the type of exchange rate regime adopted by these countries (El Bejaoui, 2013). The type of exchange rate regime adopted and the independence of the central bank are fundamental prerequisites for exchange rate pass-through (Ho & Hafrad, 2020). Flexible exchange rate regime countries tend to have lower pass-through effect, compared to countries that adopt fixed exchange rate regime. For instance, under a floating exchange rate system, economic agents normally accept exchange rate variation as temporal, so they tend not to adjust prices instantaneously. On the other hand, under a fixed exchange rate system, changes in the exchange rate are considered permanent. Hence, prices are normally adjusted instantaneously. This immediate price adjustment tends to widen the pass-through effect because agents deem exchange rate variation to have immediate effect on their cost of inputs (El Bejaoui, 2013).

Accordingly, the effect of exchange rate pass-through to domestic prices tends to be complete and fast in developing countries and slow in developed or emerging markets economies (Ho and Hafrad, 2020). Sierra Leone depends heavily on imported consumption goods and services as well as primary commodity export and foreign aid. It cannot influence the price of its exports or imports and it uses a managed floating exchange rate regime. Average inflation in the 1980s was 51.92%, which increased to 43.96% in the 1990s. It was 15.27% in the first decade of the 2000s, 11.17% in the second decade of the 2000s and 10.92% in 2020, while average exchange rate depreciation was 68.10% in the 1980s, 46.63% in the 1990s, 6.72% in the first decade of the 2000s, 10.54% in the second decade of the 2000s and 9.10% in 2020 respectively. In this regard, as a small open developing economy with a flexible exchange rate system, but high inflation episode and strong import appetite, the need to understand exchange rate pass-through to domestic prices in Sierra Leone cannot be overemphasized. Bangura et al. (2012) found a significant but incomplete exchange rate pass-through to domestic prices in Sierra Leone. Theoretically, the appreciation of the domestic currency tends to trigger more pass-through to import and export prices than depreciation of the currency (Delatte & Lopez-Villavcencio, 2012). That is, asymmetry of exchange rate pass-through in this context implies prices respond more to an appreciation than to a depreciation of the exchange rate. The paper investigates the existence of asymmetry in the exchange rate pass-through to domestic prices in Sierra Leone-it determines whether appreciation and depreciation face the same response face by domestic inflation in Sierra Leone. While there are previous studies on Sierra Leone on the effect of exchange rate on inflation, the investigation of the issues, paying attention to the possibility of asymmetric effect has not been investigated. Studies that have investigated the effect of exchange rate on inflation in Sierra Leone include Kallon (1994), Tarawalie et al. (2012) and Korsu (2014).

The rest of the paper is organized as follows. Section two presents the extant literature on asymmetry approach to exchange rate pass-through to domestic prices. Section three presents the methodology while Section four presents and discusses empirical findings. Section 5 concludes the paper.

2. Literature review

Several studies have been undertaken on the asymmetry of exchange rate pass-through to domestic prices in advanced, emerging markets and developing economies. Some studies argued that the pass-through effect of exchange rate to domestic prices seems to be weaker in countries that practice flexible exchange rate regime than countries that practice fixed exchange rate regime (El bejaoui, 2013; Ho & Hafrad, 2020). These countries are considered to be developed or emerging markets economies. Others considered the exchange rate pass-through effect to be symmetric, where an appreciation of the exchange rate has stronger effect on price than does depreciation (El bejaoui, 2013). The bulk of these studies used the nonlinear autoregressive distributed lag model.

There are a number of studies on the effect of exchange rate pass-through to domestic prices in developed countries and investigation of pass-through using a non-linear model is common in the developed economies. For instance, El bejaoui (2013) used the non-linear autoregressive distributed lag model to examine the asymmetric effect of exchange rate pass-through to export and import prices for four developed economies comprising Japan, France, United States of America and Germany using quarterly data from 1980q1 to 2011q2. The findings revealed evidence of asymmetric pass-through via appreciations and depreciations of the currencies of these countries, with appreciation having a stronger pass-through effect to import prices than depreciation. The results of El bejaoui (2013) is similar to that of Delatte and Lopez-Villavicencio (2011), who found that prices respond differently to appreciation and depreciation in the long-run in Japan, Germany, United Kingdom and United States of America.

