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Inflation thresholds and relative price variability in the ECOWAS region

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INFLATION THRESHOLDS AND RELATIVE PRICE VARIABILITY IN THE ECOWAS REGION[1]

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[*] The views expressed in this paper are those of the authors and do not necessarily reflect the official position of the West African Monetary Institute (WAMI). Corresponding authors: Santigie M. Kargbo (skargbo8@gmail.com) and Sani Bawa (sanibawa@yahoo.com).

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INFLATION THRESHOLDS AND RELATIVE PRICE VARIABILITY IN THE ECOWAS REGION

Abstract

While the relationship between inflation and relative price variability (RPV) has been widely investigated in developed and emerging market economies because of its direct relevance to monetary policy implementation, research has neglected this linkage in most developing countries especially in the ECOWAS region. This paper examines whether RPV responds differently to different inflation regimes across the ECOWAS region, determining the inflation threshold that would minimize the distortionary impact of expected inflation on RPV in the region. Using the Panel Smooth Transition Regression (PSTR) model over the period 2008:M1 to 2019:M12, the paper finds that ECOWAS countries would achieve lower RPV in the moderate/intermediate inflation regime where the undesirable effect of expected inflation on RPV fades out. This regime ranges from an inflation rate of 7.1 percent to 8.3 percent per annum. The paper further establishes different inflation thresholds for the WAEMU and WAMZ countries, which reflects the differences in inflation tolerance levels between the Zones. It shows that inflation targets below the thresholds of 5.5 percent and 8.3 percent per annum, are desirable in the WAEMU and WAMZ, respectively. Along these lines, this paper concludes that ECOWAS countries should adopt a two-tier inflation compliance regime, until a common monetary policy framework is adopted across the region. The determination of appropriate inflation targets in line with these thresholds in both Zones would pave the way for the adoption of an inflation targeting (IT) regime to anchor inflation expectations and enhance credibility to monetary policy across the wider ECOWAS region.

JEL Classification : C23, E31, E52, O55

Key Words: Inflation threshold, relative prices, monetary policy, ECOWAS

1.0 Introduction

In both advanced and emerging markets economies, scholars have extensively investigated the nexus between inflation and relative price variability (RPV), recognizing RPV as an important channel through which inflation affects the real economy (e.g. Bick and Nautz, 2008; Gu et al., 2016). At its simplest level, relative price describes the price of one category of goods or services relative to those of another. It is central in understanding the consumption and production decisions of economic agents, influencing profitability, resource allocation, and a country's international competitiveness (Lipschitz and Schadler, 2019). A common view among researchers is that larger variability in relative prices, induced by inflation, creates distortions through the reduction in the information content of nominal prices transmitted to economic agents via the price system, which causes resource allocation inefficiency and welfare loss (Caraballo and Dabus, 2008; Rather, Durai and Ramachandran, 2014). Indeed, an increase in inflation would lead to different nominal price adjustments at different times, causing relative prices to deviate from levels determined by economic fundamentals, which affects the decisions of economic agents and leads to misallocation of resources (Ball and Romer, 2003).

The welfare costs of inflation are well documented in the literature. The distortional impact of inflation on RPV is probably the ultimate source for the welfare costs of inflation (Gu et al., 2016). Ball and Romer (2003) demonstrates that inflation induced RPV reduces consumers' welfare through the reduction in the information about future prices contained in current prices of firms. One important source of costs associated with unanticipated inflation arises through the redistributions of income and wealth (Todter and Manzke, 2007). Similarly, they further argue that inflation uncertainty would increase the level of uncertainty about real income and consumption.

Given these distortionary effects of inflation on relative prices, understanding this relationship would enable policymakers gain deeper insights into inflationary processes, its transmission mechanism and welfare costs associated with (dis)inflation policies (Da Silva, 2015). More specifically, the literature asserts that the impact of expected inflation on RPV is a major channel in the transmission of the real effects of inflation (Becker and Nautz, 2009; Ndou and Gumata, 2017). In this respect, exploring this relationship is extremely important for effective monetary policy implementation since central banks would be able to estimate the threshold level of inflation to anchor inflation expectations. This argument is underpinned by the belief that deviation of inflation expectations from inflation targets will induce the recurring of high inflationary or disinflationary episodes (Ndou and Gumata, 2017; Doh and Oksol, 2018). Achieving low and stable inflation creates an enabling economic environment that would optimize the allocation of resources within an economy. However, while the adoption of a common monetary policy would allow countries participating in a monetary union to reduce inflation, it is not likely to be effective in mitigating the indirect or second–round real effects of inflation, which are transmitted through inflation uncertainty and RPV (see Valdovinos and Gerling, 2011). In response to the second-round effects, countries may need to undertake adjustments in goods and labour markets to realign relative prices, which cannot be undertaken independently under a monetary union. As such, it is extremely useful to determine an inflation threshold that would minimize the undesirable impact

of expected inflation on relative prices to provide guidance on the desirable range of inflation targets to be adopted by countries participating in a monetary union to ensure well-anchored inflation expectations.

The theoretical models explaining the inflation-RPV linkage present different views regarding the effects of the components of inflation (expected inflation, unexpected inflation, and inflation uncertainty) on RPV. The menu-costs model (e.g., Sheshinski and Weiss, 1977) predicts a positive association between expected inflation and RPV, as expected inflation amplifies the distorting effect of menu costs on relative prices (Becker and Nautz, 2009). The signal-extraction model (Lucas 1972, 1973; Baro, 1976) emphasizes the positive effect of ex-ante inflation uncertainty on RPV, while the extension of signal-extraction model (Hercowitz, 1981) posits that unexpected inflation is positively related to RPV. The empirical literature offers similarly mixed evidence on how these components of inflation explain RPV. It is argued that higher actual inflation would amplify inflation expectations, inflation surprises and inflation uncertainty (Gu et al., 2016). However, there is little consensus on which theoretical model adequately explains the empirical relationship between inflation and RPV. This suggests that the inflation-RPV linkage remains an empirical question, especially within the Economic Community of West African States (ECOWAS) region that has received very little research attention on this topic.[2]

A growing body of literature has emphasized the threshold effects of inflation in explaining inflation-RPV linkage (e.g., Bick and Nautz, 2008; Becker and Nautz, 2009; Nautz and Scharff, 2012; Gu et al, 2016). In assessing this relationship in the ECOWAS region, Ukoha (2007) focused on the agricultural sector in Nigeria. Valdovinos and Gerling (2011) explored the causality between inflation and inflation uncertainty, and the asymmetric impact of inflation and deflation, and unexpected inflation on RPV in the West African Economic and Monetary Union (WAEMU). Yet, it is not clear whether the impact of expected inflation on RPV varies across the different inflation regimes in the ECOWAS region, especially when most countries have experienced episodes of low, moderate, and high inflation rates over time.

