THE NON-LINEAR EFFECTS OF MONETARY POLICY RATE ON INFLATION IN SIERRA LEONE

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Abstract

The weak monetary transmission mechanism in Sierra Leone is well documented in the literature. However, no study has considered the possibility of a monetary policy rate threshold below or beyond which monetary policy rate becomes an ineffective tool for countering inflation. In this paper, we examine the extent to which monetary policy affects inflation using data for the period 2011:Q1-2022:Q3. Using threshold auto-regression models, we find evidence that monetary policy is effective up to the level when inflation was at most 10 percent inflation rate, beyond this policy rate became less relevant in controlling inflation. Consequently, the optimal inflation rate for the effectiveness of monetary policy rate in Sierra Leone implementation is 11.3% and this requires MPR to be less than or equal to 10%. This finding is robust to the inclusion of different proxies of shocks, and the non-linear model is a good alternative to linear models for capturing abrupt breaks or asymmetries observed in most macroeconomic time series over the course of a business cycle. We therefore recommend that strong structural reforms to support containing inflationary *pressure be prioritised. Also, development of financial inclusion and payments systems development are useful in order to reduce transactions in cash to strengthen the impact of monetary policy.*

1. Introduction

The recent twin crises of Russian-Ukraine war and Covid-19 have led to economic downturns with inflation at its highest since the 1970s. In most parts of the world, inflation has even surpassed its expectations. Due to supply chain snags, drought and fertilizer prices, food prices are even more than their past surges in 2008 and 2011. According to World Economic Outlook (October 2022 edition), inflation in the US and Euro area stand on average at 8% and 11% respectively. Global inflation is forecast to rise from 4.7 percent in 2021 to 8.8 percent in 2022 but will decline to 6.5 percent in 2023 and further drop to 4.1 percent by 2024. In particular African countries are the hardest hit as inflation in most countries is above 20 percent. Nigeria, the largest economy in Africa has inflation of 21.34% as of October 2022. Sierra Leone's inflation was at 37.09% as at December 2022 and it is not expected to abate to pre-pandemic level in 2023 as inflationary expectations and disruption in the real sector continue to exacerbate.

More so, real economic growth appears bleak, and many analysts are lowering their projections of economic growth in the foreseeable future. Latest data from IMF (2022) indicate that world growth will now be 3.2%, and 2.7% in 2022 and 2023 respectively from 6% in 2021. The same could be said for sub-Saharan Africa as growth has fallen to 3.6% in 2022 from 4.7% in 2021. In Sierra Leone growth has been revised severally and is now revised to stand at 2.4 % in 2022 from an initial estimate of 3.8 % and 4.1% in 2021.

Consequently, central banks across the world are aggressively raising interest rates to curtail inflationary pressures to reset the economy back to its natural steady path of economic growth. The move is expected to ease demand, encourage investment, and lower prices of key commodities such energy, food, and housing. However, just like other countries, rate raises have not matched the pace of inflation in Sierra Leone. Figure 1 shows trend in monetary policy rate and inflation in Sierra Leone. Figure 1 also shows that policy rate and exchange rate have not kept pace with the inflationary trend in Sierra Leone. As a result, central bank policy makers are muddled as to whether monetary policy response to inflation is weak and possibly the impacts monetary policy rate has on inflation (linear or non-linear) if at all.

In Sierra Leone achieving and maintaining price stability in the economy is a core objective of monetary policy. Thus, the Monetary Policy Committee meets on a quarterly basis to take a

decision on the stance of monetary policy by increasing, reducing or keeping the monetary policy rate constant as previous quarter's decision. The decision depends largely on price developments, including the forecast for inflation and the dynamics on the part of output. The decisions on the monetary policy stance are communicated through a monetary policy statement, which is published on the BSL's website and in local newspapers, 48 hours after the MPC meeting. Monetary policy reaction functions can provide insights into the factors influencing monetary policy decisions. Empirical estimates suggest that differences exist across countries as to whether monetary policy reacts solely to expected inflation or also considers expected output developments.

In addition, a corridor system is run. That is, the MPR lies between the standing lending facility and the standing deposit facility and once the MPR is adjusted upward or downward, the standing lending facility and the standing deposit facilities are also adjusted by the same magnitude .This framework allows the BSL discount window to be accessed by commercial banks with excess liquidity and those in need of funds to meet liquidity shortages, while bank interaction in term of transacting in the interbank market is the preference of the Bank of Sierra Leone.