Similar studies have also been done on Sub-Sahara African (SSA) countries using a non-linear approach. The results seem to corroborate those on advanced and emerging markets economies. For example, Kassi et al. (2019) estimated nonlinear ARDL model for forty SSA countries using quarterly data from 1990q1 to 2017q4 to investigate the asymmetrical relationship between exchange rate and consumer prices. The results found strong evidence of exchange rate pass-through for the region in the short-run but mixed long-run result across the region. The result further revealed high exchange rate pass-through for countries that use fixed exchange rate regime with low inflationary pressure, compared with low pass-through with countries that use flexible exchange with regime but with high inflation environment. These results conform with Abdulqadir (2020) who used asymmetric threshold regression and General Method of Moments techniques to examine the asymmetric effect of exchange rate pass-through in forty-four SSA countries using annual data from 2008 to 2017.

At the country specific level, similar results have also been identified as evidenced by Simonyan (2020), who used a nonlinear ARDL technique to examine possible asymmetries in the reaction of import and export prices in Turkey using quarterly data from 1980q1 to 2011q2. The results showed both long-run and short-run asymmetric effects of exchange rate on import and export prices, where the degree of pass-through declined as Turkey switched to the floating exchange rate regime. Ho and Hafrad (2020) found similar results for Vietnam when they used the nonlinear ARDL technique to measure the effect of exchange rate pass-through to domestic prices using quarterly data from 2000q4 to 2018q2. In particular, their results revealed evidence of high pass-through effect in the long-run and short-run, with the impact of exchange rate depreciation stronger on domestic prices than appreciation in the long-run. Mughal et al. (2020) found evidence of asymmetric effect of exchange rate pass-through on domestic prices in Pakistan using nonlinear ARDL and quarterly data from 2005q1 to 2018q4.

In the case of developing countries, previous studies on the effect of exchange rate pass-through to domestic prices focused on linear effect. This is the case also for Sierra Leone. However, there are a few study on other developing countries focusing on the asymmetric effect of exchange rate pass-through to domestic prices. For example, Adekunle, Tiamiyu and Odugbemi (2019) used the nonlinear ARDL technique to model the existence of asymmetry in exchange rate pass-through to consumer prices using monthly data from 2001 to 2015 for Nigeria. Their results revealed that consumer prices had adaptive expectations in the short-run. They also found evidence of incomplete pass-through and that the pass-through becomes larger with asymmetric effect. Amoah and

Aziakpono (2020) found similar result for Ghana when they reexamined the speed and magnitude of exchange rate pass-through to consumer prices using quarterly data from 1990q1 to 2015q4. The Johansen Maximum Likelihood estimates revealed significant asymmetry with respect to the direction and size of exchange rate variation. There was also evidence of incomplete but high pass-through during periods of depreciation than appreciation.

Moreover, the bulk of the studies that concentrated on the symmetry aspect of the exchange rate pass-through to domestic prices used the structural VAR technique and found evidence of incomplete but significant pass-through effect of exchange rate to domestic prices. For example, Bangura et al. (2021) found evidence of incomplete but significant pass-through using quarterly data and the SVAR technique for Sierra Leone. Bwire et al. (2013) also used SVAR and quarterly data to reveal incomplete pass-through effect of exchange rate in Uganda. Mushendami and Namakalu (2019) also found incomplete pass-through effect in Namibia using SVAR and quarterly data to examine the degree of the exchange rate pass-through to prices. Helmy et al. (2018) found similar result for Egypt when they used SVAR to investigate underlying relationship between exchange rate and prices. Balcilar et al. (2019) found evidence of complete pass-through effect for Nigeria but an incomplete pass-through effect for South Africa in both long-run and short-run. Similarly, Asafo (2019) used the Bayesian VAR technique to estimate pass-through of exchange rate to domestic prices in Ghana using quarterly data from 2006q3 to 2017q4. He found evidence of moderate but not unitary pass-through of exchange rate dynamics to domestic prices.

Unlike previous studies on the asymmetric nature of exchange rate pass-through to domestic prices, which use the price level and therefore adopt the partial sum of positive and negative changes to represent positive and negative depreciations respectively, we use a transformation based on the actual depreciation and appreciation rates, as the interest is to determine the effect of exchange rate depreciation but not the effect of only the change in the exchange rate. Thus, we develop two new variables from the exchange rate depreciation series, where one represents positive exchange rate depreciations and the other one represent negative depreciations. This is important because partial sum of positive or negative changes does not capture the actual rate of depreciation itself but captures only the sign and change in the nominal exchange rate rather than the magnitude of the depreciation.

