

Olowofeso, Olorunsola E. et al.

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Exchange rate pass-through to inflation in the WAMZ: Are there asymmetric threshold effects?

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WAMI OCCASIONAL PAPER SERIES NO. 36



**EXCHANGE RATE PASS-THROUGH TO INFLATION IN THE
WAMZ: ARE THERE ASYMMETRIC THRESHOLD EFFECTS?**

JUNE 2025



WEST AFRICAN MONETARY
INSTITUTE



INSTITUT MONÉTAIRE DE
L'AFRIQUE DE L'OUEST

Exchange Rate Pass-Through to Inflation in the WAMZ: Are There Asymmetric Threshold Effects?*

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Exchange Rate Pass-Through to Inflation in the WAMZ: Are There Asymmetric Threshold Effects?

Abstract

This study provides country-specific empirical evidence on the optimal exchange rate pass-through to inflation in the WAMZ for the 1980-2023 period. Although there is a large empirical literature on this subject, previous studies have primarily focused on linear approaches to determining optimal exchange rate pass-through, where inflation is presumed to react similarly to both small and large changes in the exchange rates. This paper contributes to the policy debate by endogenously determining the individual WAMZ countries' threshold effects of exchange rate pass-through to inflation at different episodes. The results from the study show optimal nominal exchange rate pass-through to inflation of 15.5 percent for The Gambia, 23.8 percent for Ghana, 18.3 percent for Guinea, 11.2 percent for Liberia, 18.5 percent for Nigeria, and 19.6 percent for Sierra Leone. Moreover, in most WAMZ countries, the nominal exchange rate pass-through is negative and statistically insignificant during periods of currency appreciation (lower regime), whereas it becomes positive and significant during episodes of currency depreciation (upper regime), indicating a stronger inflationary impact when currencies weaken. This study provides strong empirical evidence of incomplete and asymmetric pass-through of the exchange rate to inflation, as ERPT is high during currency depreciation and low during appreciation. Hence, ignoring asymmetric threshold effects of exchange rate movements on inflation may lead to inappropriate policy prescriptions and inferences. Notably, this result aligns with the ECOWAS exchange rate variability convergence criteria (± 10 percent). Thus, monetary authorities within the zone are encouraged to continue pursuing appropriate monetary policy measures that will lower exchange rate variability below the desirable threshold levels, thereby helping to control inflation.

Key Words: Exchange rate pass-through; Inflation; Smooth transition regression; Asymmetry; West Africa

JEL Classification: C22, F31, F41.

1.0 Introduction

Exchange rate fluctuations remain a major concern for the economic stability of developing and emerging market economies. This is especially true because these fluctuations can significantly impact domestic price levels through the exchange rate pass-through (ERPT). Essentially, ERPT measures how much changes in exchange rates affect the prices of goods and services within an economy. A higher ERPT means that a significant portion of the exchange rate change is reflected in prices, and the opposite is true for a lower ERPT. In the West African Monetary Zone (WAMZ), where exchange rates can be quite volatile and the economies are sensitive to external shocks, grasping the intricacies of ERPT is crucial for crafting effective monetary policies (Coulibaly & Kempf, 2021; IMF, 2023). As the region moves towards monetary integration and the eventual adoption of a common currency, understanding the nature and extent of ERPT to inflation among member countries becomes particularly important for achieving price stability.

The focus of this study stems from the current challenges of inflation and currency depreciations across WAMZ economies, which have sparked concerns about how stable and consistent the exchange rate pass-through (ERPT) is across various inflation regimes. While many existing studies tend to view the relationship between exchange rate fluctuations and inflation as straightforward, there's a growing body of evidence indicating that the ERPT process might be more complex and dependent on the economic context, particularly in low-income and structurally vulnerable regions like the WAMZ (Bussière et al., 2022; Iwegbu & Uyaabo, 2020). This raises a critical issue for monetary authorities in the WAMZ and whether ERPT varies depending on macroeconomic thresholds such as inflation levels, exchange rate volatility, or external shocks.

Given the recent inflation surge in the West African Monetary Zone (WAMZ), the importance of exchange rate pass-through (ERPT) to inflation dynamics cannot be overemphasised. Empirical studies have demonstrated that ERPT tends to be higher in economies with weaker monetary policy credibility and high import dependence, which are common to many WAMZ countries (Aziakpono, 2013; WAMA, 2023).

The integration efforts within WAMZ are yet to materialise, primarily due to member countries struggling to meet the necessary macroeconomic convergence criteria. Lately, inflation has become the toughest primary criterion to tackle, while maintaining exchange rate stability has proven to be the most challenging secondary criterion. This situation is largely driven by ongoing inflationary pressures and a steady decline in currency value throughout the

Zone (WAMI, 2024). In 2023, the average inflation rate in WAMZ reached 24.1 percent, with Sierra Leone experiencing the highest rate at 47.6 percent, while Guinea had the lowest at 7.8 percent (WAMA, 2024). Over the last five years, the region's average inflation has been 15.5 percent, highlighting the ongoing macroeconomic instability. Similarly, most WAMZ countries have experienced significant currency depreciation over the past five years, with the notable exception of Guinea, whose currency appreciated marginally. In 2023 alone, the currencies of The Gambia, Liberia, Sierra Leone, and Ghana depreciated by 5.7 per cent, 17.8 per cent, 21.0 per cent, and 38.5 per cent, respectively. Nigeria experienced an unprecedented depreciation of 95.5 percent following exchange rate reforms (CBN, 2024; IMF, 2024). As a result of these macroeconomic challenges, meeting the 5 percent inflation target and the ± 10 per cent exchange rate variation limit, as stipulated in the WAMZ convergence criteria, is still not feasible for most member countries (WAMI, 2024). These developments highlight the difficulty of maintaining price stability and exchange rate convergence in the Zone, particularly in the face of external shocks and structural vulnerabilities.

Despite growing interest in the ERPT, empirical studies on the subject matter in the Zone remain scarce and predominantly focused on linear models or single-country analyses (Adu et al., 2018; Akpan & Atan, 2021). What's missing is a thorough exploration of how ERPT might behave differently depending on whether inflation or depreciation levels are high or low, especially in a regional context. This study aims to fill that gap by specifically examining non-linearities and threshold effects in ERPT across the WAMZ countries, using a Smooth Transition Regression (STR) technique introduced by Terasvirta (1994). This method offers a more adaptable way to model the ERPT process, allowing us to capture dynamics that change with different regimes and test for threshold effects that fluctuate over time under various economic conditions. Ultimately, the goal is to deepen our understanding of the diversity and intricacies of ERPT in the WAMZ, providing more nuanced policy insights that could help shape effective inflation targeting strategies and exchange rate policies in the region.

The primary objective of this study is to investigate whether exchange rate pass-through to inflation in the WAMZ exhibits asymmetric threshold effects. Specifically, it examines whether the magnitude of ERPT differs across high and low inflation regimes, and whether depreciation shocks induce stronger inflationary effects compared to appreciation. By doing so, the study contributes to the literature by providing the first region-specific evidence of non-linear ERPT dynamics in the WAMZ, incorporating recent developments in threshold modelling (Zhang et al., 2020; Balcilar et al., 2021). The findings are expected to inform the

design of exchange rate and inflation targeting frameworks in the WAMZ region and contribute to ongoing convergence discussions toward a common monetary zone.

In addition to the introduction, the rest of the paper will be patterned as follows: Section two outlines stylised facts on Exchange Rate Pass-Through to Inflation in the WAMZ with key macroeconomic variables, including exchange rates and inflation. The third section reviews the theoretical and empirical studies. Section four delineates the methodology and estimation procedures, followed by a presentation and discussion of results in the fifth section. The final section covers the summary, conclusion, and policy implications.

2.0 Stylised Facts on Exchange Rate Pass-Through to Inflation in the WAMZ

The WAMZ economies are characterised by varying degrees of dependency on imports and differing levels of economic stability, exhibiting unique ERPT patterns over the years. In the WAMZ, ERPT remains a critical issue given these economies' exposure to external shocks, structural constraints, and varying exchange rate regimes. Understanding ERPT in WAMZ countries aids policymakers in designing effective monetary and fiscal policies to mitigate adverse effects on the economy, especially in terms of inflation, trade balances, and overall economic stability. This section presents stylised facts on ERPT to inflation for the individual WAMZ countries.

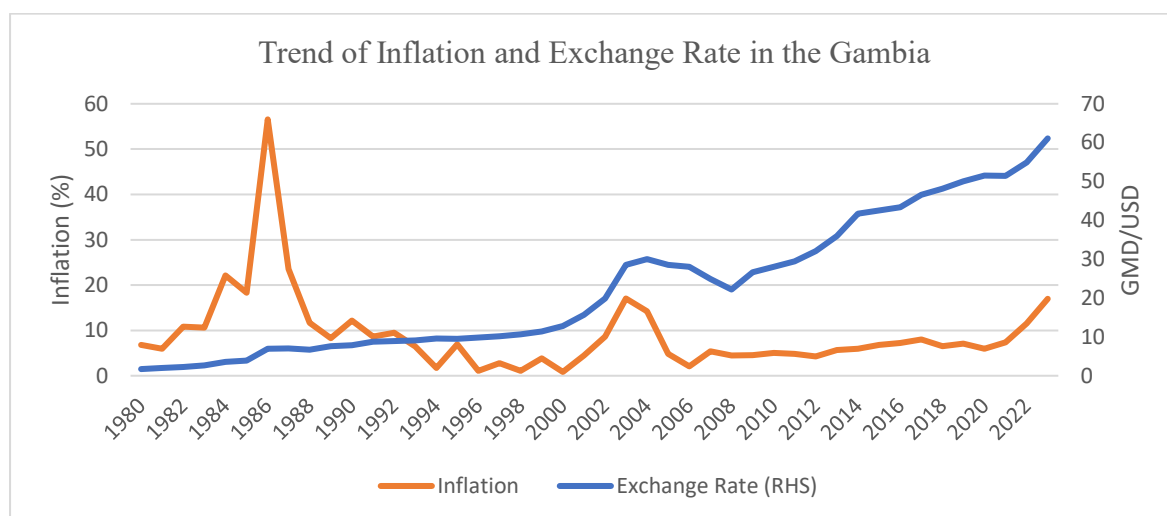
2.1 Country-Level Stylised Facts about ERPT to Inflation

The Gambia

In the Gambia, exchange rate and inflation show a modest correlation, with notable inflation spikes around 2016–2017 and again in 2020–2021. The 2016–2017 period saw a political transition crisis following the presidential election, leading to investor uncertainty and capital flight. The 2020–2021 spike was largely due to COVID-19-induced trade disruptions and global commodity price hikes. The dalasi's persistent depreciation (from 1.72 GMD/USD in 1980 to 61.10 in 2023) drives medium ERPT, with inflation closely tracking exchange rate changes. Major depreciation episodes (e.g., 43.8% in 2002–2003, 11.5% in 2022–2023) led to inflation spikes (17.03% in 2003, 16.97% in 2023).

Thus, the ERPT to inflation in the Gambia is medium with a delayed effect due to structural constraints and import dependency. Inflation is moderately persistent, with ERPT amplified by reliance on imported food and fuel. Tourism, a key foreign exchange earner, is sensitive to global shocks (e.g., COVID-19), increasing ERPT during crises.

Figure 2.1: Trend of Inflation and Exchange Rate in the Gambia



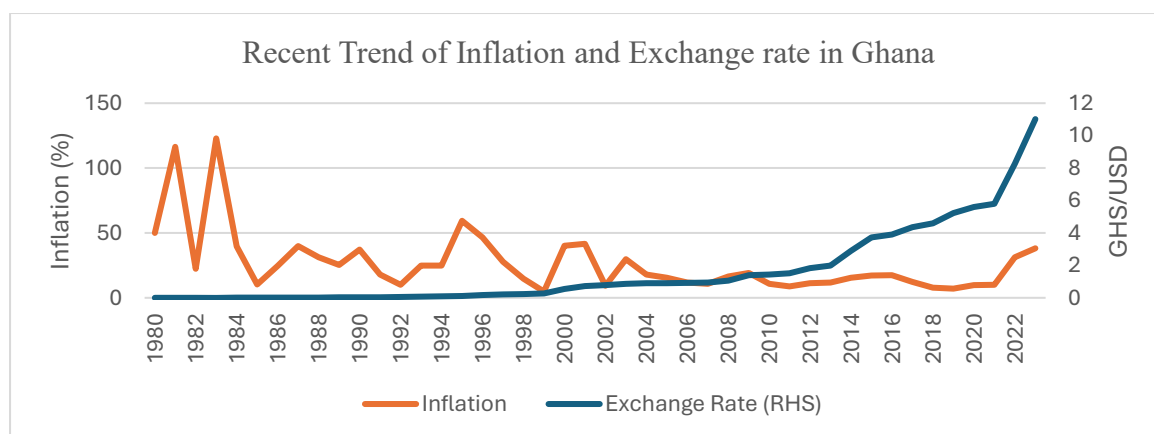
Data source: World Development Indicators Database, World Bank.

Ghana

In Ghana, there is strong synchronisation between inflation and exchange rate, notably in 2014–2016, 2018, and 2022. The period, 2014–2016, was characterised by large fiscal deficits and falling commodity prices (gold, cocoa, oil), whilst 2022 witnessed sharp cedi depreciation from global inflation and debt sustainability issues. The cedi’s depreciation drives high ERPT, with inflation peaks following major depreciations (e.g., from 5.81 to 8.27 GHS/USD, led to 31.26% inflation).

Ghana had a relatively high ERPT, particularly in the short run, as the country's dependency on imported goods, including fuel and raw materials, meant exchange rate movements were quickly reflected in domestic prices. Also, the reliance on primary exports (gold, cocoa) exposes Ghana to terms-of-trade shocks, amplifying ERPT.