This paper examines whether RPV responds differently to different inflation regimes across the ECOWAS region, determining the inflation threshold that would minimize the distortionary impact of expected inflation on RPV in the region. Taking these issues into consideration, this paper contributes to the policy debate in the ECOWAS region along two important lines. First, it offers new insights into the threshold effects of inflation on RPV of ECOWAS countries, by exploring the variations in the impact of expected inflation on RPV across the different inflation regimes. One of the few studies on this relationship in the ECOWAS region, Valdovinos and Gerling (2011), employed the ordinary least squares (OLS) estimation technique to analyse the inflation-RPV relationship in the WAEMU. One limitation of this approach lies in its implicit

[2] The Economic Community of West African States (ECOWAS) comprises 15 countries, sub-divided into the West African Monetary Zone (WAMZ) (The Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone), West African Economic and Monetary Union (WAEMU) (Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo) and Cape Verde.

assumption that the marginal impact of inflation on RPV is the same across these countries. Looking at the wider ECOWAS region, the inflation-RPV relationship is likely to be heterogeneous across countries due to differences in institutional arrangements and policy environment between the WAMZ and WAEMU. For instance, WAMZ countries currently operate a flexible exchange rate regime, which points to immediate adjustments in the decisions of economic agents in response to relative price changes induced by external shocks that feed through nominal exchange rate depreciations/appreciations. On the contrary, the WAEMU countries have adopted the CFA franc that is pegged to the Euro currency. It is anticipated that under such a fixed exchange rate regime, relative prices do not automatically adjust following negative external shocks until the imbalances in the goods and labour markets induce such price adjustments (see Australian Government Treasury, 2012). Equally, while countries in the WAEMU have adopted a harmonized Consumer Price Index (CPI) framework, there is presently no unified framework in the WAMZ to compute CPI across countries. Based on these considerations, one would argue that there is heterogeneity in the impact of expected inflation on RPV between the two Zones. Such heterogeneity is reflected in the significant differences in the monthly inflation rates across the ECOWAS region, which ranged from -6.5 percent per annum in Guinea Bissau (WAEMU Member State) in November 2009 to 31.3 percent in Liberia (WAMZ Member State) in August 2019. The statistics points to potential differences in inflation tolerance levels between these Zones. This paper exploits such inflation heterogeneity to endogenously determine the threshold level of inflation that would minimize the distortionary impact of expected inflation on RPV in the ECOWAS region. Secondly, the paper further explores the inflation heterogeneity within each Zone to determine the inflation thresholds that would minimise such distortionary effects in the WAMZ and WAEMU sub-regions. To the best of our knowledge, these issues have not been explored for the ECOWAS region.

The paper considers a panel of all the 15 ECOWAS countries using monthly data covering the period 2008-2019. The chosen sample period was influenced by available data on monthly Consumer Price Index (CPI) to generate the RPV variable across countries. This paper uses a Panel Smooth Transition Regression (PSTR) model, which allows us to exploit the heterogeneity in inflation across countries and explore the nonlinearity in the effects of expected inflation on RPV across the different inflation regimes. It is extremely important to take into consideration such variations to avoid biased parameter estimates and misleading conclusions about the relationship between inflation and RPV (Gu et al., 2016). Our results provide strong evidence of the presence of threshold effects of inflation on RPV, showing different thresholds of inflation between the Zones. The paper finds that across the wider ECOWAS region, the distortionary effect of expected inflation on RPV fades out in the moderate/intermediate inflation regime. This regime ranges from an inflation rate of 7.1 percent to 8.3 percent per annum, which implies that the inflation target for the region should be set within this band. It further establishes that inflation rates below the thresholds of 5.5 percent and 8.3 percent per annum are desirable for WAEMU and WAMZ countries, respectively.

Following this introduction, the rest of the paper is structured as follows. Section 2 reviews the literature on the relationship between inflation and RPV, while section 3 analyses the dynamics in inflation and relative price variability in the WAMZ and WAEMU countries. Section 4 describes the empirical model, estimation techniques and data sources. Section 5 analyses the empirical results and section 6 concludes with some policy recommendations.

2.0 Literature Review

2.1 Theoretical Literature

Theoretical explanations of the inflation-RPV linkage are fairly well-developed, with the literature neatly documenting four models, notably the signal-extraction model attributed to Lucas (1972; 1973), and Barro (1976); extension of the signal-extraction model (Hercowitz, 1981); menu-cost model (Sheshinski and Weiss, 1977); and monetary search models (e.g. Stigler and Kindahl, 1970; Van Hoomissen, 1988; Reinsdorf, 1994). Each of these models offer peculiar predictions regarding how the components of inflation affect relative price variability. In the signal-extraction models, emphasis is clearly on the relationship between *ex ante* inflation uncertainty and RPV, predicting that increased inflation uncertainty is associated with greater RPV. A key assumption of these models is that inflation is not always anticipated correctly by firms and households (Becker and Nautz, 2009). Given the difficulty in predicting inflation, increases in *ex ante* inflation uncertainty induces misperceptions among firms and households about absolute and relative price changes, which in turn makes it harder for these agents to distinguish clearly between real shocks and aggregate shocks. Consequently, they respond to aggregate shocks through price changes rather than quantity changes. In this version of the model, realized aggregate demand shocks have no effect on RPV, because all firms respond in a similar way to any given aggregate shock as they have identical price elasticity of supply (Aarstol, 1999; Caraballo and Dabus, 2008). As such, greater variability in relative price changes occurs through increases in *ex ante* inflation uncertainty, while unexpected inflation does not have any effect on RPV.

Variants of the signal-extraction models include models of imperfect information proposed by Hercowitz (1981), which stress the importance of unexpected inflation in explaining RPV. It is predicted in these models that realized aggregate demand shocks do influence RPV. The relationship is explained through the sluggish adjustment in prices by firms with higher supply elasticity in response to an unexpected aggregate demand shock than their counterparts with lower elasticities of supply (Bakhshi, 2002). In addition, it is assumed that the size of the aggregate demand shock amplifies the magnitude of the discrepancy in price adjustments across sectors (Aarstol, 1999). One reason behind this view is that in the presence of sectoral heterogeneity, it is anticipated that sectors with relatively more flexible prices respond more to an external shock than do sectors with relatively sticky prices (Choi, 2010). Along these lines, the extension of the signal-extraction theory predicts a positive relationship between inflation surprise and RPV, pointing to possible asymmetric responses of RPV to positive and negative expected inflation. In effect, this

theory suggests that the size of the shocks and, therefore, sign of unexpected inflation does not matter in explaining the effect of unexpected inflation on RPV (Caraballo and Dabus, 2008).

The menu-costs model developed by Sheshinski and Weiss (1977) predicts that increased relative price variability stems from increases in expected inflation. In particular, the Sheshinski-Weiss model stresses that firms should operate according to optimal price-adjustment rules(S, s). This pricing rule suggests that when inflation increases, firms adjust nominal prices of their goods upwards to the upper bound of S as inflation erodes real prices to a lower bound s. The upward adjustments in the nominal prices of goods should be such that the resulting increase in real prices should equal the upper bound of S. Accordingly, the theory predicts that an increase in inflation widens the bounds between the optimal s and S, which leads to greater variability in relative price changes (Aarstol, 1999). This occurs because the monopolistically competitive sellers adjust nominal prices infrequently even when real prices are continuously being eroded by rising inflation rate (Reinsdorf, 1994).