**Figure 1: Policy rate, Inflation and Exchange rate 2018-2022**
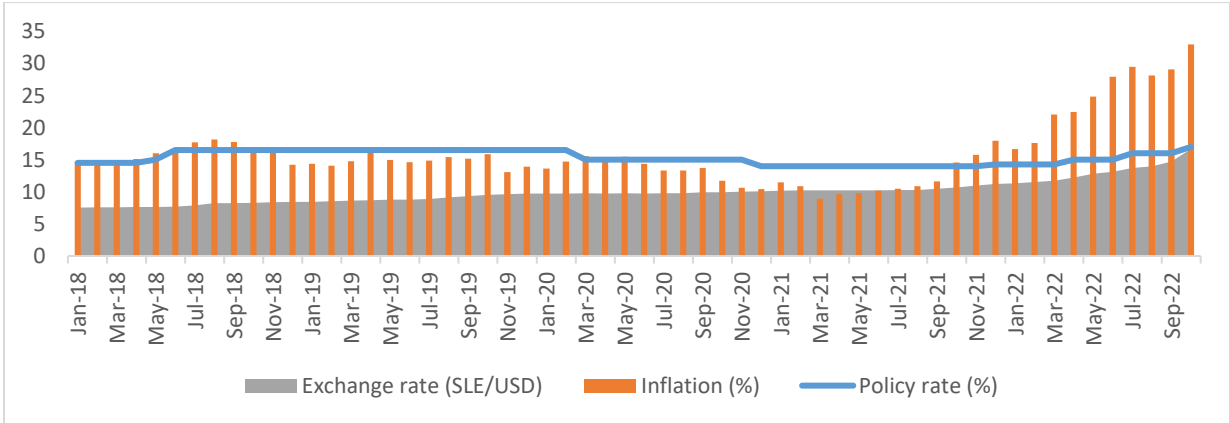
Source: Bank of Sierra Leone

As in the case of many central banks that have been raising interest rates while inflation remains on an upward trend, the key questions of interest is: should the MPR continue to rise as inflation rises and vice versa? Or is there a threshold beyond or below which the MPR becomes less effective or more effective in curbing inflation? In other words, is the impact of MPR on inflation

linear or non-linear or is linear in Sierra Leone? A myriad of studies have focused on the monetary policy transmission mechanisms in Sierra Leone and almost all found weak or no transmission. This includes Faux (2022), Tucker (2005) and Lavally and Nyambe (2019)). Faux (2022) also reveals that inflation and interest rate had negative effect on economic growth but are not effective monetary policy transmission channels and that understanding the effectiveness of how monetary policy channels work in Sierra Leone is critical for policy.

Figure 2: Inflation, Policy rate and Real GDP 2018-2022
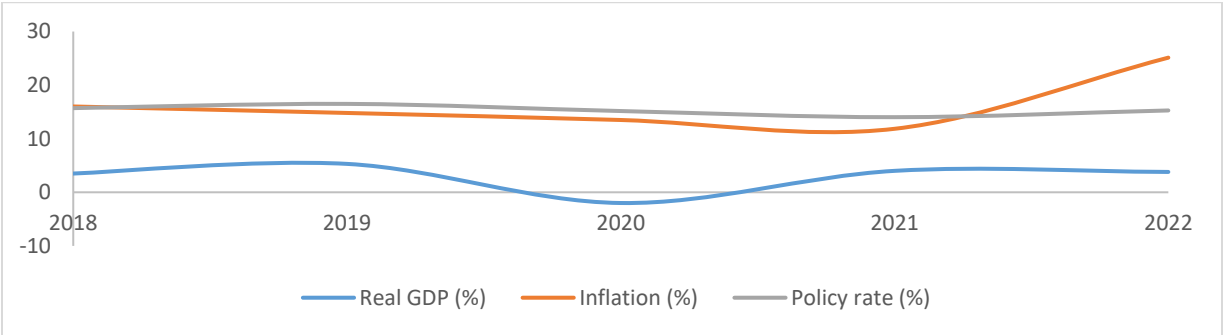
Source: Bank of Sierra Leone

This study therefore attempts to answer the above questions by investigating the non-linear effect of monetary policy rate on inflation in Sierra Leone. The outcome is useful for monetary policy formulation and implementation. Using Tong (1983)'s threshold autoregressive model, we estimate that monetary policy rate indeed has a threshold below and above which it becomes an ineffective instrument for controlling inflation in Sierra Leone.