Figure 2.2: Trend of Inflation and Exchange Rate in Ghana



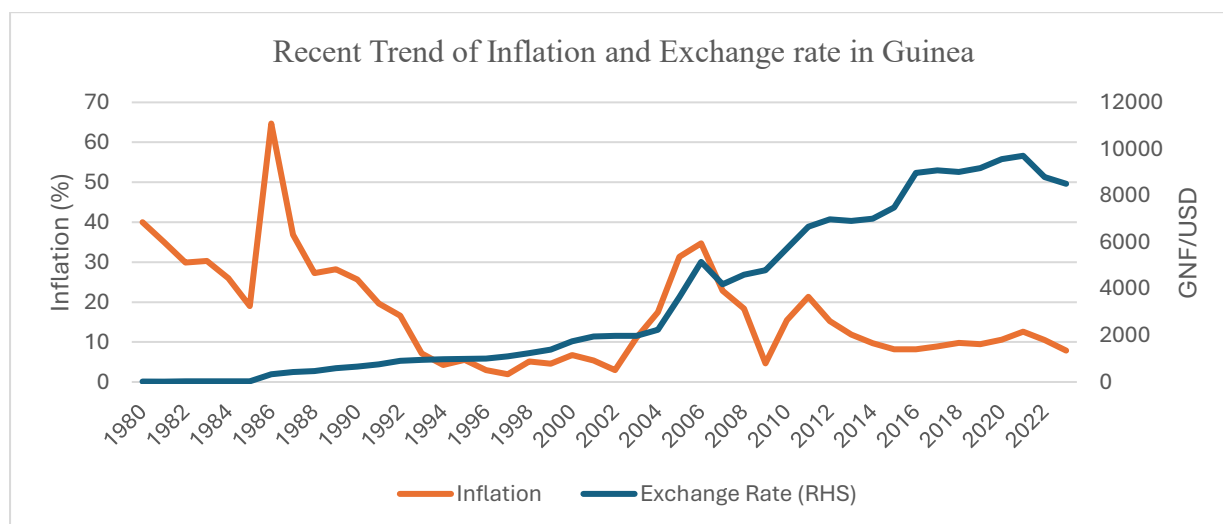
Data source: World Development Indicators Database, World Bank.

Guinea

In Guinea, inflation and exchange rate are loosely correlated, and the ERPT to inflation was moderate but significant in the medium term, influenced by structural constraints and limited financial sector development. The Guinean franc's massive depreciation (18.97 GNF/USD in 1980 to 8510.70 in 2023) drives high ERPT, particularly in the 1980s (e.g., 1663% depreciation, 1985–1986, led to 64.7% inflation). Post-1990s, ERPT moderated due to improved monetary management. Bauxite exports, a key foreign exchange earner, are sensitive to global price shocks, driving ERPT. In addition, weak institutions and high transportation costs limit price arbitrage, increasing pass-through during depreciations (Kinda, 2011).¹

In 1986, a 1663% depreciation (24.33 to 333.45 GNF/USD) amid structural reforms and commodity price shocks drove hyperinflation. Similarly, in 2005–2006, a 62.6% depreciation (3644.33 to 5148.75 GNF/USD) and rising global fuel prices increased ERPT. Also, in 2011, a 16.3% depreciation (5726.07 to 6658.03 GNF/USD) and political instability post-election amplified inflation. Inflation persistence was high pre-1990s but declined post-2000.

Figure 2.3: Trend of Inflation and Exchange Rate in Guinea



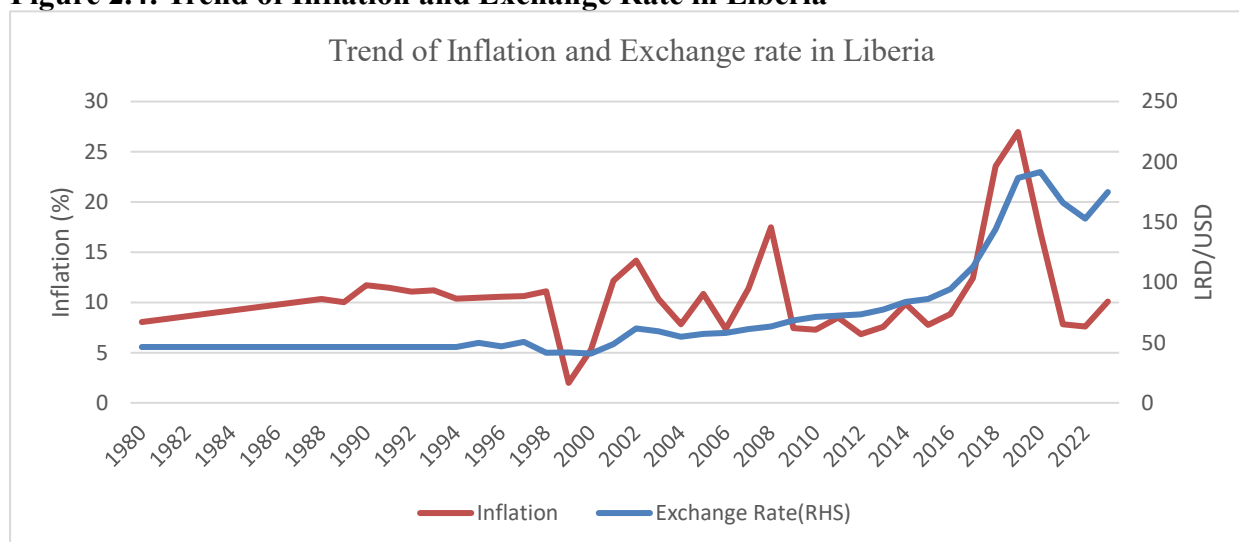
Data source: World Development Indicators Database, World Bank.

¹ Kinda, T. (2011). "Modelling Inflation in Chad and Guinea: A Structural Approach." IMF Working Paper WP/11/94.

Liberia

In Liberia, the economy experienced high co-movement of inflation and exchange rate, especially in 2016–2017 and 2020. Commodity price drops and COVID-19 disruptions were key contributors. The ERPT to inflation is high and quick, reflecting weak policy credibility and dollarisation (CBL, 2020).² Liberia’s dual-currency system (LRD and USD) results in high ERPT, as most goods are USD-priced, and LRD depreciation directly affects local prices. Inflation data is sparse pre-1999, but post-1999 shows strong ERPT. For example, in 2008, a 3.2% depreciation (61.27 to 63.21 LRD/USD) and global food/fuel price spikes increased inflation. Similarly, in 2018–2019, a 27.9% depreciation in 2018 (112.71 to 144.06 LRD/USD) and 29.5% in 2019 (to 186.43) due to declining rubber/iron ore exports and dollarisation drove high ERPT to inflation. Whilst a 2.7% depreciation (186.43 to 191.52 LRD/USD) in 2020, which was largely due to COVID-19 trade disruptions, amplified ERPT. Inflation persistence is high in Liberia, with prolonged effects from exchange rate shocks. External shocks (e.g., commodity price drops, COVID-19) and weak institutions increase inflationary pressures.

Figure 2.4: Trend of Inflation and Exchange Rate in Liberia



Data source: World Development Indicators Database, World Bank.

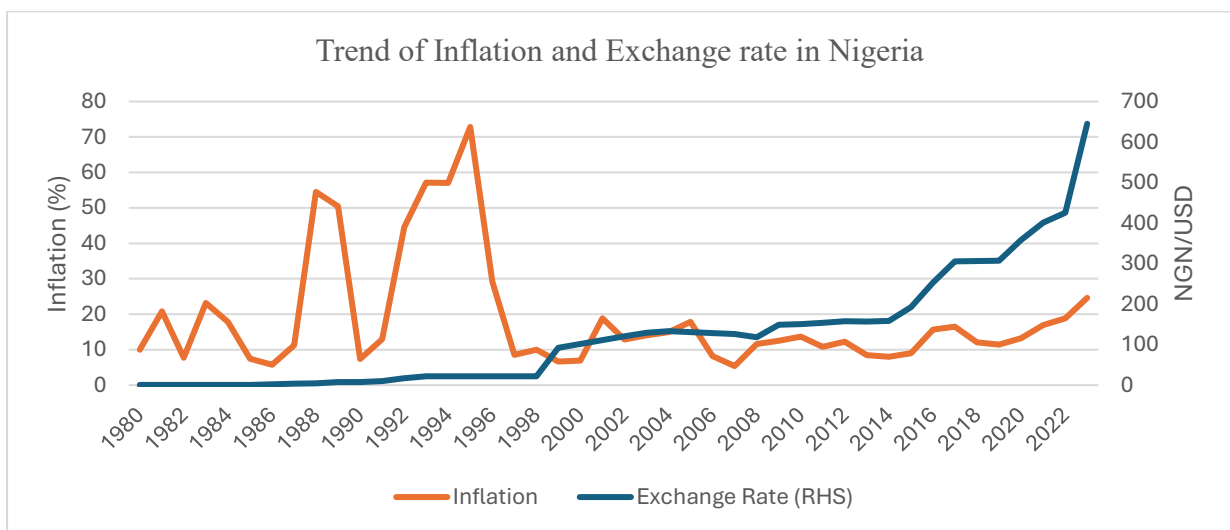
Nigeria

Nigeria’s naira depreciation (0.55 NGN/USD in 1980 to 645.19 in 2023) drives moderate ERPT, moderated by oil revenues during booms. Major depreciations (e.g., 31.9% in 2016, 51.6% in 2023) led to inflation spikes (15.7% in 2016, 24.66% in 2023). A minor depreciation in 1995 (22.00 to 21.90 NGN/USD) coupled with structural adjustment policies

² Central Bank of Liberia (2020). Annual Report 2019. www.cbl.org.lr

and import cost surges, drove hyperinflation (72.84%). In 2016, a 31.9% depreciation (192.44 to 253.49 NGN/USD) due to the oil price collapse amplified ERPT. Oil price crashes, FX restrictions, and reform-related volatility are major causes of the high ERPT to inflation. High ERPT, especially for food and energy. Administrative FX controls distort true pass-through. In addition, oil price volatility drives naira fluctuations, with direct effects on ERPT to inflation (CBN, 2022)³. Multiple exchange rate regimes and monetary policy distortions increase pass-through during crises in Nigeria (IMF, 2022)⁴.

Figure 2.5: Trend of Inflation and Exchange Rate in Nigeria



Data source: World Development Indicators Database, World Bank.

Sierra Leone

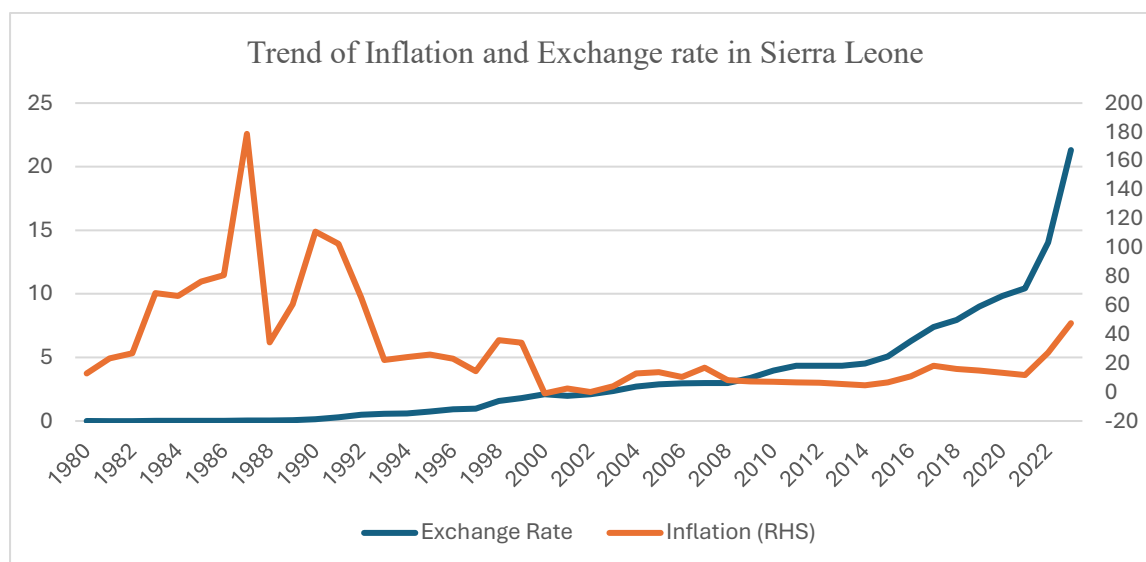
The Leone's depreciation over the years drives high ERPT, with inflation closely tracking exchange rate changes (e.g., 51.9% depreciation in 2022–2023 led to 47.72% inflation). In 1987, a 50% depreciation (0.02 to 0.03 SLE/USD) and post-conflict economic instability drove hyperinflation (178.7%). Similarly, between 2017–2018, a 17.3% depreciation (6.29 to 7.38 SLE/USD) coupled with the Ebola recovery challenges increased ERPT. Also in 2023 a 51.9% depreciation (14.05 to 21.30 SLE/USD) and global supply chain disruptions amplified ERPT to inflation, with inflation increasing to 47.72%. Reliance on diamond and iron ore exports exposes Sierra Leone to terms-of-trade shocks, amplifying ERPT. High inflation persistence and weak monetary frameworks prolong the impact of exchange rate

³ Central Bank of Nigeria (2023). "Economic Report: Fourth Quarter 2022"

⁴ International Monetary Fund (2022). "Nigeria: 2022 Article IV Consultation." IMF Country Report No. 22/33.

shocks (Kovanen, 2011)⁵. In addition, ERPT is strong during crisis periods, especially 2016–2017 and 2022. Post-Ebola stress, donor withdrawal, import reliance, weak domestic production and fuel price hikes were the major drivers.

Figure 2.6: Trend of Inflation and Exchange Rate in Sierra Leone



Data source: World Development Indicators Database, World Bank.

2.2 Implications of ERPT to Inflation in the WAMZ

Exchange rate movements significantly impact inflation in the WAMZ, though the speed and scale of ERPT vary widely. Countries with stronger monetary policy frameworks and more diversified production structures exhibit more contained inflation responses. The ERPT to inflation in the WAMZ is high but varies across countries, driven by import dependence, monetary policy effectiveness, and external shocks. Peaks occur during major depreciations, commodity price spikes, and crises (e.g., 2008–2009, 2020–2023), while troughs align with exchange rate stability and monetary interventions. Structural factors like dollarisation (Liberia), oil dependence (Nigeria), and weak institutions (Sierra Leone, Guinea) shape ERPT dynamics, highlighting challenges for monetary convergence in the WAMZ.