One important assumption underlying the monetary search model is that buyers are faced with incomplete information about the prices of goods offered by different sellers (Becker and Nautz, 2009). There are two competing theories explaining inflation-RPV linkage under the monetary search models, with studies predicting a positive relationship while others suggest a negative effect of inflation on RPV. The literature suggests that inflation increases price dispersion through the obsolescence of price information of consumers, which prevents the elimination of price dispersion through more search of the prices offered by sellers (Stigler and Kindahl, 1970). Inflation reduces the price information stock held by heterogeneous customers (Van Hoomissen, 1988). Through increased search costs that inhibit further search efforts, firms gain market power, offering higher prices for goods sold that causes greater price dispersion (Valdovinos and Gerling, 2011). Reinsdorf (1994) suggests a negative effect of inflation on price dispersion, which reflects more consumers' search efforts induced by unexpected inflation due to incomplete information about price distributions. This study distinguishes clearly between short run and long run effects of inflation on RPV, to reconcile the opposing predictions of the monetary search theories. On the one hand, theories predicting a negative effect of inflation on price dispersion relate to short-run behavior, reflecting the lagged adjustment of expectations as inflation rises. On the other hand, it is predicted that there is a positive association between inflation and price dispersion. This relationship arises when customers are discouraged from replenishing decreasing price-information stocks in an inflationary environment as prolonged rise in inflation creates expectations of inflation persistence. Overall, the literature reviewed suggests that the relationship between inflation and RPV cannot be adequately explained by a single theoretical model. Considering the effect of expected inflation on RPV, the menu-costs and monetary search models are probably more relevant to explaining this relationship in the ECOWAS region.

2.2 Empirical Literature

A growing body of empirical literature lends credence to the various predictions of the theoretical models explaining the relationship between inflation and RPV. Consistent with own theoretical model of inflation-RPV nexus under the monetary search models, Van Hoomissen (1988) found strong positive relationship between the rate of market price inflation and price dispersion in Israel covering the period 1971-1984. Using micro level data for the United States, Reinsdorf (1994) showed a negative relationship between inflation and price dispersion. This finding ties with the prediction that unexpected inflation induces more search when customers have incomplete information about prices offered by sellers. To further explore the issue, the study found positive impact of expected inflation on price dispersion, while unexpected inflation was negatively related to price dispersion.

While some studies have tested specific theories explaining inflation-RPV relationship, Aarstol (1999) showed that it is useful to conduct a comprehensive test of these theories simultaneously. This influential empirical work spawned research interest on the response of RPV to expected, unexpected inflation and inflation uncertainty. Aarstol (1999) decomposed unexpected inflation into positive and negative components to capture the asymmetric response of RPV to unexpected inflation. Both expected inflation and ex ante inflation uncertainty were generated using a Generalized Autoregressive Conditional Heteroscedasticity-GARCH (1 1) model of inflation. Results show a positive and statistically significant effect of expected inflation, positive unexpected inflation shocks and inflation uncertainty on RPV, while negative unexpected inflation showed a positive but insignificant coefficient. Considering separate tests for the menu-costs, signal-extraction, and extension of the signal-extraction theories, Aarstol (1999) concluded that none of these models individually or collectively, completely explained the inflation-RPV in the United States over the period 1948-1997.

One issue that is increasingly receiving research attention is determining the appropriate functional form to explain the relationship between inflation and RPV. This is extremely important for monetary policy implementation, in assessing the optimal level of inflation that minimizes the variability of relative prices (Fielding and Mizen, 2008). Several studies have shown evidence of nonlinearity between inflation and RPV, with some pointing to a relationship that takes a U-shaped profile (e.g. Fielding and Mizen, 2008; Choi, 2010). This functional form depends on the degree of price rigidity, with the U-shaped profile reflecting more rigid price setting environments, while it disappears in more flexible price setting environments (Choi, 2010). Applying a non-parametric approach and decomposing inflation into expected and unexpected components using a GARCH model of inflation to predict inflation uncertainty, Fielding and Mizen (2008) showed a nonlinear relationship between expected inflation and RPV that depicts a quadratic functional form. It is implied from this finding that there exists a positive optimal level of inflation that would minimize RPV.

Caraballo and Dabus (2008) applied a Markov-Switching model, disaggregating unexpected inflation into positive and negative components and using a GARCH (1 1) inflation model to derive

a proxy for inflation uncertainty in Argentina. Results showed a nonlinear relationship between inflation and RPV, with the impact of the components of inflation on RPV varying across different inflation regimes. It showed that inflation uncertainty, expected and unexpected inflation were significant components explaining RPV in high, very high and hyperinflation regimes. Both expected and positive unexpected inflation were important determinants of RPV during a moderate regime depicted by stable inflation period. It showed that for the moderate regime characterised by changing inflation period, unexpected inflation was statistically significant while expected inflation was not significant.

Applying the rolling regression analysis, Choi (2010) showed a U-shaped relationship between inflation and RPV around a positive inflation rate for a group of Inflation Targeting (IT) countries. The study clearly showed a U-shape profile in low inflation environments characterized by sticky price adjustments, which disappeared in high-inflation environments associated with more flexible price setting adjustments.

Considering the threshold effect of inflation in explaining inflation-RPV linkage across a panel of US cities, Bick and Nautz (2008) found a positive impact of inflation on RPV in the US when inflation exceeds a threshold value which ranges from 2.8 percent to 4.4 percent. On the other hand, inflation is negatively related to RPV below the threshold value of 1.67 percent. Becker and Nautz (2009) showed that the impact of expected inflation on RPV weakened in the US since the 1990s when inflation expectations were stabilized to a lower level.

Few studies have applied panel threshold approaches to explore nonlinearities and threshold effects of inflation on RPV. Nautz and Scharff (2012) considered the panel threshold model attributed to Hansen (2000) to explore nonlinearities and threshold effects of inflation on RPV in the Euro Area. The study revealed a U-shaped relationship between inflation and RPV, clearly showing threshold effects of expected inflation on RPV. They found that expected inflation induces greater variability in relative prices when it is either too high (at least 4.96 percent per annum) or too low (at most 0.95 percent per annum).

Exploring similar threshold effects in explaining inflation-RPV across Chinese cities, using a PSTR, Gu et al. (2016) showed significant variation in the marginal impact of inflation on RPV over time. The study reveals the existence of three different inflation regimes (low, intermediate, and high), with the threshold value of inflation in the intermediate regime ranging from 3.60 percent to 6.10 percent per annum. Results show that the impact of expected inflation, unexpected inflation, and inflation uncertainty on RPV depends on the different inflation regimes. The coefficient of expected inflation showed negative but insignificant effect in the low inflation regime, which turned positive in the intermediate inflation regime and significantly positive in the high inflation regime. Similarly, the *ex-ante* inflation uncertainty revealed qualitatively similar effects across the three different inflation regimes, although it is weakly positively related to RPV in the intermediate inflation regime. Regarding inflation surprise, the study found strong negative effect of positive unexpected inflation on RPV in the intermediate inflation regime. In low and

high inflation regimes, positive inflation surprise showed a significantly positive effect on RPV. In contrast, the study found significantly negative effect of negative unexpected inflation on RPV in the intermediate inflation regime, which is not statistically significant under both low and high inflation regimes.

Studies on inflation-RPV linkage in ECOWAS region are scarce. Ukoha (2007) explored this relationship for the agricultural sector in Nigeria, which offers narrow evidence on the real effects of inflation. Looking at the WAEMU, Valdovinos and Gerling (2011) found strong positive effect of expected inflation on RPV in some countries. Results also provide evidence on the asymmetric response of RPV to inflation surprise in some countries. While this study found considerable variation in these results across countries, it did not explore the time-varying impact of the various components of inflation on RPV across the different inflation regimes over time.