The rest of the paper is divided as follows. Section 2 briefly presents the Bank of Sierra Leone's monetary policy implementation and inflation dynamics while section 3 discusses the data and methodology. Section 4 is the key findings and section 5 is the conclusion.

2. Bank of Sierra Leone Monetary Policy Implementation and Inflation

The Bank of Sierra Leone implements monetary policy based on indirect instruments. This has been the case since 1992 when it abandoned the direct instrument approach. The reform was gradually followed by linearization of the foreign exchange market and various forms of financial sector reforms. Monetary targeting framework is used to conduct the monetary policy of the Bank of Sierra Leone. Figure 1 shows the current Bank of Sierra Leone Monetary Policy Framework. The ultimate goal variable of the framework is inflation rate and broad money is the intermediate

target while the operating targets are the reserve money and the interbank rate and the instruments are monetary policy rate, standing lending and deposit facilities, reserve requirement, discount window operations and forex transactions.

Figure 1. Bank of Sierra Leone Monetary Policy Framework
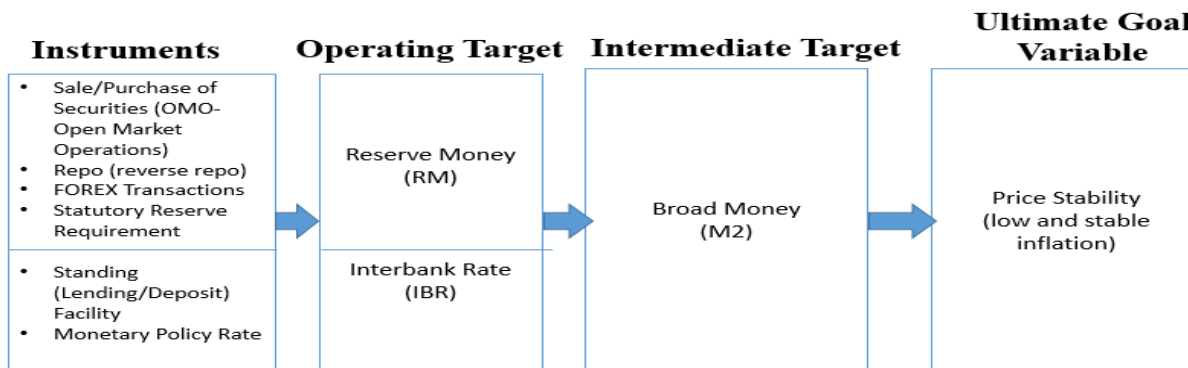
The monetary policy committee meets on a quarterly basis to review developments in the economy and intermediation environment and the likely direction of inflation rate and key macroeconomic variables, including real GDP growth in the near term. Guided by this, the Committee takes monetary policy decisions by adjusting the MPR upward, downward or keeping it unchanged. This decision flows into the SLF and SDF also. The expectation is that changes in MPR affects the interbank rate, the SLF and the SDF. This then translates into changes in the lending rate, which ultimately affects the demand for credit by the private sector. Thus, affecting the money creation feature of the commercial banks accordingly and the money supply is affected. The effect of money supply is then expected to translate into the price level. Figure 2 shows how the changes in the MPR are expected to affect the price level in Sierra Leone.

**Figure 2 shows how the changes in the MPR affects the price level in Sierra Leone.**

The monetary policy rate was introduced by the BSL in February 2011, it was introduced at 26.0 percent, at which time the inflation rate was 13.88 percent. Figure 3 shows the trend of MPR and

inflation rate in Sierra Leone from MPR introduction date to June 2016, the MPR was above the inflation rate and between June 2016 to November 2018, inflation rate was above the MPR. From November 2018 to October 2021 the MPR was generally above the inflation rate. It is also observed that from October 2021, inflation rate has been above the MPR.

It is also observed that during periods when MPR is above the inflation rate, inflation rate has a declining trend and during periods when MPR is below the inflation rate, inflation has a rising trend.