Policy implications include the need to strengthen monetary policy credibility, enhance FX market transparency, diversify production, and coordinate fiscal and monetary responses to external shocks. Thus, monetary policy coordination and exchange rate management are crucial for WAMZ countries to manage inflationary pressures from ERPT. Flexible exchange rate policies combined with foreign exchange interventions can help stabilise exchange rate

⁵ Kovanen, A. (2011). "Monetary Policy Transmission in Sierra Leone." IMF Working Paper WP/11/192.

fluctuations and mitigate ERPT effects on inflation. Structural reforms to diversify economies and reduce dependency on imports can help mitigate the adverse effects of exchange rate depreciation on inflation and economic growth. Enhancing trade policies to improve competitiveness and trade openness can help countries better integrate into the global economy despite exchange rate challenges. Implementing inflation targeting frameworks can help anchor inflation expectations and improve monetary policy effectiveness in managing ERPT.

In essence, WAMZ policymakers should carefully consider the implications of exchange rate fluctuations and implement strategies to mitigate adverse effects on inflation, growth, and overall economic stability. Understanding the nuances of ERPT can aid in designing effective monetary and fiscal policies tailored to the specific needs and characteristics of each country within the WAMZ.

3.0 Literature Review

The relationship between exchange rate fluctuations and inflation has been extensively examined in the economics literature, particularly through the lens of ERPT. ERPT is the extent to which variations in the nominal exchange rate are reflected in domestic prices. Foundational models, such as the Dornbusch (1976) overshooting model and the New Keynesian Phillips Curve (NKPC) framework, provide a theoretical basis for comprehending ERPT. These models posit that exchange rate fluctuations influence domestic prices via changes in the prices of imported goods and production costs, thereby affecting inflation dynamics.

The theory of Purchasing Power Parity (PPP) also explains how exchange rates could influence consumer prices. The theory posits that domestic currency depreciation will leave the domestic economy needing more units of its currency to purchase foreign goods or the value of the same unit in foreign currency. Consequently, acquiring imported goods will come at a higher price to the domestic economy because of the exchange rate. Given that the PPP theory promotes the view that the exchange rate is a factor that reflects the price difference between two trading partners, a sizeable number of researchers have confirmed that exchange rate movements transmit to domestic prices (Campa & Goldberg, 2005; Golfajn & Werlang, 2000)

The magnitude and velocity of ERPT are contingent upon various structural and policy-related factors. In developing economies and regions such as WAMZ, factors including high import dependence, exchange rate volatility, and weak monetary policy credibility typically result in more pronounced and persistent pass-through effects (Calvo & Reinhart, 2002). Additionally, menu cost models and pricing-to-market behaviour indicate that ERPT may exhibit nonlinearity. Firms may only adjust prices when exchange rate changes surpass certain

thresholds, introducing nonlinearities and asymmetries in the pass-through process (Taylor, 2000).

Recent theoretical advancements have incorporated the concept of asymmetric threshold effects, wherein the pass-through of exchange rate depreciation differs from that of appreciation, often due to nominal rigidities, market power, or anchored expectations (Devereux & Yetman, 2010). These theories are consistent with the Smooth Transition Regression (STR) framework, which accommodates regime-switching behaviour in economic relationships. In the context of WAMZ, where inflation-targeting regimes are either weak or non-existent and currencies frequently experience persistent depreciations, such threshold effects may significantly shape the inflationary consequences of exchange rate movements.

Many empirical studies have examined the relationship between exchange rate pass-through and inflation. In recent times, several studies have characterised the relationship as non-linear as well as asymmetric (see Bigerna, 2024; Kwon & Shin, 2023; Tihamiyu & Kehinde, 2022; Aisen, Manguinhane & Simone, 2021). Correa & Minella (2010), for example, established that in Brazil, the short-run pass through is higher when the economy is booming, when the exchange rate depreciates and when exchange rate volatility is lower.

Studies have also delivered varying results on the degree of ERPT to inflation. Risher (1989) made a strong case that the degree of the pass-through depended on the dynamics of the economy, which is contingent on the level of openness of the economy, the market structure and or type, and the level of external competitiveness. Moreover, exchange rate transmission to inflation has been tested strongly, and a certain degree of exchange rate variation would distort price stability (see Valogo *et al.*, 2023; Citci & Kaya, 2023). Therefore, it is crucial to understand the magnitude of ERPT to inflation and its effect on consumer prices, as well as expectations, while formulating policies.

Some findings have indicated that the monetary policy framework employed could impact exchange rate pass-through to inflation. Karagoz *et al.* (2016) observed that with the introduction of the inflation targeting regime, the effect of exchange rate pass-through weakened. However, Pham *et al.* (2020) observed that the exchange rate effect on inflation varied between and among inflation-targeting and non-inflation-targeting countries, and that oil price shocks impacted inflation the most regardless of the monetary policy regime.

Import-based economies were observed to be prone to exchange rate shocks (see, Valogo *et al.*, 2023; Tiarniyu & Kehinde, 2022; Aisen *et al.*, 2021), and with limited hedging opportunities, importers usually adopt pricing strategies that incorporate exchange rate movements. Citci and Kaya (2023) showed that such pricing behaviour creates a link between exchange rate uncertainty and headline inflation.

The exchange rate has also been argued as a powerful tool in an inflation-targeting monetary policy framework because of its transmission to inflation. In an inflation-targeting regime, it is assumed that policy is set to respond to changes in inflation and output gaps, where the inflation gap is defined as the future inflation deviation from target, and the output gap is the deviation of the actual output from the potential output. Using monthly data from 2002 to 2018 in Ghana, a study by Valogo *et. al* (2023) used the Threshold Autoregressive (TAR) model and indicated that exchange rate depreciation above 0.7 percent leads to a significant positive ERPT. The study also further showed that exchange rate movements, even below the threshold of 0.5 percent, influence the monetary policy rate, suggesting that the monetary authorities in Ghana should monitor exchange rate fluctuations closely to prevent excessive ERPT.

ERPT was considered low and declining in developed nations, explained by a stable macroeconomic environment and credible monetary policy regimes (Gagnon & Ihrig, 2004). Sentiments may also influence how exchange rates affect consumer prices. The rationale behind the observed decline of ERPT under a credible monetary policy regime was also explained in the Taylor hypothesis. It was explained that firm pricing power reduces, hence the pass-through cost, in a low-inflation environment. Kwon and Shin (2023), when analysing the Korean economy between 1998 to 2022, using the smooth transition vector autoregression model, found that the degree of ERPT to inflation was higher in Korean states with low monetary credibility, and lower in states with higher credibility. Campa and Goldberg (2005) also found that OECD countries experienced low pass-through due to pricing-to-market practices and inflation anchoring. Additionally, persistent exchange rate depreciation will likely affect expectations and consequently accelerate prices (Taylor, 2000). The study asserted that the exchange rate pass-through effect on inflation is more prevalent in an inflationary environment compared to markets with lower-level inflation. Loloh (2014) found evidence of the Taylor hypothesis that the ERPT effect was more ubiquitous in an inflationary environment. Furthermore, Nasir *et al.* (2020) implied that periods of price stability can help anchor inflation expectations, and other determinants of inflation expectations include fiscal stance, money supply, unemployment, oil price shock, and GDP growth. The exchange rate has also been

researched and tested to impact the cost of production indices and consumer prices at different magnitudes, depending on the industry and degree of openness. Campa *et al.* (2003) observed that within the Euro area, the exchange rate pass-through effect on the cost of production index and consumer prices varied across different countries, industries, and products when considering the common currency. However, the long-run pass-through effects do not differ significantly across countries and industries.

Emerging markets often exhibit stronger and more volatile ERPT. Goldfajn and Werlang (2000) affirmed that countries with high inflation and fragile monetary institutions experienced stronger ERPT. The magnitude of exchange rate pass-through could also be determined by the degree of dollarisation (Anaya, 2000). In analysing two groups of emerging markets, Karagoz *et al.* (2016) pointed out that the existence of dollarisation increases vulnerabilities and price stability and leads to a stronger exchange rate pass-through effect. The study also asserted that de-dollarisation would limit the pass-through, which was consistent with Taylor (2000), highlighting the significantly strong correlation between ERPT and dollarisation. However, Honohan and Shi (2001), found that in emerging economies that were highly dollarised, the impact of exchange rate shock was incomplete because of weak monetary transmission. Scholars have suggested that the exchange rate regime employed could influence the exchange rate-inflation nexus. Jiang and Kim D. (2013) noted that exchange rate stability plays a unique role in price stability. The study observed that as the Chinese authority abandoned the peg exchange rate regime (to the U.S. dollar) in 2005, and opened its economy, exchange rate movements started to influence price inflation in China in a significant way.

In the WAMZ countries, work on ERPT to domestic prices is limited, and with most studies where available, adopt the linear model approach. For the case of Nigeria, Aliyu *et al.* (2019) employed the Vector Error Correction Model (VECM) to investigate the ERPT to prices. They found evidence of incomplete ERPT, owing to structural rigidities and weak monetary policy transmission. This result is similar to the study by Touray *et al.* (2017) for The Gambia using the VAR and ARDL approaches. Moreover, examining the impact of exchange rate fluctuations on consumer prices in Sierra Leone using the VECM, Kallie *et al.* (2024) concluded that ERPT is not complete. This indicates that movements in the exchange rate partially transmit to domestic prices. Investigating the asymmetrical relationship between exchange rate and consumer prices in Ghana, Obeng *et al.* (2022) found that currency depreciation has a more significant effect on prices than appreciation, both in the short and long run.

Table 2: Summary of the Relevant Empirical Literature

S/NO	Studies	Sample/Scope	Theoretical Framework	Methodology		Empirical Results/Findings
				Estimation Methods	Variables	
Exchange Rate - Inflation Nexus Studies						
1	Simona Bigerna, (2024)	11 MENA, 2010 - 2022	Oil price shock, inflation, exchange rate nexus	VARX model	Oil price, inflation, exchange rate (REER),	Empirical evidence pointed towards an asymmetric contagion effect, ERPT to inflation was relevant only for oil importing countries while oil price declines had more effect on oil exporters.
2	Kwon J., Shin W., (2023)	Korea, 1998 - 2022	Nonlinear effects of exchange rate shocks on inflation	Smooth transition vector autoregression model	Exchange rate, CPI, IPI, PPI, interest rate	Found that the degree of ERPT to inflation was higher in Korean states with low monetary credibility, and lower in states with higher credibility.
3	Anderl C., Caporale G. M., (2023)	Five IT regime countries (UK, Canada, Australia, New Zealand and Sweden), 1993 – 2021	Nonlinearities in the ERPT to consumer and import prices	Smooth transition regression model	Inflation expectation, CPI, IPI	Result suggested that managing inflation expectations can reduce the ERPT and that EPRT to import prices was stronger than that to consumer prices
4	Ding S., Zheng D., Cui T., Min Du, (2023)	China, 2008 - 2022	ERPT effect of Inflation, oil prices nexus	VAR-MIDAS model.	Exchange rates, inflation, oil price	Result revealed that oil price shock has a strong and persistent impact on exchange rate and therefore constitute a significant weight of ERPT to inflation
5	Valogo et al., (2023)	Ghana, 2002 - 2018	Threshold effect of ERPT on Inflation	Threshold Autoregressive (TAR)	Exchange rate, CPI, inflation gap, output gap, MPR	Result showed that exchange rate depreciation beyond a monthly threshold of 0.70 percent had significantly positive pass-through effect to inflation

6	Sadettin Haluk Citci, Hüseyin Kaya, (2023)	149 Countries, 1980 - 2017	Exchange rate uncertainty, Inflation connectedness	GARCH model	Exchange rates, inflation, oil price, output gap	Result showed a nonlinear connection between exchange rate uncertainty and inflation. Also, the effect of exchange rate uncertainty on inflation was significant, however the degree of ERPT and the effect of exchange rate uncertainty on inflation varies among country group and have decreased over time.
7	Simona Bigerna, (2023)	15 G20 countries, 2010 - 2021	Energy price shocks, exchange rates and inflation nexus	VARX model	Exchange rate (REER), CPI, oil prices, interest rate, unemployment,	Result shows evidence of asymmetric contagion but relevant only for some oil importing countries. Also, the significant effect depended on the oil price considered.
8	Tiamiyu, Kehinde A., (2022)	Nigeria, 2000 - 2021	ERPT, Inflation Symmetric	Non-linear ARDL	CPI, PPI, WPI, IPI, IMP, money supply	Results suggested an asymmetric behavior of exchange rate changes over time, the pass-through effect was stronger in the short-run and declining over time. Also, inflation was seldom due to money supply as exchange rate was found to explain inflation better.
9	Aisen, Manguinhane and Simone, (2021)	Mozambique, 2001 - 2019	ERPT magnitude and Speed	ARDL	CPI, Exchange rate (NEER), import price (MPI), money supply, rainfall index	the paper suggested an asymmetric effect of the pass-through. Also the effect was termed substantial, and that the ER variation was transmitted to prices in less than 6 months

10	Pham et al., (2020)	ASEAN-5 Countries, 2000 - 2019	Exchange rate Inflation & Inflation targeting regime	Non-linear ARDL	Inflation, GDP growth, REER, oil price, money supply	Result showed that exchange rate shocks led to significant changes in inflation, and that the effect varied between and among inflation targeting and non-inflation targeting countries. It was also observed that oil price shock impacted inflation the most regardless of the monetary policy regime.
11	Muhammad Ali Nasir et al., (2020)	Czechia 1999 - 2018	ERPT to Inflation expectation	Non-linear ARDL	Inflation Expectations, GDP, inflation, unemployment, fiscal stance, oil prices and money supply	The study found that ERPT substantially influenced inflation expectation and inflation impacted future expectations significantly.
12	Jasov M. et al., (2019)	11 Advance and 22 Emerging economies, 1994 - 2017	ERPT to Inflation	Dynamic panel regression with system GMM	Exchange rate (NEER & bilateral-USD), CPI, inflation expectation, oil price, output gap (domestic & global)	Found that ERPT remain relatively low in Advance economies. Also, ERPT showed a declining effect over time and that the decline is related to moderating inflation. Finally, the study revealed that it was important to control for non-linearities when estimating ERPT to inflation
13	Baharumshah, (2017)	Mexico, 1990 - 2015	Asymmetry of ERPT	Non-linear ARDL	CPI, oil price, exchange rate (REER) output gap, labour	Result confirmed asymmetric relationship and revealed that ERPT were seen more during currency depreciation than appreciation. Also, ERPT significantly weakened post IT regime when low inflation was

						experienced. However, oil price passthrough to domestic prices strengthened.
14	Baharumshah, et al., (2017)	6 Asian Countries, 1980 - 2014	Non-linearity of ERPT to domestic prices	Markov-switching model	Exchange Rate, inflation,	The study revealed that domestic prices were sensitive to external factors when inflation uncertainty was higher. Result also asserted that output gap influenced inflation the most
15	Karagoz et al., (2016)	Turkey, Asian pacific & Latin (south) America economies	ERPT to Prices	VAR model	Consumer price index, producer price index, growth, commodity prices, exchange rate	Result showed that the pass-through effect in Asia Pacific economies was lower than that of Latin America and Turkey. Moreover, the moderated pass-through for Asia Pacific economies depended on lower historical inflation and dollarization problem compared than Turkey and the Latin America economies.
16	Rehim Kiliç, (2015)	6 Advance economies, 1975 - 2010	ERPT to import prices, linearity	logistic smooth transition pass-through (LSTP) regression	Exchange rate, import prices, real GDP	Result showed that the pass-through appeared to be incomplete for moderated currency appreciation and depreciation during low inflationary and disinflationary period(s). However, it was seen to be complete in the long run when it reaches or exceeds a certain threshold. The result also revealed both non-linearity and asymmetric dynamics.