Although the literature provides ample evidence on the existence of nonlinearity and threshold effects of inflation on RPV, it is not clear whether these arguments hold true in the ECOWAS countries. Interestingly, most governments in the ECOWAS region influence the pricing policy of private companies on petroleum products, despite the elimination of subsidies, to avoid complete pass through of increases in global crude oil prices to domestic pump prices. Given such price stickiness, it is imperative to determine whether the impact of expected inflation on RPV varies across the different inflation regimes in the WAMZ, WAEMU and ECOWAS for more effective monetary policy formulation and implementation. To our knowledge, previous research has neglected this issue in the ECOWAS region, which is empirically explored in section 4.

3.0 Inflation and Relative Price Variability Dynamics in ECOWAS

ECOWAS was established in May 1975 with the main objective of establishing an economic union in West Africa. The Community adopted the ECOWAS Monetary Cooperation Programme (EMCP) in 1987, culminating in the development of macroeconomic convergence criteria, which is a core element of the EMCP to be fulfilled by all member countries prior to the formal take-off of the Union. To fast-track the integration process, the ECOWAS Authority in 1999 adopted a two-track approach, leading to the signing of the WAMZ Agreement in 2000. The Zone was expected to adopt a single currency and eventually work towards joining Member States of WAEMU/UEMOA, which had a single currency. This is to enable the adoption of a common currency in ECOWAS.

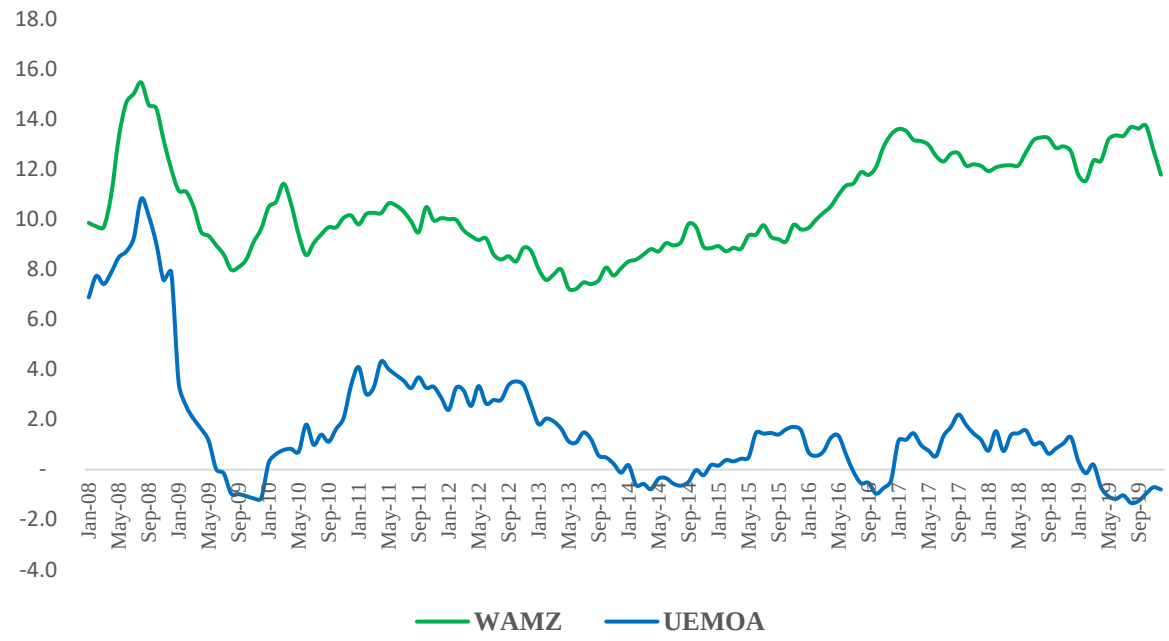
The WAEMU, harmonized their CPI in 1997, allowing Member countries and the Commission to report consistent, accurate and comparable price level indicator for the eight Member countries. Inflationary pressures in the Zone intensified in 2008, as the Zone's average inflation rate increased significantly to 8.5 percent in 2008, from 2.9 percent in 2007, mainly due to drought in some Member countries and an increase in the prices of petroleum products at the beginning of the year.[3] However, the Zone had recorded low and stable inflation rates since then, with average rates remaining below 3.5 percent since 2009. It averaged 3.4 percent in December 2010, but gradually

[3] WAMA (2009), Macroeconomic Convergence Report 2008.

declined to -0.1 percent in December 2013. The Zone's average inflation rate was 0.7 percent during the 2014 – 2018 period but declined significantly to -0.7 percent in 2019. The main reason for low inflation in the Zone was the fixed exchange rate regime operated by the Member countries, with the currency of the Zone (CFA) pegged to the Euro. This eliminates fluctuations and minimizes the exchange rate pass-through effect to inflation. On the domestic side, food inflation, which was a major driver of prices in the sub-region, had been on the downward trend in most Member countries during 2017 – 2019, recording -2.2 percent in 2019. This downward trend is attributed to, among others, interventions of public authorities to scale up real sector activities, and food distributed by Non-Governmental Organizations. Even though it is desirable that inflation remains within the ECOWAS macroeconomic convergence threshold, it should be noted that persistent negative inflation constitutes a risk of downturn in an economy since it gives incentives to put off spending in expectation of lower price in the future, causing output, profits, and employment to fall (Kumar et al., 2003).

The WAMZ CPI, however, has not been harmonized, as the six Member countries utilize different methodologies/frameworks to compile the CPI. As a result, inflation comparability remains challenging within WAMZ countries, given the differences in the composition of the basket, number of subcategories and coverage. Average inflation rate in the Zone, which stood at 12.0 percent in December 2008, declined to 10.2 percent and 10.1 percent in December 2010 and December 2011, respectively. Inflationary pressures eased during 2012 – 2015, as average inflation fell to 8.7 percent during the period. However, it inched up to 13.4 percent in December 2016, but subsequently declined to 11.8 percent in December 2019. Major reasons for the increase in inflationary pressures in WAMZ countries include expansionary fiscal and monetary policies and the subsequent monetization of such deficits by the banking system, depreciation of the domestic currencies, adverse weather conditions culminating in increase in food prices, rising energy and utility prices and surge in international commodity prices.