3. Methodology

3.1 Theoretical Framework

The theoretical framework for the determination of the price- exchange-rate effect is the Purchasing Power Parity (PPP), which has been used by other studies in Sub-Saharan African countries, including Korsu, (2014) for Sierra Leone and Amoah and Aziakpono (2018) for Ghana. The purchasing power parity (PPP) doctrine states that the exchange rate is determined by the ratio of internal purchasing powers of two currencies with respect to other domestic prices. The basic idea of the PPP concept is that, goods sold in one country cost the same in another country when the same exchange rate is applied based on a market basket. According to the PPP, price level is the weighted average of prices of both tradable and non-tradable goods.

Let p^{TD} and p^{NTD} denote prices of tradable and non-tradable goods respectively, so that in log form, the price level is given as in equation (1), where L denotes natural logarithm.

$$LP_t = \theta(LP_t^{TD}) + (1-\theta)(Lp_t^{NTD}), \quad 0 \ p \ \theta \ p \ 1 \tag{1}$$

Assume the price of tradable goods is exclusively determined in the global market, which is a function of foreign price and the bilateral nominal exchange rate. Let (P^{FN}) and BNEXR represent foreign price and the bilateral nominal exchange rate respectively so that under the PPP theory equation (2) holds with L denoting natural logarithm.

$$LP_t^{TD} = LBNEXR_t + LP_t^{FN} \tag{2}$$

Equations (1) and (2) indicate that anytime there is an increase in the price of tradable goods, domestic price level will accordingly increase either via a depreciation in the bilateral nominal exchange rate or an increase in foreign price level.

Similarly, the price of non-tradable goods is determined within the domestic money market economy and is proportional to excess money supply. In the money market equilibrium, real money balances (M^{s}) equals real money demand (M^{d}) and in log form the price of non-tradable goods is given as in equation (3),

$$LP_t^{NTD} = \alpha(LM_t^s - LM_t^d) \tag{3}$$

Where L is natural logarithm, α is a scale factor representing the nexus between total demand in the economy and the demand for non-tradable goods. Standard economics theory of money demand posits that money demand is an increasing function of the scale variable (real GDP) and a decreasing function of the opportunity cost variable (interest rate) so that in linear formulation, the demand for money model is,

$$LM_t^d = \beta_0 + \beta_1 LRGDP_t + \beta_2 LENDR_t \, , \quad \beta_1 \succ 0, \beta_2 \prec 0 \tag{4}$$

Substituting equation (4) into equation (3) yields equation (5) as,

$$LP_t^{NTD} = \alpha(LM_t^s - \beta_0 - \beta_1 LRGDP_t - \beta_2 LENDR_t) \tag{5}$$

Combining equations (2) and (5) and substituting in equation (1), gives the price level determinants as in equation (6).

$$P = f(M^S, RGDP, NEXR, LENDR) \tag{6}$$

However, our interest is in inflation rate dynamics and exchange rate depreciation but not in the price level. We also note that the inflation rate is the growth rate of the price level and therefore transform the right hand variables in equation (6) in growth forms, to get money supply growth, real GDP growth and nominal exchange rate growth (exchange rate depreciation). However, for lending rate as the unit of measurement is percentage point, our interest is in determining the effect of a percentage point increase in lending rate on the inflation rate. Hence, we keep it in the model in its original form. The coefficient of the growth of each of the other variables (for example, money supply growth) represents the response of inflation rate to a one percent change in the growth of the variable. Therefore, the equation used to estimate the exchange rate pass-through to domestic prices is formulated as follows.

$$INF_t = \gamma_0 + \gamma_1 M2\_g_t + \gamma_2 RGDP\_g_t + \gamma_3 LENDR_t + \gamma_4 EXR\_dep_t + \omega_t$$

$$\gamma_1 > 0, \gamma_2, < 0, \gamma < 0_3, \gamma_4 > 0 \qquad (7)$$

Where INF denotes inflation rate and is computed as the percentage change in the price level, M2_g is broad money growth and is expected to have a positive impact on inflation rate. RGDP_g is real GDP growth and is expected to have a negative effect on inflation. EXR_dep is exchange rate depreciation and we expect its coefficient to have a positive effect on inflation, when it is considered to have a linear effect on inflation. LENDR is commercial banks' lending rate with an expected negative impact on inflation.