17	Loloh F. W., (2014)	Ghana, 1994 – 2012	ERPT effect on domestic prices	Six-variable recursive Vector autoregression (VAR) approach	oil prices, output gap, exchange rate, Headline and non-food inflation, and interest rates (money market)	Found that the effect of nominal exchange rate shock on domestic prices was incomplete, largely moderated and disappears between 18 to 24 months. Moreover, there were evidence of the Taylor hypothesis
18	Peóna & Brindisb, (2014)	Mexico, 2001 - 2013	ERPT to domestic prices	Recursive SVAR-X	Exchange rate, CPI, PPI, IPI,	Result showed minimum effect of ERPT to consumer prices post inflation targeting regime with a small cumulative pass-through elasticity. However, the ERPT to import prices was nearly complete with 0.91 elasticity, and the transmission of the shock is seen after 7 months.
19	Jiang J., & Kim D., (2013)	China, 1999 - 2009	Impact of Exchange rate changes on prices	Structural vector autoregression (SVAR) model	Nominal exchange rate, PPI, RPI	Found that ERPT to Producer price index & retail price index were generally incomplete and relatively rapid. However, the pass-through to PPI was higher than that of RPI
20	Campa et al. (2003)	Euro area, 1989 - 2001	Differences in ERPT	Nested model	CPI, PPI, exchange rates, foreign price index, Output	Found that for the common currency, there were different degrees of exchange rate pass-through effect to cost of production index and consumer prices across countries and industries and product. However, the long run passthrough effects don't differ significantly across countries and industries.

Drawing from the literature, the ERPT to domestic prices is mixed across countries, marked by varying inflation and exchange rate regimes, monetary policy frameworks as well as macroeconomic conditions. While most existing studies in the WAMZ region rely on linear models and assume symmetric responses of prices to exchange rate changes, recent evidence suggests that ERPT may also be non-linear. Therefore, the study will employ both linear and non-linear approaches and also test for the presence of threshold effects in the Member States. Given the persistent exposure of WAMZ economies to currency depreciation and price pressures, this methodological gap hinders a comprehensive understanding of how exchange rate movements truly transmit to inflation. This, therefore, limits the ability of the monetary authorities of the region to effectively respond to inflationary pressures arising from exchange rate volatility.

4.0 Methodology and Empirical Framework

4.1 Estimation Technique

The estimation technique adopted in this study is the Smooth Transition Regression (STR) technique developed by Terasvirta (1994). The STR allows for a nonlinear and smooth adjustment of the dependent variable to changes in the independent variables. It generalises the threshold autoregressive (TAR) model, assuming a sudden and discrete switch between different regimes. The STR model has been widely used in the empirical literature to examine nonlinear relationships between/ among economic variables because of its advantages over other nonlinear models. Specifically, it has been utilised to investigate the ERPT to inflation in some studies (Shintani *et al.*, 2013; Kilic, 2015; Anderl & Caporale, 2023).

The STR estimation technique is attractive to modellers because of its several advantages. First, STR models are flexible as they can capture non-linear relationships between variables, allowing for a more accurate representation of complex economic phenomena (Teräsvirta, 1994). Second, STR models can capture regime-dependent dynamics, where the relationship between variables changes across different regimes (Franses & van Dijk, 2000). In addition, STR models are robust to outliers and non-normality, making them suitable for modelling economic data (Lin & Terasvirta, 1994). Also, it can accommodate asymmetric effects, where the response to positive and negative changes in the explanatory variable differs (van Dijk & Franses, 2000). Finally, STR models provide clear and interpretable results, making it easy to understand the relationships between variables (Terasvirta & Anderson, 1992).

The specification of the standard STR model is shown in equation (1):

$$y_t = \beta_1 x_{t-1} + \beta_2 x_{t-1} \cdot G(z_{t-d}, \gamma, c) + u_t \quad (1)$$

Where β_1 is the vector of coefficients for the linear part of the model and β_2 is the vector of coefficients for the non-linear part of the model. x_t is a vector of the explanatory variables, including the threshold variable, u_t is a vector of the stochastic error term and $G(z_{t-d}, \gamma, c)$ is the transition function.

The transition function is a continuous function of the threshold variable. It is normalised to range between 0 and 1 and depends on the transition variable z_{t-d} , the slope parameter γ , and the threshold parameter c . The smoothness of the transition function and the threshold value depend on γ and c , respectively. The transition variable, z_{t-d} , is exogenous and has a delay parameter d . In equation (2), we specify the STR as the basis for the determination of the transition regimes, where it allows for a smooth transition depending on the transition variable z_{t-d}

$$y_t = \begin{cases} \beta_{10} + \beta_{20}x_{t-1} + \varepsilon_{1t} & \text{if } z_{t-d} \leq c \\ \beta_{11} + \beta_{21}x_{t-1} + \varepsilon_{2t} & \text{if } z_{t-d} > c \end{cases} \quad (2)$$

Terasvirta (1994) identified two different STR models with different degrees of regressive decay. They are the exponential STR and the logistic STR. To determine which of the STR models to use in a study, Escribano and Jordá (2001) developed an improved LM test for that purpose. The logistic STR model has a transition function of the form specified in equation 3:

$$F(z_{t-d}, \gamma, c) = \frac{1}{(1 + \exp\{-\gamma(z_{t-d} - c)\})} \quad (3)$$

From equation 3, the Logistic function value is bounded between 0 and 1, and it depends on the transition variable z_{t-d} as follows: if $z_{t-d} \rightarrow -\infty$, $F(z_{t-d}, \gamma, c) \rightarrow 0$, $F(z_{t-d}, \gamma, c) = 0.5$ for $z_t = c$, and $F(z_{t-d}, \gamma, c) \rightarrow 1$ as $z_t \rightarrow +\infty$. The transition variable (z_{t-d}) and the transition parameter (γ) determines the speed of reversion. That is, for a specific value of the transition variable (z_{t-d}), the speed of transition between regimes depends on the transition parameter (γ). Therefore, low values of the transition parameter imply a slower transition. Thus, the threshold parameter (c) can be interpreted as the threshold between the two regimes corresponding to when the transition function takes the value 0 and 1, i.e. $F(z_{t-d}, \gamma, c) = 0$ and $F(z_{t-d}, \gamma, c) = 1$. The logistic function changes monotonically and can depict asymmetric behaviour between negative and positive deviations of z_{t-d} from c . Thus, the logistic model specifically accounts for asymmetries in EPRT arising due to an increase or decrease in the

threshold of the exchange rate (Kilic, 2015; Anderl & Caporale, 2023). The transition function of the exponential form is as follows:

$$G(Z_{t-d}, \gamma, c) = 1 + \frac{1}{\exp(-\gamma(Z_{t-d}-c))} - \frac{1}{2} \quad (4)$$

The parameters are the same as in the Logistic form above but the transition function of the exponential form changes symmetrically around the threshold parameter c , unlike the Logistic form which changes monotonically. This implies that the interpretation of the results varies based on the form of the transition function used. The advantage of the logistic model is that it can explain asymmetric behaviour between negative and positive deviations of Z_{t-d} , from c . On the other hand, the exponential model provides for symmetric behaviour of negative and positive deviations but considers the distance of Z_{t-d} , from c .

4.2 Model Specification

This paper investigates the asymmetric threshold effects of the ERPT on inflation for individual WAMZ member countries. To this end, we employ the Logistic Smooth Transition Regression (LSTR) model to capture the potential nonlinear and asymmetric effects of exchange rate changes on inflation. The LSTR model is particularly suited for capturing nonlinear dynamics and potential asymmetries in the ERPT to inflation. The LSTR model allows for different regimes in the data, which can be interpreted as periods of low (currency appreciation) and high (currency depreciation)⁶ pass-through of exchange rates to inflation. The LSTR is a component of a family of Threshold Autoregressive (TAR) models known as smooth transition regression (STR) models introduced by Teräsvirta (1994). The LSTR model is a powerful tool for capturing nonlinear relationships and regime changes in time series data. Its counterpart is the exponential smooth transition regression (ESTR) model. However, the LSTR model was selected because it is a simple modelling framework that can capture the response of consumer prices to changes in the exchange rate when such changes are both asymmetric and of smooth transition types.

Following the methodology of Kilic (2015) and Anderl and Caporale (2023), we specify the LSTR model to capture the asymmetric threshold effect of ERPT to inflation for individual WAMZ member countries as follows:

⁶ We utilise the direct quote measurement approach, hence, a higher fluctuation in exchange rate indicates that the domestic currency is depreciating or weaker since the price of the foreign currency is technically rising and vice versa.

$$\Delta \pi_t^j = \alpha + \left[\sum_{i=0}^p \beta_i \Delta s_{t-i}^j \right] \left(1 - F(\gamma, c, z_{t-d}) \right) + \left[\sum_{i=0}^p \beta_i^* \Delta s_{t-i}^j \right] F(\gamma, c, z_{t-d}) + \sum_{i=0}^p \omega_i \Delta X_{t-i}^j + u_t^j \quad (5)$$

Where π_t^j is the log difference of consumer price index (CPI) for country j at time t ; Δs_{t-i} is the lagged changes in the nominal exchange rate (the threshold variable); X_t is a vector of control variables that influence the inflation rate and include nominal GDP, foreign prices, interest rate and real effective exchange rate; α is the intercept term β_i is the coefficients on the exchange rate changes — this is the linear effect of exchange rate changes on inflation, β_i^* is the coefficients that interact with the transition function — represent the nonlinear, regime-dependent effect of exchange rate changes, ω_i are coefficients of the control variables and ε_t is the error term. $F(\cdot)$ is the transition function that controls the nonlinear dynamics. It controls the smooth shift between regimes and allows the pass-through to differ during depreciation vs. appreciation, and is based on a logistic function given as:

$$F(\gamma, cz_{t-d}) = \frac{1}{\left[1 + \exp(-\gamma(z_{t-d} - c)) \right]} \quad (5)$$

In Eq. (5), z_t is the transition variable, d is the delay parameter, γ is a slope parameter (or the transition parameter), and c is a location/ threshold parameter. The parameter restriction $\gamma > 0$ is an identifying restriction. The transition variable's (z) d -lagged period values characterise the transition and pass-through dynamics and link the ERPT to the macroeconomic conditions. In this study, the exchange rate change is our transition variable.

The logistic transition function approaches zero when the transition variables are very large negative values and approaches 1 when the transition variables are very large positive values, i.e. as $z_t \rightarrow -\infty$, $F(\cdot) \rightarrow 0$ and as $z_t \rightarrow +\infty$ $F(\cdot) \rightarrow 1$. Also, when the transition variable is close to the threshold parameter c , the transition function becomes 0.5. When $\gamma \rightarrow \infty$, the logistic transition function $F(\cdot)$ gravitates towards a step function, making the LSTR model effectively a threshold model. This implies that the LSTR model nests a two-regime threshold pass-through regression model and the parameter c is the threshold between the two regimes corresponding to $F(z_t; \gamma, c) = 0$ and $F(z_t; \gamma, c) = 1$ given that the logistic function changes monotonically from 0 to 1 as z_t rises. Additionally, there exists an intermediate regime that occurs when $F(z_t=c; \gamma, c) = 0.5$. Therefore, depending on the values of the ERPT parameters, (β_i, β_i^*) , $i=0, 1, \dots, p$, the inflation rates in both the short run and the long run can vary between these extreme regimes. The LSTR model specification allows both the short-run and long-run EPRT coefficients to change smoothly between the extreme regimes corresponding to $F(\cdot)=0$ and $F(\cdot)=1$.