Figure 1:Trends in Inflation in WAMZ and UEMOA (2008 – 2019)



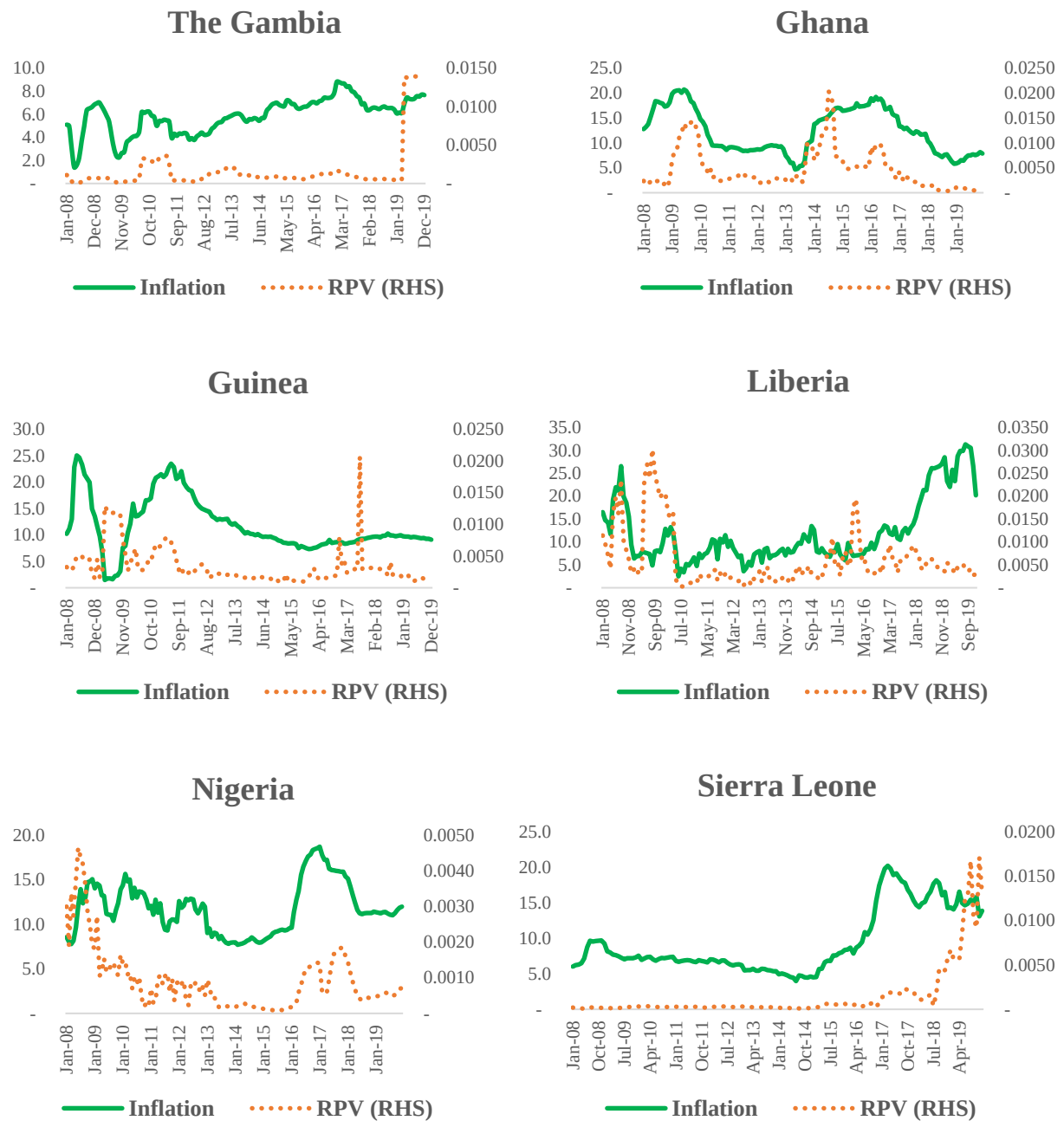
The trends in inflation and RPV for each of the 15 Member States of ECOWAS are depicted in figure 2.[4] It indicated a relatively positive association between inflation and RPV in most countries, signifying that inflation increases RPV in most ECOWAS countries. To further confirm this relationship, we also computed the correlation coefficients between inflation and RPV in all ECOWAS countries for the period January 2008 – December 2019. The correlation coefficients turned positive in most countries[5], thereby supporting the positive relationship in ECOWAS countries during the study period.

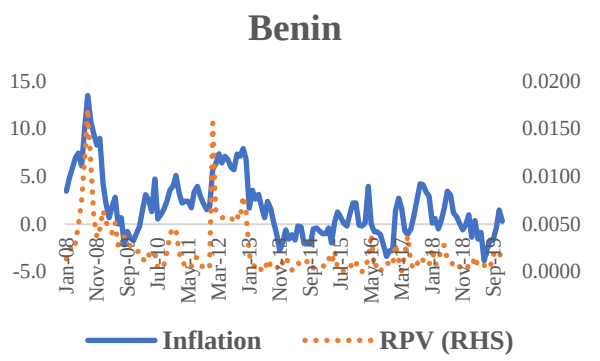
Furthermore, RPV get more dispersed in periods of high or very low inflation rates in many countries. For instance, high inflation culminated in high RPV in Ghana (June 2009), Liberia (August 2008), Benin (August 2008), Burkina Faso (August 2008), Cote d'Ivoire (April 2011) and Togo (October 2008), among others. In contrast, transition to very low inflation in Liberia (August 2009), Cote d'Ivoire (April 2012) and Cape Verde (October 2009 and July 2016) led to high RPV in those countries during the periods.

[4]RPV is computed as the weighted sum of squared deviations of the individual commodity price changes around the average inflation for each country. See equation 9.

[5] The Gambia (0.3211), Ghana (0.6052), Guinea (-0.0069), Liberia (0.0796), Nigeria (0.3484), Sierra Leone (0.5039), Benin (0.7105), Burkina Faso (0.6171), Cote d'Ivoire (0.6697), Guinea Bissau (0.5463), Mali (0.0712), Niger (0.5054), Senegal (0.3709), Togo (0.7951) and Cape Verde (-0.0738).

Figure 2: Inflation and Relative Price Variability in ECOWAS Countries (2008 – 2019)