Figure 3: Movements of Monetary Policy Rates and Inflation, 2018-2022.
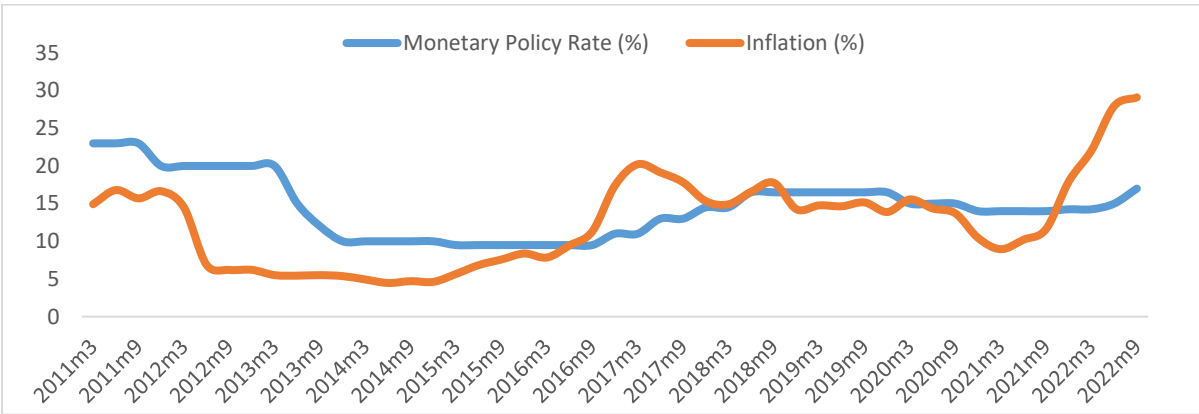
Source: Bank of Sierra Leone (2022)

3. A Brief Review of the Literature

Most of literature on monetary policy in Sierra Leone have focused on transmission mechanisms and almost all found weak or no transmission. Ndikumana (2014) investigated the implication of monetary authorities' policy effect on domestic credit to the private sector and investment for 37 SSA countries including Sierra Leone using annual data from 1980 to 2012 and dynamic panel data estimation technique. Key variables employed included domestic investment as percentage of GDP and domestic credit. Discount rate, treasury bill rate and lending rate were used as indicators of monetary policy. The result suggested that domestic credit to private entities emerged as a major channel which triggers domestic investment in SSA. However, the result found this variable to be infinitesimal in SSA, limiting its potency to propel investment. Structural and institutional encumbrances also emerged as sources that worsen the already limited lending facilities to private

economic agents. In this regard, it was concluded that contractionary monetary policy achieved through high discount rate was inimical to domestic investment. Hence, domestic investment can only be enhanced with moderate interest rate.

Lavally and Nyambe (2019) examined the effectiveness of monetary transmission mechanisms in Sierra Leone using annual data from 1980 to 2012. The Granger causality test showed that gross capital formation Granger causes exchange rate and real interest rate. The impulse response function showed that output responded positively to monetary shocks, as interest rate increased. For exchange rate and private domestic credit, output showed that even in the long run, the effects of the shocks might not be transitory to converge towards a steady state. The variance decomposition indicated that fluctuations in gross domestic product per capita (GDPPC) were attributed to itself. While the total contribution of the real interest rate (RIR) and exchange rate (ER) was relatively insignificant. They therefore found evidence of ineffective channels in the Sierra Leone economy. This result was also consistent with findings from Tucker (2005) who investigated the channels of monetary policy using quarterly data from 1981 to 2005. Applying the VAR framework, he found inconclusive outcomes with no evidence of appropriate channel of policy transmission in Sierra Leone.

On their part, Ogunkola & Tarawalie (2008) analysed the monetary policy transmission in Sierra Leone using quarterly data from 1980 to 2006. The following variables were used to estimate three models that describe the channels of transmission of monetary policy namely income, CPI inflation, effective exchange rate in real terms, private sector credit, short-term interest rate, treasury bills rate, United States funds rate and global oil price. The Johansen cointegration technique was applied to establish cointegration effect. Empirical results provide evidence that the bank lending channel was appropriate in transmitting policy actions to the economy. Similarly, Toe' et al. (2009) applied the VAR technique on monthly data spanning from February 2002 to December 2007 on real output, CPI inflation, 91-day treasury bills rate (as stance of monetary policy) and exchange rate to investigate channels of transmission of monetary policy in Sierra Leone. Stability in the VAR model was confirmed using Chow's structural breakpoint test. Treasury bills rate and market interest rates (lending rate and deposit rate) proxy the interest rate channel. Granger causality test results confirm interest rate pass through effect from authorities'

policy instrument to market rates. Results further confirm the exchange rate channel as robust way of monetary policy transmission to inflation but not output.