We perform a test for linearity between the exchange rate and inflation against the alternative hypothesis of the STR model. This test allows us to ascertain whether there is a nonlinear relationship between the exchange rate and inflation in the WAMZ. To determine the presence of nonlinearities in the ERPT to inflation relationship, the null hypothesis of homogeneity, $H_0: \gamma = 0$ or $H_0: \beta_0 = \beta_1$, is tested against the alternative of the STR model. This test involves testing a linear model ($r = 0$) against the STR model with one transition function ($H_0: r = 1$) or two extreme regimes. The test is evaluated using the probability values of the Wald, Fisher and Likelihood ratio test statistics. A rejection of the null hypothesis of linearity means that the relationship is nonlinear. This implies that further testing of the remaining heterogeneity is necessary to determine the number of location parameters and transition functions. We will conduct additional tests to ensure no remaining nonlinearities exist in the underlying relationship. The tests are determined by the outcome of the probability values of the Wald, Fisher and Likelihood ratio tests. The robustness of the results was tested by estimating alternative models of the STR model to determine if the nonlinearity in ERPT to inflation results is sensitive to the choice of control variables. The study also conducted diagnostic tests, which include tests for residual serial correlation, ARCH heteroscedasticity, and parameter constancy for the six WAMZ countries

4.3 Description of Data

To achieve the study, we employed annual time series data covering the period 1980 to 2023 for all six WAMZ member countries (i.e. The Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone). Data availability determined the study period. We use the log of CPI in difference form to investigate the ERPT. Like Kilic (2015), we use the log of the exchange rate as the threshold variable. The exchange rate is measured as the domestic currency per unit of foreign currency, i.e. the US dollar. This implies that an increase in the exchange rate will be interpreted as a depreciation of the domestic currency. To control for other variables that affect inflation, we include the difference in the log of nominal GDP, the difference of the log of foreign prices measured by baskets of United States (US), United Kingdom (UK), and China's CPI being the major trading partners of many of the WAMZ member countries, and the interest rate measured by treasury bills rate (TBR) for Ghana, Nigeria and Sierra Leone, lending rates (LR) for Guinea and Liberia, and Monetary Policy Rate (MPR) for the Gambia. (where TBR is not available). The data for CPI, exchange rate, real effective exchange rate and interest rate

were sourced from the IMF International Financial Statistics database, whilst that of nominal GDP was sourced from the World Bank World Development Indicators (WDI) database.

5.0 Presentation and Discussion of Results

This section presents and discusses the empirical findings on the possible existence of ERPT to inflation and its threshold values in the WAMZ Countries. The LSTR model is used to endogenously determine the presence of such threshold effects at the country level, covering the period of 1980-2023. The study also reflects on the time series properties of all the variables used in the LSTR model, as it is germane to ensure that all the variables are stationary, given the analysis period. The empirical specification is consistent with recent studies that have applied the LSTR model (Fouquau et al., 2008; Kilic, 2015; Anderl & Caporale, 2023).

5.1 Unit Root Test

There is a growing consensus among scholars that the traditional tests used in empirical research to test for the existence of non-stationary series (presence of unit roots) such as the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests have low power especially in the presence of structural breaks in nonlinear time series. Given this argument, it is helpful to analyse the time series properties of the variables, taking into consideration the second-generation tests such as Zivot and Andrews (1992), Elliott, Rothenberg, and Stock (1996), Kwiatkowski, Phillips, Schmidt and Shin (1992), Ng and Perron (2001).

The results of the unit root tests for nonlinear time series by applying the test proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992) were carried out, but we could not present them to avoid the clumsiness of the paper. Nonetheless, we considered all options: intercept only, intercept and trend, and the appropriate lag length. The results indicate that all the variables expressed in difference forms are stationary or integrated of order zero ($I(0)$) at 1 and 5 percent significance levels for all WAMZ countries. The stationarity of the series implies that the LSTR model is a suitable estimation technique to determine the possible existence of exchange rate pass-through to inflation and its threshold values in the countries.

5.2 Descriptive Statistics

The descriptive statistics for the variables used in the regression during 1980-2023 are also not presented to avoid the clumsiness of the results. The statistics show significant variations in the variables of interest (inflation rate, exchange rate, and other control variables) for the countries over time. The data also shows significant heterogeneity in levels of average

annual inflation and exchange rate variation over time. Similarly, other control variables vary substantially across countries and over time. It points to a potential nonlinear association between the exchange rate and inflation in the region. As discovered in the results, the exchange rate is likely to moderately influence changes in consumer prices (inflation) up to a certain threshold, above which it can significantly propel changes in consumer prices (inflation) of these economies. Overall, the variable descriptions reveal significant variation over time in the nominal exchange rate, inflation rate, real effective exchange rate, output growth, foreign prices, and interest rate. These are interesting features of the dataset that reinforce our view of the suitability of the LSTR model to exploit such heterogeneity and explore the possible nonlinearities in the relationship between exchange rate and inflation in each of the WAMZ member states.

5.3 Linearity and Remaining Nonlinearity Tests

It is important to first determine if there is an existence of nonlinear relationship between the exchange rate and inflation in each Member State. The results presented in Tables 5.1 to 5.6 display the linearity tests against the STR alternatives. For brevity of presentation, we could not present other alternative results of these tests for all WAMZ Member States. The test results show strong rejection of the null hypothesis of linearity at the 5 percent level across all countries. This finding indicates that there exists a nonlinear relationship between the exchange rate and inflation in each country. The outcome is consistent with the findings from other related studies (Kilic, 2015; Anderl and Caporale, 2023), which illustrate a strong nonlinear exchange rate-inflation relationship by applying the STR model across the WAMZ countries. It considers nonlinearity to endogenously determine the “acceptable” threshold level of changes in the exchange rate beyond which it drastically propels changes in consumer prices.

We performed further tests of nonlinearity in the data using the additive nonlinearity tests. Considering the decision rule for estimation of the STR model using the Terasvirta Sequential and Escribano-Jorda tests, our results strongly indicate that a first-order logistic smooth transition regression (LSTR) model should be estimated to capture the nonlinear relationship in the exchange rate-inflation nexus for each country.

5.4 LSTR Model Estimation

Following the determination of the suitability of the estimation of the LSTR model, equation (4) is estimated using the LSTR model by applying the nonlinear least squares to analyse the exchange rate-inflation nonlinearity in each country. The estimation of the LSTR allows us to determine the nominal exchange rate threshold (location parameter), analyse the

behaviour of the nominal exchange rate in both the lower (currency appreciation) regime and that of the upper (currency depreciation) regime. The estimation produces the value for the slope parameter (γ), which shows the extent to which changes in nominal exchange rates above the threshold can drastically propel changes in consumer prices. In estimating the LSTR model, the threshold value and slope coefficient are determined by a grid search. We utilised the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) iteration process in the estimation, allowing the default of 500 iterations (see EViews 13 manual for details).

Tables 5.1 to 5.6 present the parameters from the nonlinear estimation of the LSTR model with threshold changes in the nominal exchange rate for all the WAMZ countries. The results displayed are divided into three (3) components, comprising the linear, nonlinear, and threshold parts. The estimated nominal exchange rate threshold, slope parameter (γ) and relevant regression statistics for 1980-2023, with the associated exchange rate threshold and corresponding confidence intervals of both the threshold level of changes in the exchange rate and the slope parameter at the confidence intervals of 90 percent, 95 percent and 99 percent, respectively. As previously mentioned, the objective is to analyse the threshold effect of the nominal exchange rate on inflation and the associated slope parameter, which allows us to determine the smoothness of the transitions from the lower (currency appreciation) to the upper (currency depreciation) exchange rate regimes to evaluate the speed at which changes in exchange rate above estimated threshold exhibit pass through to inflation. Given this objective, the analysis focuses largely on the estimated ERPT and its threshold effects, the direction of the coefficient of the exchange rate in both the lower (currency appreciation) and upper (currency depreciation) exchange rate regimes, in assessing the possible existence of a nonlinear pass-through effect to inflation and the value of the slope parameter.

5.4.1 The Gambia

In the Gambia, a critical examination of the estimated LSTR (Table 5) shows varying degrees of ERPT for small (e.g., 1%) currency depreciation, depending on the size and direction of deviations from the estimated threshold variables. It is clear that not all changes in the exchange rate are passed through to inflation (incomplete pass-through) and that a small portion is passed through during the lower “currency appreciation” regime, but a higher degree is passed through in the upper “currency depreciation” regime. The results imply that not all changes in the exchange rates have pass-through effects on inflation dynamics. In other words, a 1% change in exchange rates is almost fully (0.9412) passed through to inflation during periods of high or upper currency depreciation, whereas a similar 1% change in exchange rates

generates a negligible (-0.0689) or statistically insignificant reaction in inflation during periods of low or currency appreciation. The responses of other control variables (such as lagged inflation (inflation persistence), real exchange rate, output gap, foreign prices, and interest rate) in the model are largely in line with theoretical predictions, except for a few deviations. This result aligns with existing literature (see Kilic, 2015; Anderl & Caporale, 2023).

The estimated results of the LSTR model (Table 5.1) indicate an exchange rate threshold of 15.49 percent which is statistically significant at the 1 percent significance level. This finding suggests that implementing a menu of policies and programmes that ensure that fluctuations in the exchange rate are below the threshold of 15.49 percent would minimise the pass-through to inflation. Above this threshold, changes in the exchange rate exhibit significantly high pass-through to inflation. This outcome is reflected in the direction of changes in the exchange rate to inflation dynamics, which is consistent with the predictions on the exchange rate-inflation nonlinear relationship. The coefficient on the nominal exchange rate changes in the lower (currency appreciation) regime (-0.0689) is negative, as expected, but statistically insignificant. In the nonlinear (Above-threshold) regime, the effect of nominal exchange rate changes is positive (0.9412), reflecting a high pass-through to inflation, but it is also statistically insignificant. The exchange rate threshold at the 95 percent confidence level is estimated to be 15.49 ± 0.1567 . While the slope coefficient is not statistically significant, the magnitude of the parameter suggests a steep transition function. The shape of the transition function implies that fluctuations in the exchange rate pass through quickly to inflation when it exceeds the threshold of 15.49 percent (see Figure 5.1).

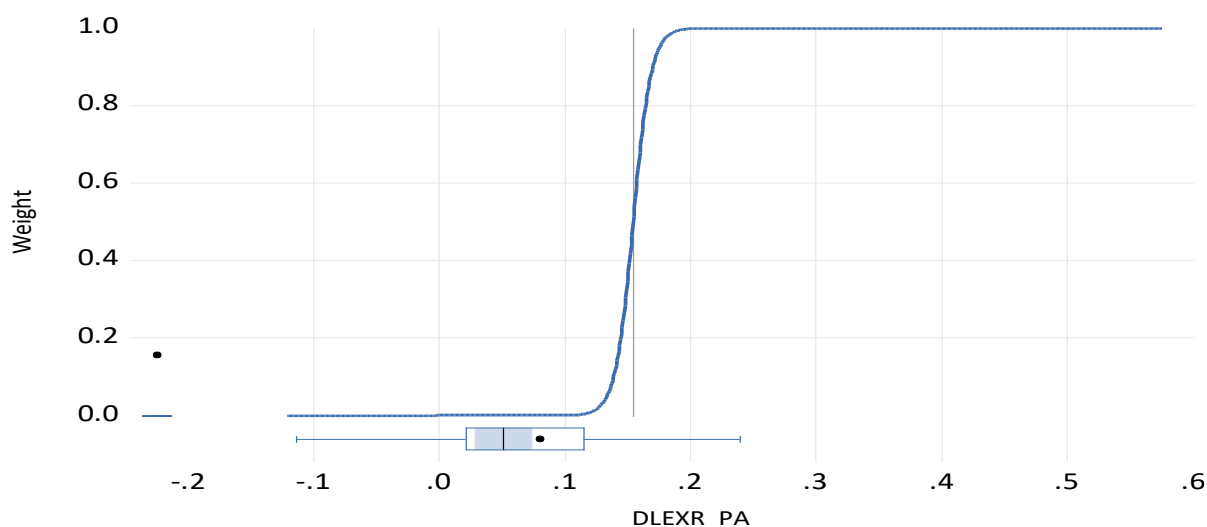
Table 5.1: Smooth Transition Exchange Rate Threshold for The Gambia

Variable	Coef.	90 % Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-2)	0.0334	-0.0241	0.0908	-0.0359	0.1026	-0.0602	0.1270
DLEXR	-0.0689	-0.2902	0.1525	-0.3357	0.1979	-0.4295	0.2918
DLREEXR	-0.1556	-0.3671	0.0559	-0.4105	0.0992	-0.5002	0.1889
DLNGDP	0.9414**	0.8634	1.0194	0.8474	1.0354	0.8143	1.0685
DLFCPI	0.0979	-0.2515	0.0558	-0.2831	0.0873	-0.3482	0.1525
INT	0.0013	-0.0014	0.0040	-0.0020	0.0045	-0.0032	0.0057
Non-Linear Part							
DLCPI(-2)	1.1907	-0.1281	2.5095	-0.3987	2.7801	-0.9579	3.3392
DLEXR	0.9412	-0.0261	1.9084	-0.2245	2.1068	-0.6346	2.5169
DLREEXR	-0.6554	-2.2957	0.9848	-2.6322	1.3213	-3.3276	2.0167
DLNGDP	-1.7655**	-3.0959	-0.4352	-3.3689	-0.1622	-3.9330	0.4019
DLFCPI	-0.0032	-0.4039	0.4103	-0.4874	0.4938	-0.6600	0.6664
INT	-0.0095*	-0.0182	-0.0008	-0.0200	0.0010	-0.0237	0.0047
Threshold Part							
C	-0.0405	-0.0838	0.0029	-0.0927	0.0118	-0.1111	0.0302
SLOPE	140.73	-1295.60	1577.07	-1590.27	1871.74	-2199.28	2480.75
THRESHOLD	0.1549*	0.0248	0.2849	-0.0018	0.3116	-0.0570	0.3667
CONFIDENCE LEVEL		0.1549±0.1300		0.1549±0.1567		0.1549±0.2118	
R-squared	0.9755						
Adj. R-squared	0.9623						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.

Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

Figure 5.1: Smooth Transition Function for the Gambia's Exchange Rate Threshold
Threshold Weight Function
Logistic (c = 0.154868)



Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

5.4.2 Ghana

As in The Gambia, Ghana also exhibits incomplete exchange rate pass-through to inflation for small exchange rate fluctuations during periods of currency appreciation (i.e., in the lower exchange rate regime), but a higher degree of pass-through during currency depreciation (i.e., in the upper exchange rate regime). For instance, the coefficient of nominal exchange rate in the lower regime is (-0.2337), indicating incomplete pass-through, while there is more than complete pass-through (1.0389) in the upper regime. The estimated results also show a threshold exchange rate value of 23.85 percent, which is statistically significant at the 1 percent level. This finding suggests that implementing a mix of policies that would ensure that fluctuations in the exchange rate are attained below the threshold of 23.85 percent would moderate inflation in the Ghanaian economy. Above this threshold, fluctuations in the exchange rate would significantly propel inflation. This outcome is reflected in the directional effects of fluctuations in the exchange rate on inflation, which is consistent with a-priori expectations and economic literature (See Table 5.2).