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May-16
Mar-17
Jan-18
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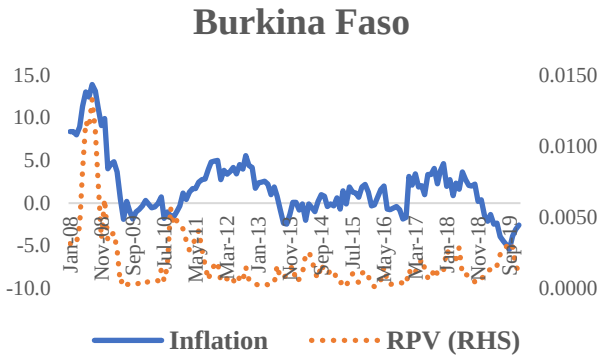
Sep-19
Inflation
RPV (RHS)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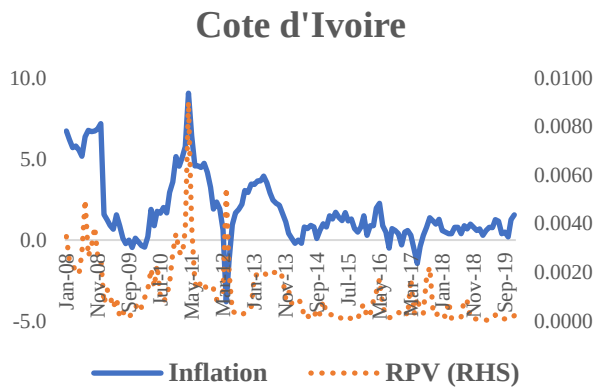
Sep-19
Inflation
RPV (RHS)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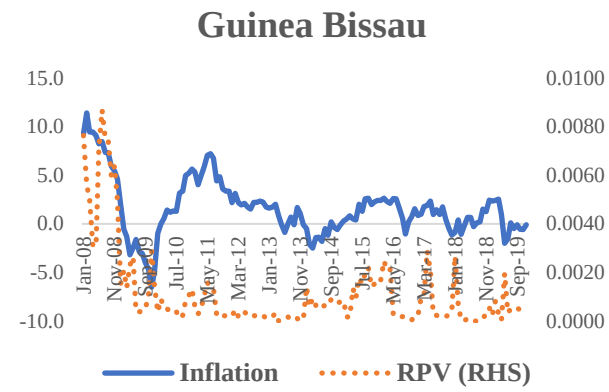
Inflation
RPV (RHS)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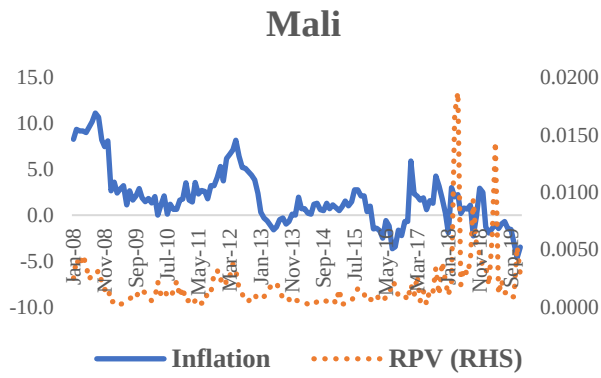
Inflation
RPV (RHS)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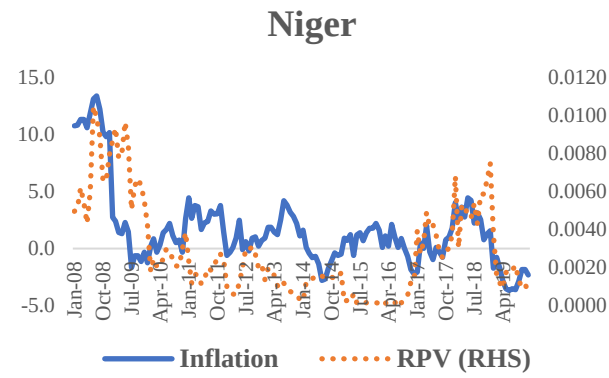
Inflation
RPV (RHS)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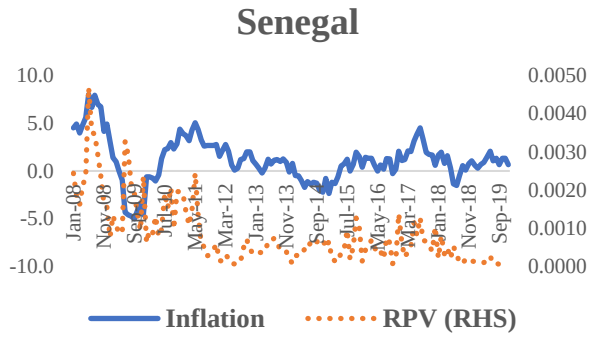
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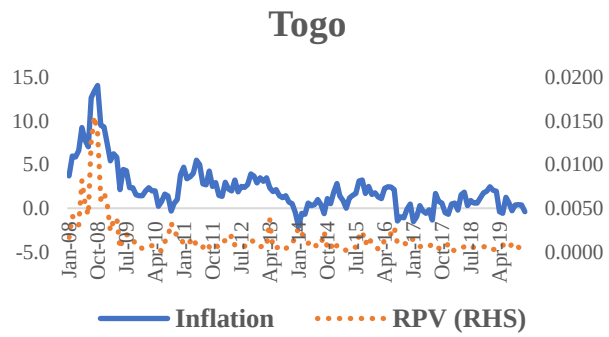
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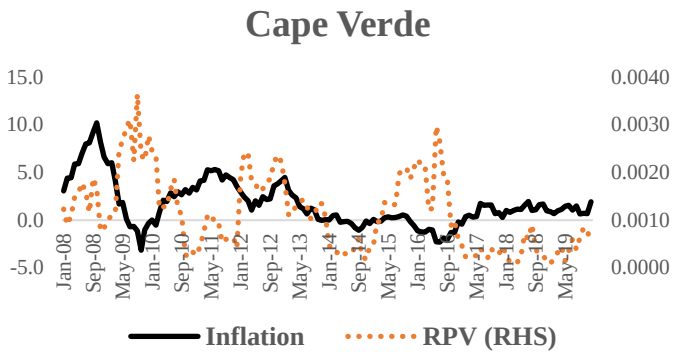
Inflation
RPV (RHS)



Available data on the components of the CPI showed that large variations of the CPI culminates into higher variability in relative prices across countries. For instance, significant rise in information and communications of CPI in The Gambia and Ghana during May 2009 and April 2019 led to high RPV. Similarly, the relationship was also visible when food CPI increased significantly in Cote d'Ivoire and Guinea in April 2011 and August 2017, respectively. In addition, rising CPI for restaurant and hotels; furnishings, household equipment and routine household maintenance as well as clothing and footwear in Liberia in May 2009 culminated in high RPV even though headline inflation declined during the period.

It is therefore pertinent to note that high fluctuations in prices culminating in high or very low inflation rates lead to high RPV across ECOWAS countries, which tend to distort the information content of nominal prices. Consequently, there could be optimal inflation thresholds on both sides which minimizes RPV in these countries, which this study intends to ascertain.

4.0 Model, Estimation Technique and Data

4.1 Model Specification

Building on the empirical literature (e.g. Bick and Nautz, 2008; Nautz and Scharff, 2012), this paper considers a baseline model that explains the relationship between inflation and RPV within a panel data setting as specified in equation (1):

$$RPV_{i,t} = \alpha_i + \beta|\pi_{i,t}| + \varepsilon_{i,t} \quad (1)$$

Where the dependent variable, $RPV_{i,t}$ is relative price variability in country i at time t; α_i is country-specific fixed effects; $\pi_{i,t}$ is actual inflation rate in country i at time t; and ε_{it} is the error term. In this specification, the absolute value of inflation ($|\pi_{i,t}|$) is used to enable us to determine the effect of the magnitude of inflation on RPV irrespective of its sign (Caraballo and Dabus, 2008). Aarstol (1996) proposed an empirical framework that includes all components of inflation (inflation uncertainty, expected and unexpected inflation) as explanatory variables to simultaneously test the competing theories of the inflation-RPV relationship. Following this

approach, we decompose $\pi_{i,t}$ in equation (1) into expected and unexpected inflation. Extending equation (1) to include inflation uncertainty yields equation (2):

$$RPV_{i,t} = \alpha_i + \beta_1|\pi^e_{i,t}| + \beta_2|\pi^{ue}_{i,t}| + \beta_3\pi^{uncer}_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where $\pi^e_{i,t}$ is expected inflation, $\pi^{ue}_{i,t}$ denotes unexpected inflation, measured as the difference between actual inflation ($\pi_{i,t}$) and expected inflation ($\pi_{i,t} - \pi^e_{i,t}$), and $\pi^{uncer}_{i,t}$ is inflation uncertainty. Following the empirical literature (Aarstol, 1999; Caraballo and Dabus, 2008; Becker and Nautz, 2009; Valdovinos and Gerling, 2011), both expected and unexpected inflation are computed using a GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model proposed by Bollerslev (1986).[6]