Considering that the effect of a positive depreciation of the Leone may be different from a negative depreciation (an appreciation), we identified the term EXR_dep to be strictly positive or negative number and refer to the former as POS and the latter as NEG. Hence, equation (7) becomes:

$$INF_t = \gamma_0 + \gamma_1 M2\_g_t + \gamma_2 RGDP\_g_t + \gamma_3 LENDR_t + \gamma_4 POS_t + \gamma_5 NEG_t + \mu_t$$

$$\gamma_1 > 0, \gamma_2, < 0, \gamma_3 < 0, \gamma_4 > 0, \gamma_5 < 0 \qquad (8)$$

Unlike previous studies on exchange rate asymmetric effect (for example, (El Bejaoui, 2013; Amoah & Aziakpono, 2018; Bahmani-Oskooee et al., 2019), which use the price level and therefore use the partial sum of positive and negative changes to represent positive and negative depreciations respectively, we use the following equations to determine the positive and negative depreciations. This is because partial sum of positive or negative changes does not capture the actual rate of depreciation itself but captures only the sign and change in the nominal exchange rate rather than the magnitude of the depreciation, though the interest is to determine the effect of the depreciation or appreciation rate on inflation as represented as follows:

$$POS_t = Max(EXR\_dep_t, 0) \qquad (9)$$

$$NEG_t = Min(EXR\_dep_t, 0) \qquad (10)$$

3.2 Estimation Techniques

Unit root tests have been considered germane in empirical research, especially when dealing with time series data. A battery of techniques has been identified in the extant literature that are used to detect unit root in the data. The Dickey-Fuller (DF) test, Augmented Dickey-Fuller (ADF) test, Philips-Perron (PP) test, etc. have been considered standard and appropriate in identifying unit root in the series. These techniques, though popular have been described impotent in detecting unit root in the series because they have low power and might pose misleading results in the midst of structural breaks in the data. To overcome these challenges, several studies have accounted for unit root with structural breaks in the data using different approaches. For instance, the Zivot and Andrews (1992) test, which accounts for only one structural break in the data. Lumsdaine and Papell (1997) test, which extended the Zivot and Andrews technique by accounting for two structural breaks in the data. The Lumsdaine and Papell (1997) technique. These approaches however, failed to elaborate on the nature of the break in the data. To circumvent this difficulty, Perron and Vogelsang (1992), Vogelsang and Perron (1998) and Clemente-Montanes-Reyes (1998) introduced unit root test with single and double structural breaks in the data respectively.

Estimation using Ordinary Least Square (OLS) in the context of non-stationary variables leads to misleading results. In this regard, an appropriate transformation of such variables is important in order to avoid having high t-ratio due to existence of common trend, but not due to a true relationship. We therefore tested for unit root in the variables using the Dickey-Fuller GLS test, the Perron-Vogelsang test and the Clemente-Montanes-Reyes test and also combine these results for a conclusion. In addition, estimation of a time series model (as in equation 8) in static form hides the role of delayed effects and the model could be plagued with misspecification problem due to omitted lags of variables. Hence, we estimate an over-parametrized model in the context of Hendry's general-to-specific model and a parsimonious model is obtained from it by dropping insignificant variables one-by-one. In the parsimonious model, the coefficients of nominal exchange rate depreciation (POS) and nominal exchange rate appreciation (NEG) are then tested for equality (asymmetry). All non-stationary variables are therefore transformed through appropriate differencing to obtain stationary variables, which are used in the estimation of the model.

3.3 Data Type and Sources

The study employed annual data from 1980 to 2020 on inflation rate, broad money growth, real GDP growth, exchange rate depreciation and lending rate. The dataset was obtained from the International Financial Statistics, World Development Indicators and the Bank of Sierra Leone database. Inflation is measured as the percentage change in the consumer price index. Money supply growth is measured as the percentage change in broad money supply. Nominal exchange rate depreciation rate is the percentage change in the period average nominal exchange rate, with exchange rate defined as Leone per United States Dollar. Real GDP growth is measured as percentage change in gross domestic product at constant prices and lending rate is measured as the average lending rate of commercial banks.