The coefficient of the nominal exchange rate in the lower regime is (-0.2337), below this threshold associated with the linear aspect of the estimation, is expected to be negative and statistically insignificant. Above the threshold, associated with the nonlinear component, the exchange rate effect on inflation is positive (1.0389), reflecting exchange rate-fuelled inflation in the domestic economy. The response of other inflation-controlled variables, such as lagged inflation (inflation persistence), the real exchange rate, the output gap, foreign prices, and the interest rate, are largely in line with theoretical predictions with a few deviations (see Table 5.2).

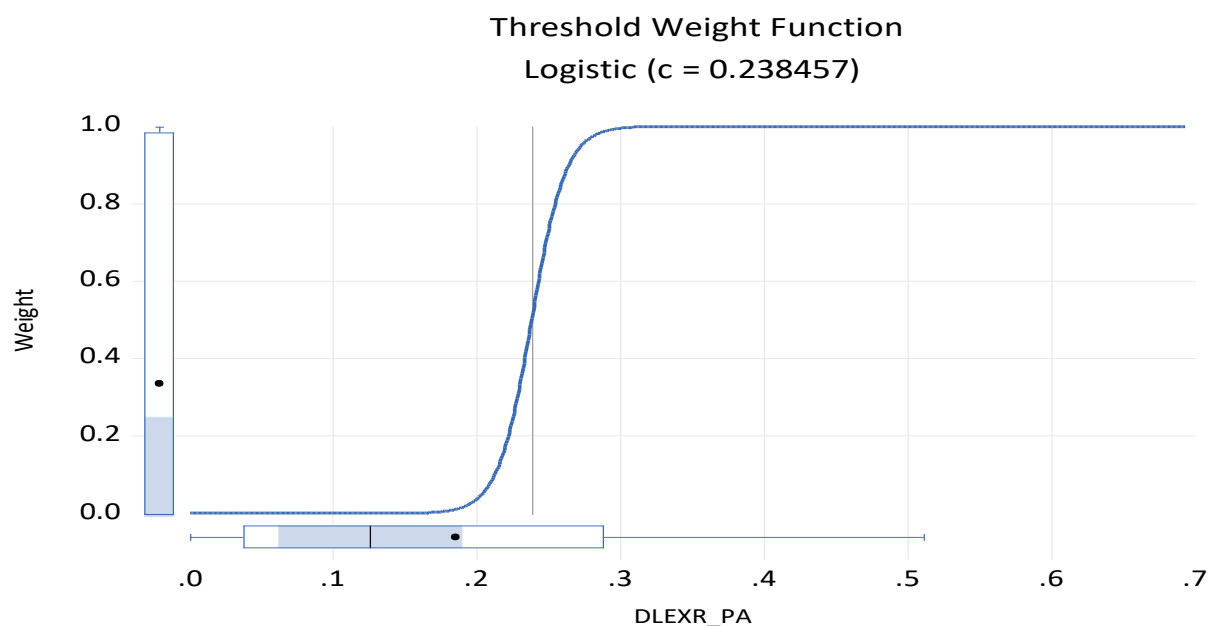
Apart from the threshold value, Table 5.2 also reports the smoothing slope parameter (γ) associated with the exchange rate threshold, and the corresponding confidence intervals of both the threshold level of the exchange rate and the slope parameter at the confidence intervals of 90 percent, 95 percent, and 99 percent, respectively. The exchange rate threshold at the 95 percent confidence level is estimated to be 23.85 ± 0.064 . While the slope coefficient is statistically insignificant, its magnitude suggests a relatively smooth transition function. The shape of the transition function implies that the exchange rate strongly influences inflation when it exceeds the 23.85 percent threshold (see Figure 5.2).

Table 5.2: Smooth Transition Exchange Rate Threshold for Ghana

Variable	Coef.	90% Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-2)	0.0094	-0.3308	0.3497	-0.4012	0.4201	-0.5478	0.5667
DLEXR	-0.2337	-0.7230	0.2557	-0.8243	0.3570	-1.0353	0.5680
DLREEXR	0.3268*	0.1045	0.5491	0.0585	0.5951	-0.0373	0.6909
DLNGDP	0.0712	-0.0801	0.2225	-0.1114	0.2538	-0.1766	0.3190
DLFCPI	1.2774**	0.7834	1.7714	0.6812	1.8737	0.4683	2.0866
INT	0.0062*	0.0006	0.0118	-0.0005	0.0129	-0.0030	0.0153
Non-Linear Part							
DLCPI(-2)	-0.2320	-0.7447	0.2807	-0.8509	0.3868	-1.0719	0.6078
DLEXR	1.0389*	0.3775	1.7003	0.2406	1.8372	-0.0445	2.1222
DLREEXR	0.5081	-0.0591	1.0753	-0.1765	1.1927	-0.4210	1.4372
DLNGDP	-0.0012	-0.6223	0.6199	-0.7508	0.7485	-1.0185	1.0162
DLFCPI	-1.4512**	-2.1481	-0.7543	-2.2924	-0.6100	-2.5927	-0.3096
INT	-0.0041	-0.0112	0.0030	-0.0127	0.0045	-0.0157	0.0076
Threshold Part							
C	-0.0174	-0.0756	0.0408	-0.0877	0.0528	-0.1128	0.0779
SLOPE	85.0523	-407.1670	577.2715	-509.0606	679.1651	-721.2069	891.3115
THRESHOLD	0.2385**	0.1857	0.2912	0.1748	0.3021	0.1520	0.3249
CONFIDENCE LEVEL		0.2385±0.0528		0.2385±0.0637		0.2385±0.0864	
R-squared	0.8372						
Adj. R-squared	0.7381						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.
 ITF – Inflation Targeting (IT) Monetary Policy Framework Dummy Variable for Ghana
 Source: Authors’ computation using EViews 13 based on data from the IMF and World Bank

Figure 5.2: Smooth Transition Function for Ghana’s Exchange Rate Threshold



Source: Authors’ computation using EViews 13 based on data from the IMF and World Bank

5.4.3 Guinea

The Guinean economy, like other WAMZ countries, exhibits asymmetric and incomplete pass-through of nominal exchange rate changes to inflation. Specifically, the LSTR model (Table 5.3) shows a small, even negative, influence of the nominal exchange rate on inflation in the lower (currency appreciation) regime, with very small fractions of currency fluctuations passed through. In the upper (currency depreciation) regime, the pass-through is higher, though still less than complete (0.1546). The nominal exchange rate coefficient in the lower regime is (-0.0023), indicating incomplete pass-through. The estimated threshold exchange rate is 18.32 percent and statistically significant at the 1 percent level. This suggests that policies minimising exchange rate fluctuations below this threshold would moderate inflation in Guinea. Above the threshold, the nominal exchange rate changes significantly and positively fuel inflation in the domestic economy. Other controlled variables (lagged inflation, output gap, foreign prices, and interest rate) generally behave as theoretically expected. This suggests that the Central Bank of the Republic of Guinea should implement policies to keep the exchange rate fluctuations below the 18.32 percent threshold.

Along with the exchange rate threshold value, Table 5.3 reports the smoothing slope parameter (γ) and its associated confidence intervals, along with the confidence intervals for the threshold level of exchange rate at the 90, 95, and 99 percent levels, respectively. The exchange rate threshold at the 95 percent confidence level is estimated to be 18.32 ± 0.5448 . While the slope coefficient is not statistically significant, its magnitude suggests a very steep transition function (see Figure 5.3). The shape of the transition function implies that changes in the nominal exchange rate very quickly pass to inflation when it exceeds the 18.32 percent threshold of 18.32.

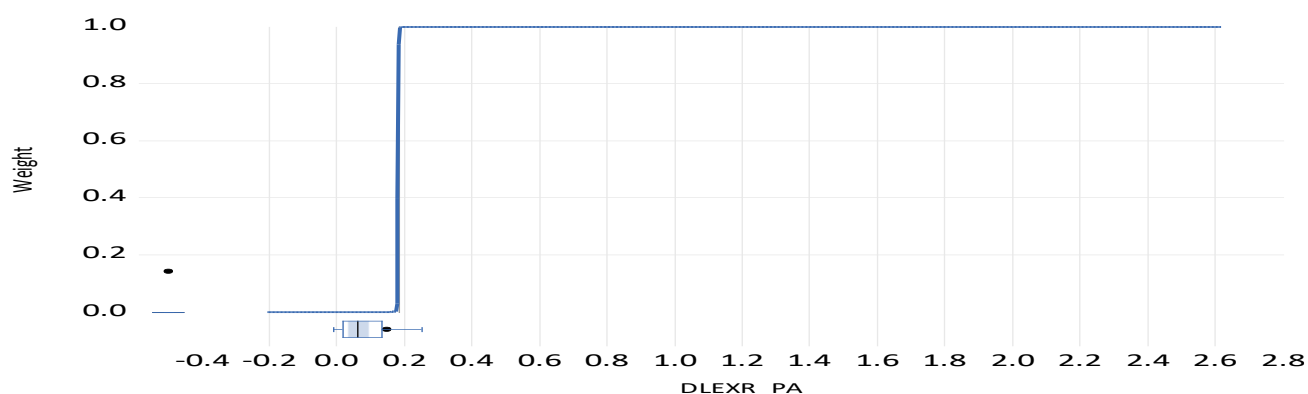
Table 5.3: Smooth Transition Exchange Rate Threshold for Guinea

Variable	Coef.	90 % Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-1)	0.5523**	0.2869	0.8178	0.2328	0.8719	0.1217	0.9830
DLEXR	-0.0023	-0.2355	0.2309	-0.2831	0.2784	-0.3807	0.3761
DLNGDP	0.1029	-0.2296	0.4354	-0.2973	0.5031	-0.4365	0.6423
DLFCPI	0.1156	-0.0417	0.2730	-0.0737	0.3050	-0.1396	0.3709
INT	-0.0019	-0.0069	0.0030	-0.0079	0.0041	-0.0100	0.0061
Non-Linear Part							
DLCPI(-1)	-2.0638**	-3.2191	-0.9085	-3.4544	-0.6731	-3.9379	-0.1896
DLEXR	0.1546	-0.0991	0.4083	-0.1508	0.4599	-0.2570	0.5661
DLNGDP	1.1528*	0.4390	1.8667	0.2936	2.0121	-0.0052	2.3109
DLFCPI	-0.4883	-1.3878	0.4113	-1.5711	0.5945	-1.9476	0.9711
INT	-0.0121*	-0.0229	-0.0013	-0.0251	0.0009	-0.0297	0.0054
Threshold Part							
C	0.0337	-0.0573	0.1247	-0.0759	0.1433	-0.1140	0.1814
SLOPE	1101.25	-198403.50	200606.00	-239041.50	241244.00	-322542.70	324745.20
THRESHOLD	0.1832*	-0.2694	0.6358	-0.3616	0.7280	-0.5511	0.9174
CONFIDENCE LEVEL		0.1832±0.4526		0.1832±0.5448		0.1832±0.7343	
R-squared	0.7655						
Adj. R-squared	0.6857						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.

Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

Figure 5.3: Smooth Transition Function for Guinea's Exchange Rate Threshold
Threshold Weight Function
Logistic (c = 0.183179)



Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

5.4.4 Liberia

In Liberia, the LSTR estimation results (Table 5.4) reveal that nominal exchange rate changes have a negative and statistically insignificant impact on inflation in the lower (currency appreciation) regime, with smaller portions of currency fluctuations passed through to inflation.

In the upper (currency depreciation) regime, these changes have a greater impact on inflation. Specifically, the coefficient of the nominal exchange rate in the lower regime is (-0.2141), signifying incomplete pass-through, while it is 3.0864 (more than complete pass-through) in the upper (currency depreciation) regime. The estimated threshold exchange rate is 11.20 percent, which is statistically significant at the 1 percent significance level. This indicates that below this threshold, smaller changes in the nominal exchange rate are transmitted to inflation in the linear (currency appreciation) region, while above the threshold (nonlinear component), the nominal exchange rate significantly and positively drives inflation in the economy. Other controlled variables (lagged inflation, output gap, foreign prices, and interest rate) generally align with theoretical anticipations. This suggests that the Central Bank of Liberia should continue to use policies to stabilise exchange rate variability below the estimated threshold of 11.20 percent.

Besides the exchange rate threshold value, Table 5.4 also reports the smoothing slope parameter (γ) and its associated confidence intervals, as well as the confidence intervals for the threshold level of the exchange rate at the 90 percent, 95 percent, and 99 percent levels, respectively. The exchange rate threshold at the 95 percent confidence level is estimated to be 11.20 ± 0.1060 . While the slope coefficient is not statistically significant, the magnitude of the parameter suggests a gentle transition function (see Figure 5.4). The shape of the transition function implies that changes in the nominal exchange rate slowly pass to inflation when it exceeds the 11.20 percent threshold.