The menu costs theory predicts that expected inflation has a strong positive impact on RPV, while the signal extraction and extension of the signal extraction models predict that increases in inflation uncertainty and unexpected inflation will increase RPV. These by implication suggest that $\beta_1, \beta_2, and\ \beta_3 > 0$. Based on the predictions of the extension of the signal-extraction theory, several studies further decomposed unexpected inflation into positive and negative unexpected inflation to capture the possible asymmetric responses of RPV to these components of inflation (e.g., Aarstol, 1999; Caraballo and Dabus, 2008; Becker and Nautz, 2009; Nautz and Scharff, 2012; Gu et al., 2016). While the present paper is concerned about the impact of expected inflation on RPV, equation (2) is extended to capture all the competing theories of the inflation-RPV relationship as specified in equation (3):

$$RPV_{i,t} = \alpha_i + \beta_1|\pi^e_{i,t}| + \beta_2\pi^{ue+}_{i,t} + \beta_3|\pi^{ue-}_{i,t}| + \beta_4\pi^{uncer}_{i,t} + \varepsilon_{i,t} \quad (3)$$

Where $\pi^{ue+}_{i,t}$ and $\pi^{ue-}_{i,t}$ denote positive and negative unexpected inflation, respectively. Following Gu et al. (2016), the positive unexpected inflation is defined as:

$$\pi^{ue+}_{i,t} = \begin{cases} \pi^{ue}_{i,t} & if\ \pi^{ue}_{i,t} \geq 0 \\ 0, & otherwise, \end{cases} \quad (4)$$

Equally, negative unexpected inflation is measured as:

$$\pi^{ue-}_{i,t} = \begin{cases} \pi^{ue}_{i,t} & if\ \pi^{ue}_{i,t} \leq 0 \\ 0, & otherwise, \end{cases} \quad (5)$$

Similarly, in line with Gu et al. (2016), a three-regime specification of a PSTR model is adopted as specified in equation (6). This modelling approach appears to depict the different inflation episodes of the ECOWAS region, since most countries have experienced low, moderate, and high inflation episodes.

$$RPV_{i,t} = \alpha_i + \beta_{0,1}|\pi^e_{i,t}| + \beta_{0,2}\pi^{ue+}_{i,t} + \beta_{0,3}|\pi^{ue-}_{i,t}| + \beta_{0,4}\pi^{uncer}_{it} + \sum_{t=1}^{r}(\beta_{\tau,1}|\pi^e_{i,t}| + \beta_{\tau,2}\pi^{ue+}_{i,t} + \beta_{\tau,3}|\pi^{ue-}_{it}| + \beta_{\tau,4}\pi^{uncer}_{it})g^{(\tau)}(q_{i,t};\ \gamma^{(\tau)}, c^{(\tau)}) + \varepsilon_{i,t} \quad (6)$$

[6] The GARCH specification is discussed in sub-section 4.3.

$$RPV_{i,t} = \alpha_i + \beta_0' x_{i.t} + \sum_{\tau=1}^{r} \beta_\tau' x_{it} g^{(\tau)}\left(q_{i,t};\, \gamma^{(\tau)}, c^{(\tau)}\right) + \varepsilon_{i,t} \quad (7)$$

Where $x_{i,t}$ is a (k_x x 1 dimension) vector of time-varying exogenous variables (expected inflation, positive and negative unexpected inflation, and inflation uncertainty) and $\varepsilon_{i,t}$ is an error term.

4.2 Estimation technique

The empirical literature points to a time-varying impact of inflation on RPV, reflecting the nonlinear effects of inflation on RPV (e.g. Fielding and Mizen, 2008; Choi, 2010; Nautz and Scharff, 2012; Gu et al., 2016). To explore such nonlinearities, this paper uses the PSTR model developed by Gonzalez, Terasvirta and van Dijk (2005). By considering such variations across the different inflation regimes, the PSTR model ensures that the resulting parameter estimates are unbiased and more accurate conclusions can be reached regarding the inflation-RPV linkage (Gu et al., 2016). As discussed, there is significant heterogeneity in inflation across the ECOWAS region. The PSTR model allows us to exploit such heterogeneity to determine the inflation threshold that would minimise the distortionary effects of expected inflation on RPV across countries. Through such variations across the different inflation regimes, the PSTR model offers a more useful approach to addressing the problems of heterogeneity and structural breaks in inflation. Structural breaks can stem from external shocks that affect food and energy prices, and domestic policies including government interventions that affect real sector activities and influence the components of CPI.

In line with Gonzalez et al. (2005), a logistic function is adopted to estimate the parameters of the PSTR model, defined as follows:

$$g^{(\tau)}\left(q_{i,t};\, \gamma^{(\tau)}, c^{(\tau)}\right) = \left[1 + \exp\left(-\gamma^{(\tau)} \prod_{z=1}^{m} (q_{i,t} - c_z^{(\tau)})\right)\right]^{-1}, \gamma^{(\tau)} > 0, c_1^{(\tau)} \leq \cdots \leq c_m^{(\tau)}, \quad (8)$$

Where $c^{\tau} = \left[c_1^{(\tau)}, \ldots, c_m^{(\tau)}\right]'$ describes an m-dimensional location parameter vector and the slope parameter $\gamma^{(\tau)}$ determines the smoothness of the transition function from low to high inflation regimes. c^{τ} is a vector of location parameters and $q_{i,t}$ is the threshold variable (inflation rate). Following Gu et al. (2016), the threshold variable is excluded from the vector of exogenous explanatory variables, $x_{i,t}$. The transition function $g^{(\tau)}\left(q_{i,t};\, \gamma^{(\tau)}, c^{(\tau)}\right)$ is a continuous function of the threshold variable, $q_{i,t}$ which takes values between 0 and 1. When the location parameter c is a fixed value, the parameters of the exogenous explanatory variables in $x_{i,t}$ change smoothly from a low inflation regime (β_0) to a high inflation regime ($\beta_0 + \beta_1$) (see Wang, Hao and Yao, 2017).

In estimating the PSTR model, Gonzalez et al. (2005) pointed out that a model with $m = 1$ or $m = 2$ is sufficient to capture cross-country heterogeneity. One issue is the possibility of simultaneity bias between inflation and RPV, as suggested by some empirical works (Grier and Perry, 1996; Parsley, 1996; Carabello and Dabus, 2008). Parsley (1996) echoed that an unobservable variable may drive both inflation and relative price variability, especially when aggregate data is used in exploring this linkage. This may lead to biased and inconsistent parameter estimates. Similarly, decomposing actual inflation into expected and unexpected inflation may create the problem of

measurement errors, leading to possible endogeneity through the correlation between the error term $\varepsilon_{i,t}$, expected and unexpected inflation. To mitigate this problem, we follow the approach by Gonzalez et al. (2005) and use one period lagged of the inflation threshold variable, and all the components of inflation captured in the vector $x_{i,t}$.