4. Empirical Results and Analysis

Table 1 presents summary of the conclusion from the various unit root tests while Appendix 2 shows the various unit root test results. A series is stationary if the DF-GLS test, which does not account for structural break indicates it is stationary in spite of the order of integration of the PV and CMR tests. This is because, the DF-GLS test is biased towards the null hypothesis of unit root when there is a structural break in the series. However, if a series is not stationary according to the DF-GLS test, but it is stationary according to the PV test, which tests and accounts for a structural break, the series is considered stationary as the break is responsible for the observed non-stationarity from the DF-GLS test. Moreover, a series is considered stationary if it is not stationary according to the PV test but is stationary according to the CMR test. This is because, the CMR test tests and accounts for two structural breaks and it is biased towards non-rejection of the null hypothesis of unit root when there are two structural break and only one is tested and accounted for. But when it is not stationary according to the PV test but is stationary according to the CMR test, the conclusion is that the series is stationary because it implies the non-stationarity observed by PV is due to failure to test and account for two structural breaks. The results show that while all the series are stationary in levels, lending rate is stationary after first differencing. Thus, lending rate entered the model in first difference form to ensure all model variables are stationary.

Table 1: Summary of conclusion from the Unit Root Test Results

Variable	Dickey-Fuller-GLS (DF-GLS)	Perron Vogelsang (PV)	Clement-Montanes-Reyes (CMR)	Conclusion
Inflation Rate	I(1)	I(0)	I(0)	I(0)
Lending Rate	I(1)	I(k)	I(k)	I(1)
Exchange Rate Dep.	I(0)	I(0)	I(0)	I(0)
Real GDP Growth	I(1)	I(0)	I(0)	I(0)
Money Growth	I(0)	I(0)	I(0)	I(0)
Positive Exchange Rate Depreciation.	I(0)	I(0)	I(0)	I(0)
Negative Exchange Rate Depreciation.	I(0)	I(0)	I(0)	I(0)

Note: k means series is not stationary after second differencing. DF-GLS means Dicker-Fuller GLS. PV means Perron-Vogelsang. CMR means Clemente-Montanes-Reyes. IO means order of integration.

. Table 2 shows the estimated inflation model. The result is presented with the symmetric model results (Model 1) for comparison of the exchange rate effects. The asymmetric effect model (Model 2) shows that increase in exchange rate depreciation increases inflation rate, with effects that are significant for up to two years as indicated by the positive coefficients of the positive exchange rate depreciation (POS) in its contemporaneous form, one lag form and two lags form. All the three forms of this variable are significant. The effect of increase in exchange rate appreciation is a reduction in inflation rate. This is because the variable Negative Exchange Rate Depreciation (NEG) has a significant negative coefficient in the estimated asymmetric model.

Comparing positive, the exchange rate depreciation and negative exchange rate depreciations (exchange rate appreciation), the former has longer effect (two lags) than the latter (one lag). This implies that in terms of length of the impact, there is asymmetry in the impact of exchange rate pass-through to domestic inflation rate, with depreciation having longer impact than appreciation. However, in terms of the magnitude of the effect, exchange rate appreciation has a stronger effect than on inflation rate than exchange rate depreciation.

Table 2: The Result of the Estimated Inflation Model

Dependent Variable is Inflation	Model 1 (Symmetric Effect)		Model 2 (Asymmetric Effect)	
Inflation (lag1)	-0.456	(0.008)	-0.583	(0.000)
Money Growth	0.722	(0.000)		
RGDP Growth			-0.518	(0.085)
Real GDP Growth (lag1)			0.435	(0.115)
Lending Rate	-0.827	(0.098)		
Lending Rate (Lag1)	1.065	(0.023)		
Lending Rate (Lag2)			0.382	(0.061)
Exchange Rate Depreciation (Lag 1)	0.583	(0.000)		
Exchange Rate Depreciation (Lag 2)	0.292	(0.011)		
Positive Exchange Rate Depreciation			0.296	(0.000)
Positive Exchange Rate Depreciation (Lag1)			0.663	(0.000)
Positive Exchange Rate Depreciation (Lag 2)			0.257	(0.013)
Negative Exchange Rate Depreciation			-7.682	(0.001)
Negative Exchange Rate Depreciation (Lag 1)			-9.229	(0.001)
Constant	-11.456	(0.170)	-3.482	(0.597)
R-Squared	0.865		0.920	
Adjusted R-Squared	0.838		0.894	
F-Stat (Prob.)	32.950	(0.000)	35.690	(0.000)
Test for Asymmetric Effect	F(1,28) =	27.080	0.000	