Given the critical ongoing debate on the effectiveness of monetary policy on inflation, Swaray (2022) revisited the transmission channel of monetary policy to real economy in Sierra Leone. Using quarterly data from 2002 to 2018, he discovered that the exchange rate channel was found to be appropriate in transmitting monetary policy effect to real economy based on the results of impulse response and variance decomposition analysis. He therefore argued that the most effective monetary policy transmission to the real economy is the exchange rate. Faux (2022) also reveals that inflation and interest rate had negative effect on economic growth but are not effective monetary policy transmission channels and that understanding the effectiveness of how monetary policy channels work in Sierra Leone is critical for policy.

In this study, we examine the nonlinear impact of monetary policy rate on inflation using a threshold model. The threshold model is a good alternative to linear models for capturing abrupt breaks or asymmetries observed in most macroeconomic time series over the course of a business cycle (Hansen 2011). The model is also useful because it can reveal optimal values of monetary policy rate based on its regime effect on inflation. This approach is not common in the literature.

4. Methodology

Since its novel invention by Tong in 1983, a number of studies on exchange rates, forecasting and business cycle in the developed world have applied the Threshold Autoregressive models (for more details see Hansen 2011). In this study, we are interested in the nonlinear effect of monetary policy rate on inflation in Sierra Leone.

To allow coefficients to differ across regions, we adapt Howell Tong (1983)'s threshold autoregressive (TAR) model, an extension of linear regression. In the threshold auto regression model, the dependent variable is a function of its own lags; and could also be the threshold variable. (See Tong 1990; Hansen 2011).

Assume a threshold regression of two regions with a threshold Ω (to be estimated), equation (1) takes the form of:

$$i_t = x_t\alpha + z_t\pi_1 + \mu_t \qquad -\infty < s_t \leq \Omega$$
$$i_t = x_t\alpha + z_t\pi_2 + \mu_t \qquad \Omega \geq s_t \leq \infty \qquad (2)$$

where i_t is the dependent variable, x_t is a 1xk vector of covariates possibly containing lagged values of i_t, α is a kx1vector of region-invariant parameters, z_t is a vector of exogenous variables with region-specific coefficient vectors π_1 and π_2, s_t is a threshold variable that may also be one of the variables in x_t or z_t and μ is an IID error with mean zero (0) and variance σ².

Additionally, to estimate the threshold (Ω), we need to minimize the lease squares of the regress with T observations and two regions as below.

$$i_t = x_t\alpha + z_t\pi_1 I((-\infty < S_t \leq \Omega) + z_t\pi_2 I(\Omega \geq S_t \leq \infty) + \mu_t \qquad (3)$$

for a sequence of T_1 values in S_t, where $T_1 < T$. We set the trimming percentage to 15%, which implies that T_1 corresponds to the number of observations between the 15th and the 85th percentile of S_t.

The estimator for the threshold is:

$$\tilde{s} = \arg\ min\ s\epsilon\tau S_{T1}(\Omega) \qquad (4)$$

where $\tau = (-\infty, \infty)$,

$$S_{T1}(\Omega) = \sum_{t=1}^{T}\{\{yt - xt\alpha - zt\pi1\ I(-\infty < st \leq \Omega) - zt\pi2\ I(\Omega \geq st \leq \infty)\}2 \qquad (5)$$

is a T_1 X 1 vector of SSR, and Ω is a T_1 X 1 vector of tentative thresholds.

The data on monetary policy rate (mpr), inflation rate (inf) and exchange rate depreciation (exr) are sourced from Bank of Sierra Leone and Statistics Sierra Leone and covers quarterly data from 2011q1 to 2022q3. The choice of data range is informed by the time the Bank of Sierra Leone (BSL) transitioned into using monetary policy rate as a key instrument (i.e., 2011 onwards).