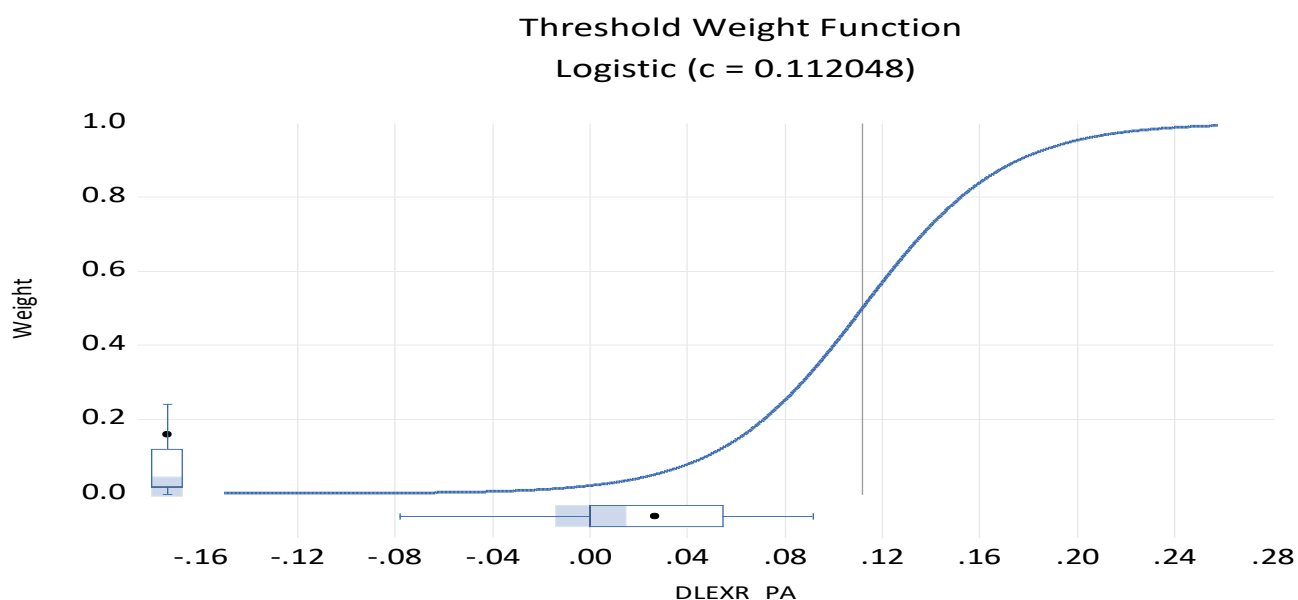
Table 5.4: Smooth Transition Exchange Rate Threshold for Liberia

Variable	Coef.	90% Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-1)	0.2279	-0.6847	0.2289	-0.7796	0.3238	-0.9778	0.5219
DLEXR	-0.2141	-0.7594	0.3311	-0.8726	0.4443	-1.1091	0.6809
DLNGDP	-0.6059	-2.0847	0.8728	-2.3919	1.1801	-3.0334	1.8215
DLFCPI	-0.0270	-0.1048	0.0509	-0.1210	0.0670	-0.1547	0.1008
INT	0.0030	-0.0180	0.0240	-0.0223	0.0284	-0.0314	0.0375
Non-Linear Part							
DLCPI(-1)	-1.2647	-0.3815	2.9109	-0.7234	3.2529	-1.4375	3.9669
DLEXR	3.0864*	0.1819	5.9909	-0.4215	6.5943	-1.6814	7.8542
DLNGDP	22.9649**	4.7079	41.2219	0.9151	45.0147	-7.0046	52.9344
DLFCPI	-0.4563	-1.0613	0.1488	-1.1870	0.2745	-1.4495	0.5369
INT	-0.0024	-0.0304	0.0257	-0.0363	0.0315	-0.0484	0.0437
Threshold Part							
C	-0.0170	-0.3438	0.3099	-0.4117	0.3778	-0.5535	0.5196
SLOPE	34.2776	-16.2951	84.8502	-26.8013	95.3565	-48.7393	117.2944
THRESHOLD	0.1120*	0.0242	0.1999	0.0060	0.2181	-0.0321	0.2562
CONFIDENCE LEVEL		0.1120±0.0878		0.1120±0.1060		0.1120±0.1441	
R-squared	0.6000						
Adj. R-squared	0.5238						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.

Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

Figure 5.4: Smooth Transition Function for Liberia's Exchange Rate Threshold



Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

5.4.5 Nigeria

Turning to the Nigerian economy, it is crystal clear from the estimated results in Table 5.5 that inflation elasticities indicate asymmetric dynamics to the nominal exchange rate, as not all trivial fluctuations in exchange rate are passed through to inflation and that this transmission is more pronounced during depreciation than appreciation. For instance, in the lower (currency appreciation) regime, changes in the nominal exchange rate are passed incompletely to inflation, while a higher degree is passed through in the upper (currency depreciation) regime. Specifically, the coefficient of the nominal exchange rate in the lower regime is (-0.2627), connoting incomplete pass-through, while there is also incomplete pass-through (0.3014) in the upper (currency depreciation) regime. The estimated results also show a threshold exchange rate value of 18.47 percent which is statistically significant at the 1 percent level. This implies that below this threshold, changes in the nominal exchange rate are transmitted in smaller portions to inflation in the linear (currency appreciation) regime, while above the threshold, associated with the nonlinear component, changes in nominal exchange rate significantly and positively drive inflation. Other controlled variables in the model, including lagged inflation, real effective exchange rate, output gap, foreign prices, and interest rate, broadly align with theoretical expectations. This finding suggests that implementing a mix of policies that would ensure that fluctuations in the exchange rate are attained below the threshold of 18.47 percent would moderate inflation in the economy.

In addition to the exchange rate threshold value, Table 5.5 reports the smoothing slope parameter (γ) and its associated confidence intervals, as well as the confidence intervals for the threshold level of the exchange rate at 90 percent, 95 percent, and 99 percent levels, respectively. The exchange rate threshold at the 95 percent confidence level is estimated to be 18.47 ± 0.0409 . While the slope coefficient is not statistically significant, its magnitude suggests a steep transition function (see Figure 5.5). The shape of the transition function implies a rapid pass-through of exchange rate changes to inflation above the 18.47 percent threshold.

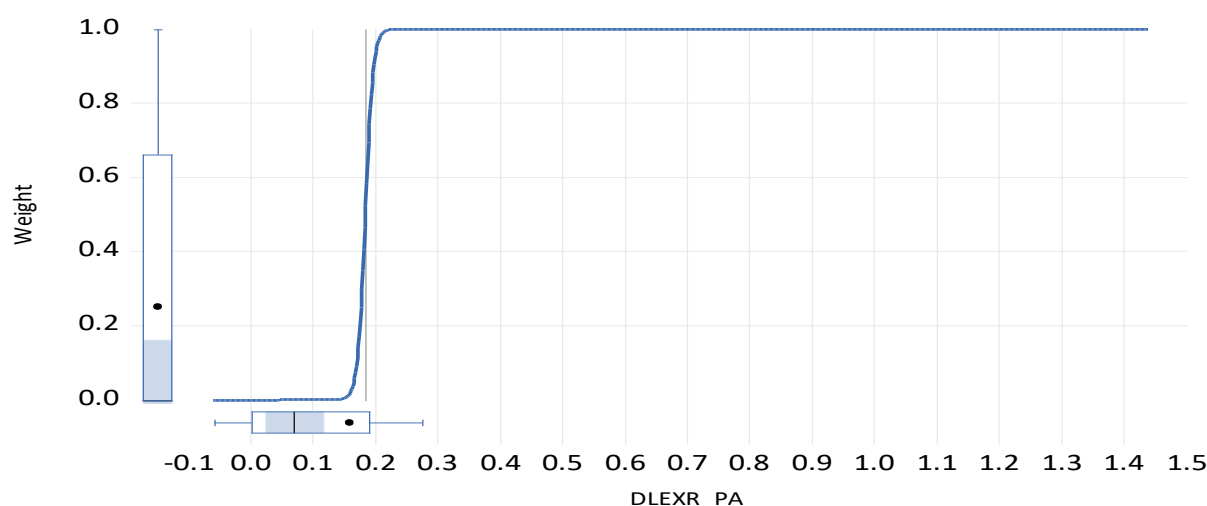
Table 5.5: Smooth Transition Exchange Rate Threshold for Nigeria

Variable	Coef.	90 % Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-2)	0.1049**	0.0666	0.1432	0.0588	0.1511	0.0425	0.1673
DLEXR	-0.2627**	0.1001	0.4253	0.0667	0.4587	-0.0022	0.5276
DLREEXR	0.1794**	0.1008	0.2581	0.0846	0.2742	0.0513	0.3076
DLNGDP	0.8706**	0.7850	0.9563	0.7674	0.9739	0.7310	1.0102
DLFCPI	0.0145	-0.0556	0.0846	-0.0700	0.0990	-0.0997	0.1287
INT	-0.0032**	-0.0051	-0.0014	-0.0055	-0.0010	-0.0063	-0.0002
Non-Linear Part							
DLCPI(-2)	-0.2262	-0.4981	0.0457	-0.5539	0.1015	-0.6692	0.2168
DLEXR	0.3014**	-0.4998	-0.1031	-0.5405	-0.0624	-0.6246	0.0217
DLREEXR	-0.1818**	-0.2958	-0.0678	-0.3192	-0.0444	-0.3676	0.0039
DLNGDP	-0.0829	-0.2668	0.1011	-0.3046	0.1389	-0.3826	0.2169
DLFCPI	0.0419	-0.2015	0.2853	-0.2514	0.3352	-0.3546	0.4384
INT	0.0094**	0.0048	0.0139	0.0038	0.0149	0.0019	0.0168
Threshold Part							
C	-0.0344**	-0.0547	-0.0140	-0.0589	-0.0099	-0.0675	-0.0012
SLOPE	159.91	-1510.78	1830.59	-1853.52	2173.33	-2561.89	2881.70
THRESHOLD	0.1847**	0.1507	0.2186	0.1438	0.2255	0.1294	0.2399
CONFIDENCE LEVEL		0.1847±0.0339		0.1847±0.0409		0.1847±0.0553	
R-squared	0.9714						
Adj. R-squared	0.9560						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.

Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

Figure 5.5: Smooth Transition Function for Nigeria's Exchange Rate Threshold
Threshold Weight Function
Logistic (c = 0.184658)



Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

5.4.6 Sierra Leone

Table 5.6 reports the LSTR model results, revealing that changes in the nominal exchange rate have a negative and statistically insignificant impact on inflation in the lower (currency appreciation) regime, with small portions of currency fluctuation passed through to inflation. In the upper (currency depreciation) regime, these changes in the nominal exchange rate have a greater impact on inflation. The coefficient of the nominal exchange rate in the lower regime is (-0.4260), signifying incomplete pass-through, while there is still incomplete pass-through (0.5365) in the upper (currency depreciation) regime. The estimated threshold is 19.55 percent, which is statistically significant at the 1 percent level. This indicates that below this threshold, smaller changes in the nominal exchange rate are transmitted to inflation in the linear (currency appreciation) region, while above the threshold (nonlinear component), the nominal exchange rate significantly and positively drives inflation in the economy. Other controlled variables (lagged inflation, real effective exchange rate, output gap, foreign prices, and interest rate) broadly align with theoretical expectations. The implication is that the Bank of Sierra Leone should continue to use its policy instruments to stabilise fluctuations in the exchange rate below the estimated threshold of 19.55 percent.

Besides the threshold value, Table 5.6 also reports the smoothing slope parameter (γ) and its associated confidence intervals, as well as the confidence intervals for the threshold level of the exchange rate at 90 percent, 95 percent, and 99 percent, respectively. The exchange rate threshold at the 95 percent confidence level is estimated to be 19.55 ± 0.1060 . While the slope coefficient is statistically insignificant, its magnitude suggests a gradual transition function (see Figure 5.6). The shape of the transition function implies a slow pass-through of the changes in the nominal exchange rate to inflation above the threshold of 19.55 percent.

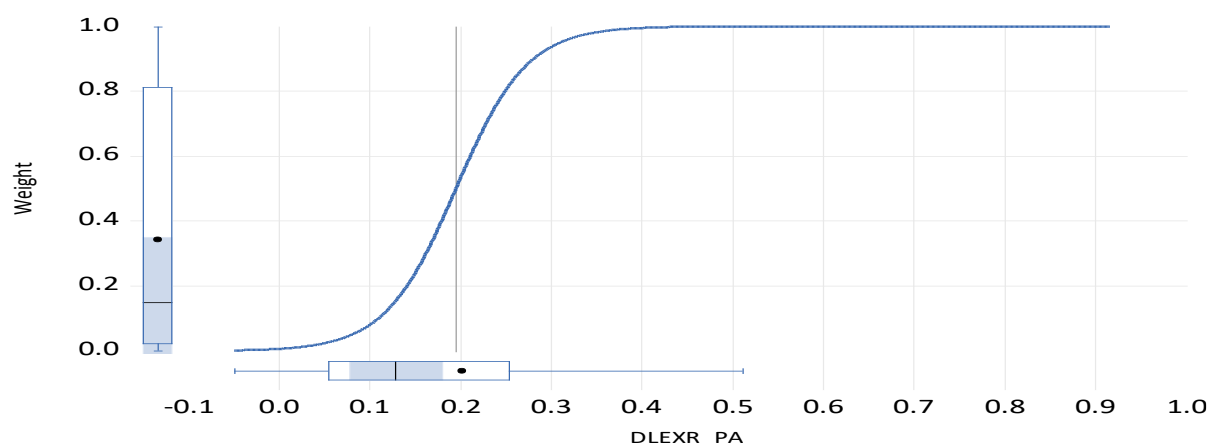
Table 5.6: Smooth Transition Exchange Rate Threshold for Sierra Leone

Variable	Coef.	90% Confidence Interval		95% Confidence Interval		99% Confidence Interval	
		Low	High	Low	High	Low	High
Linear Part							
DLCPI(-2)	0.0492	-0.1707	0.2691	-0.2163	0.3146	-0.3111	0.4094
DLEXR	-0.4260	-0.3241	1.1761	-0.4793	1.3314	-0.8026	1.6547
DLREEXR	0.5707*	0.0928	1.0486	-0.0061	1.1475	-0.2121	1.3535
DLNGDP	0.9312**	0.6058	1.2567	0.5384	1.3240	0.3981	1.4643
DLFCPI	0.0267	-0.8219	0.8753	-0.9975	1.0509	-1.3632	1.4167
INT	-0.0043	-0.0099	0.0013	-0.0111	0.0024	-0.0135	0.0048
Non-Linear Part							
DLCPI(-2)	-0.0934	-0.4623	0.2755	-0.5387	0.3518	-0.6977	0.5108
DLEXR	0.5365	-1.2491	0.1761	-1.3966	0.3236	-1.7037	0.6307
DLREEXR	-0.6434*	-1.2175	-0.0693	-1.3364	0.0495	-1.5838	0.2970
DLNGDP	-0.0849	-0.4877	0.3180	-0.5711	0.4014	-0.7447	0.5750
DLFCPI	0.6291	-0.6682	1.9263	-0.9368	2.1949	-1.4959	2.7540
INT	0.0082**	0.0019	0.0144	0.0006	0.0157	-0.0021	0.0184
Threshold Part							
C	-0.0155	-0.0980	0.0671	-0.1151	0.0842	-0.1507	0.1198
SLOPE	25.6234	-47.4707	98.7174	-62.6018	113.8485	-94.1053	145.3520
THRESHOLD	0.1955**	0.0616	0.3295	0.0339	0.3572	-0.0239	0.4149
CONFIDENCE LEVEL		0.1955±0.1339		0.1955±0.1617		0.1955±0.2194	
R-squared	0.9377						
Adj. R-squared	0.8998						

Note: ** and * denote 5% and 10 %, respectively. Dependent variable - Inflation.

Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

Figure 5.6: Smooth Transition Function for Sierra Leone's Exchange Rate Threshold
Threshold Weight Function
Logistic (c = 0.195534)



Source: Authors' computation using EViews 13 based on data from the IMF and World Bank

5.5 Robustness Analysis

To evaluate the robustness of the optimal exchange rate pass-through to inflation in each WAMZ country, we considered three different alternative model specifications to verify the sensitivity of the results. First, we extended the baseline specification in equation (4) by

replacing the growth rate of nominal GDP with the growth rate of real GDP to account for growth dynamics. Similarly, in the second alternative model specification, the treasury bill rate, as a measure of interest rate, was replaced with the monetary policy rate. In the third and final alternative model specification, we estimated a model where we replaced China consumer prices with that of US and UK consumer prices. It is interesting to note that the results of linearity and no remaining non-linearity tests show that across all the models, the results strongly reject the null hypothesis of linearity and confirm the estimation of an LSTR model associated with one nominal exchange rate threshold value or two regimes. This further supports our earlier finding on the existence of an asymmetric relationship for optimal exchange rate pass-through to inflation in the WAMZ⁷.

5.6 Diagnostic Test

The study employs tests for residual serial correlation, ARCH heteroscedasticity, and parameter constancy for the six WAMZ countries, Sierra Leone, Nigeria, Liberia, Guinea, The Gambia, and Ghana, which are essential diagnostics in threshold modelling to ensure the robustness of the estimated results. The presence of serial correlation or heteroscedasticity can distort standard errors, potentially leading to misleading inferences. Meanwhile, testing for parameter constancy is critical to ascertain whether the model's structure remains stable across various regimes. These diagnostic checks are fundamental to the study as they validate the existence of threshold effects and reinforce the reliability of the policy recommendations derived from the results. To maintain clarity and avoid cluttering the main text, the detailed results are not presented here but are provided in the appendix.

For serial correlation, all six countries successfully passed the Breusch-Godfrey LM test at the 5% significance level, indicating that the model's error terms are independently distributed over time. Similarly, in terms of heteroskedasticity, all countries passed the ARCH test, showing that their models are free from ARCH effects and are homoscedastic. However, the Smooth Threshold Parameter Constancy Tests results, which evaluate the stability and linearity of model parameters over time, were less consistent. Each of the six countries rejected the null hypothesis of parameter stability or linearity at various orders. This suggests a case of nonlinearity or parameter instability in their models. Specifically, Sierra Leone, Nigeria,

⁷ Due to large volume of these results for each of the six WAMZ countries for each alternative specifications and the fear of untidiness, we could not present them, but they are available upon request.

Liberia, Guinea, The Gambia, and Ghana all showed significant signs of threshold effects or structural breaks. This indicates that the relationships among the variables in their models can change over time or across different regimes.

In summary, although the models for all six countries show strong statistical performance with no signs of serial correlation or ARCH effects in the residuals, there is clear evidence of parameter instability or threshold nonlinearity. This indicates that, despite the apparent stability of the linear models, they may not adequately capture shifts or structural changes in the macroeconomic environment. It also implies that the relationship between inflation and exchange rate pass-through in the WAMZ may have varied over time during the 1980–2023 period, likely influenced by threshold effects or regime shifts. This is further evidence for adopting a Smooth Transition Regression (STR) technique to capture the nonlinearities and threshold effects in ERPT to inflation in the model across the WAMZ countries.

6.0 Summary, Conclusion, and Policy Recommendations

This study provides innovative, country-specific empirical evidence on the optimal exchange rate pass-through (ERPT) to inflation in the WAMZ from 1980 to 2023. Determining the ERPT threshold is crucial for monetary policy in the region to curb inflation and mitigate the adverse effects of nominal exchange rate changes on consumer prices and the economy. While extensive literature exists, previous studies have largely focused on linear approaches, assuming inflation reacts equally to small and large changes in the exchange rate. This paper contributes in three ways: it endogenously determines country-specific thresholds, uses smooth transition regression to capture gradual shifts between currency appreciation and depreciation regimes, and covers a recent, long period (1980-2023) to capture recent macroeconomic shocks.

Preliminary results from the estimated models of the study indicate some interesting outcomes for optimal exchange rate pass-through to inflation for each of the WAMZ countries with three different confidence intervals of 90 percent, 95 percent and 99 percent, associated with lower (currency appreciation) and the upper (currency depreciation) regimes, that is, below and above this threshold, respectively. The results are divided into linear, nonlinear, and threshold components.

The study finds optimal nominal ERPT of 15.5 percent for The Gambia, 23.8 percent for Ghana, 18.3 percent for Guinea, 11.2 percent for Liberia, 18.5 percent for Nigeria, and 19.6 percent for Sierra Leone, at a 5 percent significance level. Most countries show negative and

statistically insignificant ERPT during appreciation, and positive ERPT during depreciation. The estimated ERPT thresholds aligns with the ECOWAS exchange rate variability convergence criteria (± 10 percent), indicating the need for prompt policy responses when thresholds are reached. The findings provide useful insights into the effects of ERPT in the WAMZ economies. In addition, it provides evidence of asymmetric, incomplete, and declining ERPT. Hence, disregarding asymmetric threshold effects of exchange rate movements on inflation may lead to inappropriate policy prescriptions and inferences. This finding is consistent with the theoretical propositions and recent empirical findings. Thus, monetary authorities within the zone should pursue appropriate policies to maintain exchange rate variability below these thresholds to control inflation.

One limitation of the of study is that it does not consider the role of inflation expectations, as a well-anchored inflation expectations has been shown to reduce ERPT. Therefore, future studies should consider higher-frequency data and other determinants of inflation, such as drought, climate change, and insecurity for improved policy analysis.

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Appendix

Summary of Diagnostic Test Results for The Gambia

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey LM Test (2 lags)	No serial correlation	F = 0.0981 Obs*R ² = 0.3269	F = 0.9069 Chi ² = 0.8492	Do not reject Ho
ARCH Heteroskedasticity Test	No ARCH effect (homoskedasticity)	F = 1.0202 Obs*R ² = 6.2521	F = 0.4284 Chi ² = 0.3956	Do not reject Ho
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	F = 21.9766	0.0042	Reject Ho

Source: WAMI

Summary of Diagnostic Test Results for Ghana

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey LM	No serial correlation (up to lag 2)	F = 0.9812; Obs*R ² = 3.4846	0.3922; 0.1751	Fail to reject Ho
ARCH Heteroskedasticity Test	No ARCH effect (homoskedasticity)	F = 0.8582; Obs*R ² = 6.3306	0.5495; 0.5017	Fail to reject Ho
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	F = 6.2324	0.0444	Reject Ho

Source: WAMI

Summary of Diagnostic Test Results for Guinea, Conakry

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey Serial Correlation LM	No serial correlation at up to 2 lags	F(2,21) = 0.6389 $\chi^2(2) = 2.2941$	0.5379 0.3176	Fail to Reject Ho
ARCH Heteroskedasticity Test	No ARCH effect (homoskedasticity)	F(1,37) = 0.2671 $\chi^2(1) = 0.2795$	0.6084 0.5970	Fail to Reject Ho
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	F(14,9) = 4.4332	0.0151	Reject Ho

Source: WAMI

Summary of Diagnostic Test Results for Liberia

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey Serial Correlation LM Test	No serial correlation at up to 2 lags	$F(2,25) = 0.848$ $Obs * R^2 = 2.541$	0.440 0.281	Do not reject the null
ARCH Heteroskedasticity Test	No ARCH effects (homoskedasticity)	$F(1,36) = 0.218$ $Obs * R^2 = 0.229$	0.643 0.632	Do not reject the null
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	$F = 10.273$	0.039	Reject the null

Source: WAMI

Summary of Diagnostic Tests Results for Nigeria

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey Serial Correlation LM	No serial correlation at up to 2 lags	$F = 1.698$ $Obs * R^2 = 5.023$	0.2035 0.0812	Do not reject H_0
ARCH Heteroskedasticity Test	No ARCH effects	$F = 0.061$ $Obs * R^2 = 0.064$	0.8057 0.7997	Do not reject H_0
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	$F = 9.427$	0.0443	Reject H_{02}

Source: WAMI

Summary of Diagnostic Test Results for Sierra Leone

Test	Null Hypothesis	Statistic	p-Value	Decision (5%)
Breusch-Godfrey LM Test	No serial correlation at up to 2 lags	$F(2,17) = 0.9048$	0.4232	Do not reject H_0
ARCH Heteroskedasticity Test	No ARCH effect (homoskedasticity)	$F(3,31) = 1.2963$	0.2932	Do not reject H_0
Smooth Threshold Parameter Constancy Test	No parameter instability at first-order ($b_1 = 0$)	$F = 74.55$	0.0022	Reject H_0

Source: WAMI

5-Year Period Average of key Macroeconomic Variables in the WAMZ

	Year	2003-2007	2008-2012	2013-2017	2018-2022
Gambia	Period Average Exchange Rate	28.02	27.68	42.04	51.22
	Interest rate	31.68	27.40	28.62	24.03
	RGDP growth	2.81	3.19	2.46	4.53
	Broad Money Growth	21.33	13.86	12.46	19.45
	Inflation	8.70	4.62	6.74	7.69
	Import unit value index	79.35	108.76	104.55	111.49
	Import value index	40.77	93.33	105.80	98.00
	Pump price for diesel fuel (US\$ per liter)	0.86	1.08	1.18	1.25
	Pump price for gasoline (US\$ per liter)	1.00	0.98	1.27	1.41
	Trade openness	0.54	0.43	0.52	0.49
Year	2003-2007	2008-2012	2013-2017	2018-2022	
Ghana	Period Average Exchange Rate	0.90	1.45	3.37	5.90
	Interest Rate	7.94	6.58	5.91	7.59
	RGDP growth	5.49	9.05	4.76	4.28
	Broad Money Growth	29.23	30.99	24.19	23.76
	Inflation	17.13	13.28	14.83	13.21
	Import unit value index	79.35	108.76	104.55	111.49
	Import value index	40.77	93.33	105.80	98.00
	Pump price for diesel fuel (US\$ per liter)	0.57	0.88	0.94	1.15
	Pump price for gasoline (US\$ per liter)	0.61	0.87	0.99	1.23
	Openness	0.54	0.43	0.52	0.49
Year	2003-2007	2008-2012	2013-2017	2018-2022	
Guinea	Period Average Exchange Rate	3443.939568	5754.541109	7892.752033	9253.364075
	Interest Rate	15.73	19.80	13.00	12.10
	RGDP growth	2.92	3.87	6.52	5.10
	Broad Money Growth	37.01	30.25	14.19	14.45
	Inflation	29.66	15.87	9.38	10.60
	Import unit value index	74.56	106.56	105.23	111.59
	Import value index	40.28	74.74	130.92	173.97
	Pump price for diesel fuel (US\$ per liter)	0.76	1.01	1.14	1.46
	Pump price for gasoline (US\$ per liter)	0.77	1.00	1.12	1.46
	Openness	0.66	0.77	0.91	1.09
Year	2003-2007	2008-2012	2013-2017	2018-2022	
Liberia	Period Average Exchange Rate	58.13	69.73	90.95	168.22
	Interest rate	16.55	14.02	13.49	14.95
	RGDP Growth	-0.93	6.95	2.05	1.10
	Broad Money Growth	31.50	24.82	5.18	25.75
	Inflation	9.55	9.51	9.29	24.18
	Import unit value index	69.11	118.70	100.10	99.59
	Import value index	21.13	48.88	85.64	75.93
	Pump price for diesel fuel (US\$ per liter)	0.82	1.06	0.92	0.95
	Pump price for gasoline (US\$ per liter)	0.77	0.97	0.89	0.91
	Openness	107.9044479	141.2145076	93.71893988	94.10528075
Year	2003-2007	2008-2012	2013-2017	2018-2022	
Nigeria	Period Average Exchange Rate	129.57	145.82	213.52	359.79
	Interest rate	18.34	16.90	16.91	13.95
	RGDP Growth	7.14	6.47	2.96	1.85
	Broad Money Growth	36.18	22.52	10.18	12.95
	Inflation	12.10	12.18	11.55	14.51
	Import unit value index	84.88	112.00	105.00	110.40
	Import value index	47.93	105.19	101.03	104.81
	Pump price for diesel fuel (US\$ per liter)	0.58	0.97	0.75	0.70
	Pump price for gasoline (US\$ per liter)	0.44	0.54	0.49	0.49
	Openness	61.17	69.48	74.73	79.41
Year	2003-2007	2008-2012	2013-2017	2018-2022	
Sierra Leone	Period Average Exchange Rate	2.78	3.81	5.52	10.25
	Interest rate	23.13	21.98	18.12	18.01
	RGDP Growth	6.52	7.30	3.05	2.86
	Broad Money growth	22.42	27.37	14.24	-2.17
	Inflation	15.52	7.25	9.19	16.67
	Import unit value index	65.37	104.69	105.64	111.79
	Import value index	23.11	67.24	94.71	116.62
	Pump price for diesel fuel (US\$ per liter)	0.89	0.96	1.06	1.09
	Pump price for gasoline (US\$ per liter)	0.83	0.96	1.06	1.12
	Openness	0.46	0.58	0.78	0.60