Source: Authors' Estimation. Note: Values in parentheses are probability values

Specifically, when there is a one percentage point increase in nominal exchange rate appreciation, inflation rate decreases by -7.68 and -9.23 percentage points respectively. One the other hand, when there is a one percentage point depreciation, the inflation rate increases by 0.30, 0.66 and 0.26 percentage points respectively in the same year, after a year and after two years respectively. The test for the equality of the magnitude of the effect of depreciation and the effect of appreciation of the exchange rate on inflation rate, which is shown in the last row of Table 2, shows that the null hypothesis of a symmetric effect is rejected as the probability of rejecting the null hypothesis wrongly (p-value) is 0.000.

Real GDP growth is found to have a negative effect on inflation rate in the contemporaneous form, though it is significant at the 10% level. The first lag of real GDP growth, however, has a positive effect on inflation rate but it is not significant. This variable was removed from the model but the resulting model showed higher Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) and that the coefficients of a number of variables became insignificant. Thus, it was retained in the model. The lending rate is found to have a positive effect on inflation rate with a two year delayed effect but significant only at the 10% level. However, the contemporaneous and one period lag of lending rate are not found to be significant in the model and do not therefore appear in the parsimonious model. The insignificance of the contemporaneous and one-year lag effect of lending rate in the inflation model suggests a weak f interest rate channel of monetary policy in Sierra Leone.

Comparing the results of the symmetric effect and asymmetric effect with respect to the effect of exchange rate on inflation, it is observed that when exchange rate effect is considered to be linear (symmetric), the marginal effect of inflation with respect to changes in exchange rate depreciation (0.583) in the same year is more than the effect of a positive change in the asymmetric model (0.296) but lower in absolute terms than the effect of a negative change in the asymmetric model (7.682). However, for the one-year lag effect, the marginal effects in the asymmetric model for both positive depreciation (0.663) and negative depreciation (9.229) are higher than in the symmetric model depreciation (0.292). Hence, it is vital to consider asymmetric effect in modeling the effect of exchange rate on inflation rate in Sierra Leone.

4.1 Model Diagnostic Tests

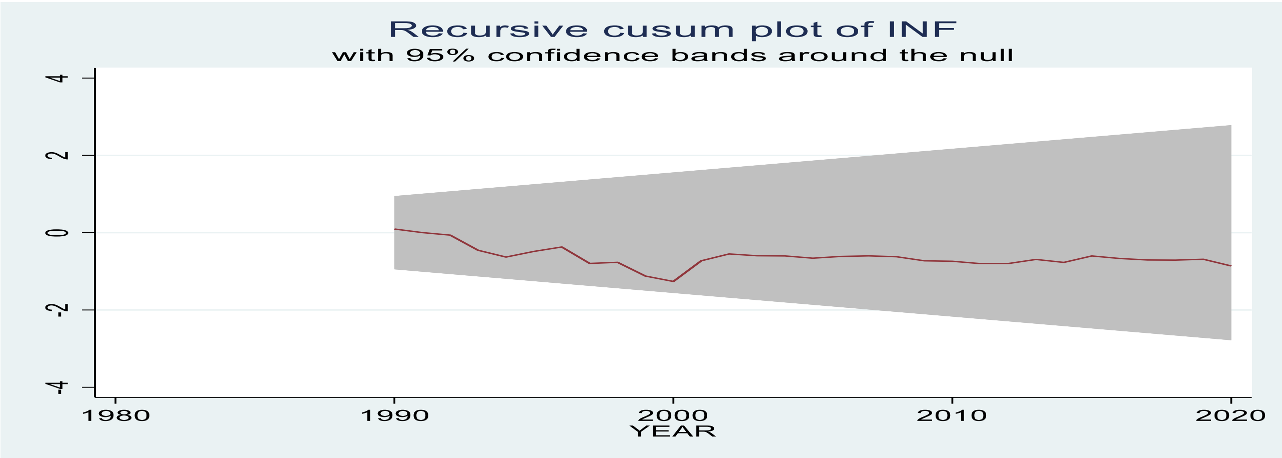
The validity of the application of the OLS was tested by conducting normality, serial correlation and heteroscedasticity tests. Table 3 shows results of the diagnostic tests. The results show that the model passes all the tests. Similarly, the stability of the model parameters was investigated using plots of the cumulative sum of recursive residuals (CUSUM). Figure 1 shows plot of the CUSUM. The plot shows that the model parameters are stable.