5. Empirical Results

In this section, the descriptive and empirical results are presented and discussed. Table 5.1 shows the summary statistics of inflation rates in Sierra Leone under the two MPR regimes. That is when MPR is less than or equal to 10% and when it is more than 10%. The descriptive statistics shows that for the periods when MPR was less than or equal to 10%, inflation rate in Sierra Leone was

between 4.47% and 11.31%. It also shows that median inflation rate was 6.26%, which is less than the mean inflation rate of 6.77%. Hence, there were more inflation figures below the mean inflation rate than above it, when the MPR was less than or equal to 10%. The upper quartile inflation rate of 8.12% when the MPR is less than or equal to 10% implies that twenty five percent of the time, inflation rate was above 8.12% but less than or equal to 11.31%. This therefore suggests that from an endogenous framework for MPR to be in the range where it can have impact on inflation in the direction of monetary authorities, inflation rate in Sierra Leone should be less than or equal to 11.31%. Thus, the maximum inflation rate that ensures MPR is in its effective range is 11.3%. Thus, the optimal inflation rate for the effectiveness of monetary policy rate in Sierra Leone implementation is 11.3% and this requires MPR to be less than or equal to 10%.

Table 5.1: Descriptive Statistics of Inflation Rate

Mean	Regime of MPR ≤ 10%	Regime of MPR ≥ 10%	All Observations
Mean	6.77	14.52	12.54
Lower quartile	4.82	10.45	6.85
Median	6.26	14.91	13.89
Upper Quartile	8.12	17.41	16.57
Minimum	4.47	5.44	4.47
Maximum	11.31	29.10	29.10
Standard Deviation	2.19	5.64	6.03
Coefficient of Variation	32.3%	38.8%	48.1%

Additionally, in order to determine the effect of monetary policy rate on inflation in Sierra Leone, we estimated an inflation model as a function of exchange rate depreciation, one period lag inflation and the monetary policy rate. The monetary policy rate enters the model as a regime variant variable, and it is the threshold variable. It is also the threshold variable and regime variant variable in order to determine whether there is a threshold level of monetary policy rate for which the monetary policy rate can have different effects on the inflation rate in Sierra Leone.

Table 5.2 shows the estimated model results. Model (1) is the linear inflation model while model (2) is the non-linear inflation model. The non-linear model considers that there is a threshold level

10

of MPR for which impact of MPR on inflation changes. The linear model considers that the impact of MPR on inflation is the same across all levels of monetary policy rates.

Table 5.2: Estimated Threshold Regression Model Results

Variables of interest	Model (1) Linear	Model (2) Non-Linear	
		MPR<10%	MPR≥ 10%
Exchange Rate Depreciation	0.177 (0.002)	0.202 (0.000)	0.202 (0.000)
Inflation (lag1)	0.848 (0.000)	0.709 (0.000)	0.709 (0.000)
Monetary Policy Rate	0.022 (0.873)	-0.607 (0.016)	-0.234 (0.131)
Constant	-0.113 (0.947)	5.847 (0.024)	5.847 (0.024)
$R^2(\text{Adj}R^2)$	0.891 (0.883)		
F-stat (prob)	106.52 (0.000)		
Threshold (MPR)		10.00%	
Number of Regressions		30	
SSR for Threshold		144.062	
Trimming %		15	
BIC		70.795	
AIC		61.989	
HQIC		65.236	

Source: Authors' computations from dataset

The estimated inflation model results show that when the effects of monetary policy rate on inflation is treated linearly, exchange rate depreciation has positive and significant effects on inflation rate in Sierra Leone. In addition, there is inflation persistent. However, monetary policy rate has a positive but insignificant effect on inflation. Considering the effect of monetary policy rate to be non-linear, exchange rate depreciation has a positive and significant effect on inflation. Also, inflation persistence is significant. In addition, monetary policy rate has a significant negative effect on inflation, but this is the case when the MPR is less than or equal to 10%. When

MPR is above 10%, it has no effect on inflation rate in Sierra Leone. The effect of monetary policy rate on inflation may come with a lag. In this regard, we also maintained monetary policy rate as a threshold variable and held exchange rate depreciation and lagged inflation and investigated whether lags as model regressors of the monetary policy rate have non-linear effects on inflation rate in Sierra Leone.

Table 5.3 shows the estimated threshold model using different lags of monetary policy rate. This is done to determine how long the effect monetary policy rate on inflation lasts when monetary policy rate is less than 10 %. The result shows that the impact remains significant for five quarters, but the magnitude of the effect declines and in the third quarter the magnitude of the effect is about half the value in the first quarter. It starts increasing in the fourth quarter and after the fifth quarter the effect is not significant though it remains positive.

Table 5.3: Model of Lag MPR & Key Variables of Interest

	MPR Lag 1	MPR Lag 2	MPR Lag 3	MPR Lag 4	MPR Lag 5	MPR Lag6	MPR Lag 7	MPR Lag 8
EXR	0.189	0.186	0.207	0.202	0.208	0.183	0.177	0.178
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
INF (lag1)	0.694	0.722	0.769	0.763	0.723	0.782	0.808	0.808
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	6.359	4.288	2.175	2.661	3.794	2.373	0.306	0.226
	(0.023)	(0.093)	(0.268)	(0.201)	(0.113)	(0.355)	(0.878)	(0.913)
MPR(Regime1)	-0.617	-0.393	-0.312	-0.345	-0.440	-0.285	-0.036	-0.029
	(0.015)	(0.064)	(0.091)	(0.067)	(0.038)	(0.193)	(0.732)	(0.777)
MPR(Regime2)	-0.247	-0.138	0.069	-0.091	-0.135	-0.067	0.064	0.070
	(0.104)	(0.299)	(0.537)	(0.403)	(0.231)	(0.551)	(0.475)	(0.433)
Threshold MPR	10%	10%	9.5%	9.5%	9.5%	9.5%	10%	10%
AIC	62.144	64.967	66.143	65.831	64.475	56.95	54.40	56.10
BIC	70.949	73.773	74.949	74.63	73.164	65.51	64.85	64.43

It shows that exchange rate depreciation is positively and statistically significant to inflation at all lags. Thus, even at various lags, the effect of monetary policy rate is negative and statistically related to inflation. Hence, there is no linear effect of monetary policy rate on inflation in Sierra Leone but its impact is non-linear with its negative effect being significant when monetary policy rate is less than 10 %, which is consistent with a maximum inflation of 11.3 %. Suggesting that for inflation rates higher than 11.3 %, monetary policy may need to be complemented with strong structural reforms to support containing inflationary pressure.

6. **Conclusion**

The current empirical evidence on monetary policy in Sierra Leone revealed weak or transmission mechanisms (Swaray 2022; Lavally and Nyambe 2019; Ndikumana, 2014). Given the weak linear monetary transmission mechanism in Sierra Leone, this study investigates the nonlinear impact of monetary policy rate on inflation using a threshold model. Tong (1983)'s threshold model is also new in the application of monetary policy mechanisms in Sierra Leone and the developing world generally. To allow coefficients to differ across regions, we adapt Howell Tong (1983)'s threshold autoregressive (TAR) model, an extension of linear regression. In the threshold auto regression model, the dependent variable is a function of its own lags; and could also be the threshold variable.

The findings of the study indicates that for the periods when MPR was less than or equal to 10%, inflation rate in Sierra Leone was between 4.47% and 11.31%. It also shows that median inflation rate was 6.26%, which is less than the mean inflation rate of 6.77%. Hence, there were more inflation figures below the mean inflation rate than above it, when the MPR was less than or equal to 10%. In addition, the effect of exchange rate depreciation on monetary policy rates is revealed to be non-linear, positive, and significant on inflation. Also, inflation persistence is significant.

In addition, monetary policy rate has a significant negative effect on inflation, but this is the case when the MPR is less than or equal to 10%. When MPR is above 10%, it has no effect on inflation rate in Sierra Leone. The effect of monetary policy rate on inflation may come with a lag. Thus, the maximum inflation rate that ensures MPR is in its effective range is 11.3%. Thus, the optimal inflation rate for the effectiveness of monetary policy rate in Sierra Leone implementation is 11.3% and this requires MPR to be less than or equal to 10%. The estimated inflation model results show that when the effects of monetary policy rate on inflation is treated linearly, exchange rate depreciation has positive and significant effects on inflation rate in Sierra Leone. In addition, there is inflation persistent. However, monetary policy rate has a positive but insignificant effect on inflation. Hence, there is no linear effect of monetary policy rate on inflation in Sierra Leone. This suggests that for inflation rates higher than 11.3 %, monetary policy may require complementing it with strong structural reforms to support containing inflationary pressure. We therefore recommend that strong structural reforms to support containing inflationary pressure be prioritised.

Also, development of financial inclusion and payments systems development are useful in order to reduce transactions in cash to strengthen the impact of monetary policy.

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