Table 3: Diagnostic Test Results

Diagnostic Test Type		**Test Statistic**	**Probability**
Normality	Jarque-Bera	5.47	0.0649
Serial Correlation	Breusch-Godfrey	1.867	0.3932
Heteroscedasticity	Breusch-Pagan-Godfrey	1.28	0.2570

Source: Authors' Computation

Figure 1: Cumulative Sum of Recursive Residuals



5. Conclusion

Inflationary pressures have major welfare implications for economic agents- governments, firms and consumers. The same holds for exchange rate depreciation. While the former leads to increased budget deficit by increasing the cost of government operations, the latter has higher external debt service implications. For open economies, which are small and rely heavily on exports of primary products and imports of basic necessities such as food and energy, the investigation of the exchange rate pass-through to domestic prices is imperative. Sierra Leone is a perfect example of such an economy. Sierra Leone has had episodes of large depreciations of the exchange rate and high inflation rates and the scenario has recently shown up again, as observed during the COVI-19 era and from the impact of geo-political tension-the Russian-Ukraine war.

The objective of the study was to investigate the exchange rate pass-through to inflation in Sierra Leone by explicitly distinguishing the effect of an appreciation from the effect of a depreciation. This dichotomy is important because the welfare implications of an appreciation of the exchange rate to consumers, importers and producers may be different from that of a depreciation of the exchange rate. Annual data from 1980 to 2020 was obtained to estimate an inflation model for Sierra Leone using an autoregressive distributed lag (ARDL) model, which was estimated using OLS while accounting for non-stationarity of variables. The results show that increase in appreciation of the Leone reduces inflation rate, while increase in depreciation increases inflation rate. Moreover, the impact of an appreciation was found to be stronger than that of a depreciation However, the impact of a depreciation lasts longer than an appreciation. In this regard, a major policy implication is the need for domestic policies that can constrain exchange rate depreciation, which requires the efforts of a number stakeholders including all actors in the economic transformation of Sierra Leone.

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Appendix 1:

Table 4: Dynamics in Inflation and Exchange Rate Depreciation

Year	Inflation Rate	Exchange Rate Depreciation
1980-1989	51.92%	68.10%
1990-1999	43.96%	46.63%
2000-2009	15.27%	6.72%
2010-2019	11.17%	10.54
2020-	10.92%	9.10%

Source: Authors' Estimation

Variable		Deterministic Component	Lag	Test Statistics	Conclusion
Inflation Rate	L	Constant	3	-2.452	
	1D	Constant	1	-5.512	I(1)
Lending Rate	L	Constant	1	-2.048	
	1D	Constant	1	-4.781	I(1)
Exchange Rate Dep.	L	Constant	2	-5.779	I(0)
	1D				
	2D				
POS	L	Constant	2	-5.766	I (0)
	1D				
	2D				
NEG	L	Constant	1	-4.017	I (0)
	1D				
	2D				
Real GDP_Growth	L	Constant	1	-3.543	I(0)
M2_Growth	L	Constant	2	-4.488	I (0)

Critical Values

Constant	**Constant and Trend**
1%: -2.634	**1%:** -3.770
5%: -2.384	**5%:** -3.314

Appendix 2:

Table 5: Dickey-Generalized Least Squares (DF-GLS) Unit Root Test Results

Table 6: Perron-Vogelsang Single Break Unit Root Test Result

Variable		Additive Outlier (Immediate Break)			Innovative Outlier (Gradual Break)			Conclusion
		Breakpoint	P-Value for Break	Test Statistics	Breakpoint	P-Value for Break	Test	
Inflation Rate	L	1989	0.054	-0.114	1990	0.004	-5.211	I(0)
Lending Rate	L	1988	0.065	0.892	1994	0.108	-2.714	I(K)
	1D	1992	0.010	-1.411	1991	-	-3.977	
	2D	1991	0.973	-4.874	1992	-	-5.551	
Exchange Rate Dep.	L	1992	0.000	-2.493	1991	0.000	-8.200	I(0)
POS	L	1992	0.000	-2.496	1991	0.000	-8.109	I (0)
	1D							
	2D							
NEG	L	1999	0.939	-0.423	2000	0.028	-15.082	I (0)
	1D							
	2D							
Real GDP Growth	L	1999	0.012	-4.113	2001	0.043	-2.826	I(0)
M2 Growth	L	1989	0.001	-5.577	1990	0.000	-6.992	I(0)
	1D							
	2D							
5% Critical Values:								
Additive Outlier:		**-3.560**				**Innovative Outlier:**	**-4.270**	

Note: 1. L = level, 1D = 1st Difference and 2D =2nd difference. 2. I(K) means series is not stationary after second differencing

Table 7: Clemente-Montanes-Reyes (double break) Unit Root Test Results

Panel A: Additive Outlier (Immediate Break) Results

Variable		First Break			Second Break			Conclusion
		Breakpoint	P-Value for Break	Test Statistics	Breakpoint	P-Value for Break	Test	
Inflation Rate	L	1985	0.001	-2.676	1993	0.000	-2.676	I(K)
	1D	1985	0.475	0.339	1989	0.990	0.339	
	2D	1989	0.758	-0.712	1993	0.624	-0.712	
Lending Rate	L	1988	0.000	-3.242	1995	0.000	-3.242	I(K)
	1D	1986	0.062	0.035	1992	0.003	0.035	
	2D	1990	0.020	-0.251	1993	0.023	-0.251	
Exchange Rate Dep	L	1992	0.011	-3.821	1998	0.445	-3.821	I(K)
	1D	1984	0.967	-0.098	1991	0.535	-0.098	
	2D	1988	0.417	-0.913	1991	0.661	-0.913	
POS	L	1992	0.011	-3.683	1998	0.450	-3.683	I (K)
	1D	1984	0.967	0.031	1991	0.529	0.031	
	2D	1988	0.437	-0.902	1991	0.684	-0.902	
NEG	L	1986	0.521	-0.675	1999	0.835	-0.675	I (K)
	1D	1986	1.000	-26.745	1999	1.000	-26.745	
	2D	1986	1.000	-6.321	1999	1.000	-6.321	
Real GDP_Growth	L	1999	0.014	-3.668	2011	0.471	-3.668	I(K)
	1D	1990	0.881	-9.289	2013	0.439	-9.289	
	2D	1990	0.997	-6.232	2013	0.829	-6.232	
M2_Growth	L	1991	0.000	-6.189	2012	0.225	-6.189	I(K)
	1D	1989	0.049	-7.129	1994	0.132	-7.129	
	2D	1990	0.608	-7.517	1996	0.936	-7.517	
Additive Outlier 5% Critical Values: -5.490								

Panel B: Innovative Outlier (Gradual Break) Results

Variable		Variable			First Break			Conclusion
		Breakpoint	P-Value for Break	Test Statistics	Breakpoint	P-Value for Break	Test	
Inflation Rate	L	1984	0.000	-7.187	1991	0.000	-7.187	I(0)
	1D							
	2D							
Lending Rate	L	1988	-	-1.728	1992	0.000	-1.728	I(K)
	1D	1991	-	-5.256	1996	0.270	-5.256	
	2D	1991	-	-5.551	1993	-	-5.551	
Exchange Rate Dep.	L	1983	-	-6.281	1992	0.000	-6.281	I(K)
	1D	1985	-	-2.960	1992	-	-2.960	
	2D	1986	-	-3.654	1992	-	-3.654	
POS	L	1983	-	-6.253	1992	0.000	-6.253	I (K)
	1D	1985	-	-3.075	1992	-	-3.075	

	2D	1986	-	-3.662	1992	-	-3.662	
NEG	L	1987	-	-15.082	2000	-	-15.082	
	1D	1987	-	-15.379	2000	-	-15.379	
	2D	2000	0.000	-6.789	2004	0.000	-6.789	I (2)
Real GDP_Growth	L	2000	0.000	-10.649	2013	0.000	-10.649	I(0)
	1D							
	2D							
M2_Growth	L	1983	0.004	-9.408	1990	0.000	-9.408	I(0)
	1D							
	2D							
Innovative Outlier 5% Critical Values :								

Note:1. L = level, 1D = 1st Difference and 2D =2nd difference. 2. I(K) means series is not stationary after second differencing