4.3 Data description and sources

This paper uses monthly data on RPV and the various components of inflation over the period 2008:M1-2019:M12. The choice of the study period was driven by available data on monthly CPI for all the countries in the ECOWAS region. Appendix 1 presents the description of the variables used in the regression. Following Parks (1978) and the empirical literature, the dependent variable, RPV is constructed as the weighted sum of squared deviations of the individual commodities price changes (π_{ijt}) around the average inflation for each country i (π_{it}).

$$RPV_{it} = \sum_{j=1}^{n} w_{ijt}(\pi_{ijt} - \pi_{it})^2 \quad (9)$$

Where w_{ijt} is the country-specific weight of the jth commodity in the CPI basket;$\pi_{ijt_{it}} = 100 * \Delta lnp_{ijt}$, where p_{ijt} is the CPI of the jth commodity in country i in period t; and $\pi_{it} = 100 * \Delta lnP_{it}$, where $P_{it} = \sum_{j=1}^{n} w_{ijt}p_{ijt}$. Data on consumer price indices in the WAMZ were obtained from the respective Central Banks and Statistics Offices, while those of WAEMU were sourced from the Central Bank of West African States (BCEAO). It is worthwhile to note that in 1997, WAEMU adopted a Harmonized Consumer Price Index (HCPI), which comprised 12 subcategories of commodities. In contrast, the CPI framework is yet to be harmonized across countries in the WAMZ and countries currently use different categories of commodities in computing the CPI.

The threshold variable, absolute headline inflation, is measured as year-on-year percentage change of monthly CPI. As previously mentioned, one period lagged of this variable is applied as the threshold variable to minimize the problem of potential endogeneity issues. Similarly, all the components of inflation in the vector $x_{i,t}$ were lagged one-period to mitigate this possible simultaneity bias. To check the robustness of the results, we considered one period lagged absolute value of core inflation as an alternative threshold variable. Core inflation is obtained by excluding food and energy prices from the CPI basket, which allows us to control for supply shocks (Becker and Nautz, 2009). The literature recognizes that both inflation and RPV are distorted by supply shocks, which leads to potential endogeneity problem through the correlation between the error term and inflation in the model. To mitigate the problem of endogeneity, the core inflation measure is used as an alternative measure of inflation (e.g. Jaramillo, 1999; Nautz and Scharff, 2012).

In the absence of survey data on inflation expectations for all the countries in ECOWAS, we adopted a GARCH Model proposed by Bollerslev (1986) to generate both expected inflation and inflation uncertainty. This approach is widely used in empirical studies to obtain acceptable measures of expected inflation and inflation uncertainty (e.g. Aarstol, 1999; Caraballo and Dabus,

2008; Becker and Nautz, 2009; Valdovinos and Gerling, 2011). The GARCH (1 1) Model allows us to capture the persistence of shocks while obtaining a time-varying measure of both expected inflation and inflation uncertainty. This model can be estimated from a general model of inflation (eq. 10) over the period 2008:M1-2019: M12:

$$\pi_{i,t} = \alpha_0 + \alpha_1\pi_{i,t-1} + \cdots + \alpha_{12}\pi_{i,t-12} + \beta_1 v_{i,t-1} + \cdots \beta_{12} v_{i,t-12} + v_{i,t} \quad (10)$$

where $\pi_{i,t-1}$, …,$\pi_{i,t-12}$ denotes the autoregressive (AR) process and $v_{i,t-1}$, …,$v_{i,t-12}$ the moving average (MA) process. The inclusion of the AR terms helps to capture inflation persistence, while the MA terms control for seasonal effects. The appropriate GARCH (1 1) Model is determined by the model that minimizes the Akaike Information Criterion (AIC). From the GARCH (1 1) Model, the conditional variance of inflation is expressed as a function of one period lagged of both conditional variance and the squared error terms.

$$\sigma_{i,t}^2 = \omega + \alpha v_{i,t-1}^2 + \beta\sigma_{vi,t-1}^2 \quad (11)$$

where $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$ is the GARCH parameter, which captures inflation persistence and $\alpha + \beta < 1$ to ensure a covariance stationary process. This paper has adopted the symmetric GARCH (1 1) using one-period-ahead forecast of both headline and core inflation to derive estimates of expected inflation and conditional variance of inflation. Inflation uncertainty is computed as the square root of the conditional variance of inflation obtained from the estimation of the GARCH (1 1) Model of inflation over a 12-month forecast horizon. While a variant of the GARCH Model, exponential (EGARCH) model captures the asymmetric effect of inflation on inflation uncertainty, this paper considers the symmetric GARCH (1 1) Model, since the empirical literature points to the asymmetric response of RPV to inflation through positive and negative unexpected inflation instead of inflation uncertainty. As noted, unexpected inflation is derived by subtracting expected inflation, $\pi_{i,t}^e$ from actual inflation, π_{it}.

Across countries in the ECOWAS region, both expected inflation and *ex ante* inflation uncertainty were obtained from estimating a GARCH (1 1) Model reported in Appendix 2. This model was estimated using four lags of the AR term and the first and twelfth moving average (MA) terms, determined by the Akaike and Schwartz Information criteria. Table 1 displays the descriptive statistics of RPV, headline inflation and *ex ante* inflation uncertainty in the WAMZ and WAEMU countries. Complementing the descriptive analysis in section 3, we compare the distribution of RPV and inflation between these Zones over the period 2008:M1 to 2019:M12. Looking at these statistics shows that the WAMZ countries had experienced higher inflation rates, which averaged 9.29 percent per annum compared to 1.70 percent per annum in the WAEMU countries over the period. There is significant inflation heterogeneity across countries in both Zones, ranging from -3.1 percent to 31.3 percent per annum in the WAMZ; and from -6.5 percent to 14.1 percent per annum in the WAEMU countries. Accordingly, higher inflation in the WAMZ was associated with relatively greater variability in relative prices, which averaged 0.003 compared to 0.002 in the WAEMU countries over the period. These differences raise the question of whether the threshold

effects of inflation on RPV significantly differ between the WAMZ and WAEMU countries. The next section empirically explores these issues.

Table 1: Descriptive statistics for WAMZ and WAEMU (Headline Inflation)

Panel A: WAMZ countries					
Variable	Obs.	Mean	Std.Dev.	Min	Max
Relative price variability	1,008	0.00277	0.00395	2.40e-05	0.0303
Inflation	1,008	9.293	5.767	-3.147	31.32
Inflation uncertainty	1,008	0.920	0.688	0.238	4.086

Panel B: WAEMU countries					
Variable	Obs	Mean	Std.Dev.	Min	Max
Relative price variability	1,152	0.00167	0.00219	3.39e-06	0.0187
Inflation	1,152	1.704	2.977	-6.508	14.07
Inflation uncertainty	1,152	1.037	0.377	0.345	2.552

5.0 Empirical results and discussions

This section explores the threshold effects of inflation on RPV across the ECOWAS region. Specifically, it determines whether the impact of expected inflation on RPV could vary across the different inflation regimes.

5.1 PSTR estimation results (ECOWAS)

The existence of inflation heterogeneity across ECOWAS countries suggests that the PSTR Model is a suitable approach to determine the nonlinearities and threshold effects of inflation on RPV. In the estimation the PSTR Model, Gonzalez et al. (2005) stressed the need to conduct a test of heterogeneity to determine whether the underlying relationship is nonlinear or not. If the null hypothesis of homogeneity was not rejected, then it would be appropriate to estimate linear panel data models such as the fixed effects or random effects models, depending on the outcome of the Hausman test to determine which of these models is suitable to explain the relationship. Adopting this approach, the null hypothesis of homogeneity involves testing the linear model (H0: $r = 0$) against the PSTR Model PSTR model with at least one threshold or two regimes. The rejection of the null hypothesis implies that there is heterogeneity across countries. This requires further testing of the remaining heterogeneity to determine the number of location parameters (m) and transition functions (r).

Gonzalez et al. (2005) suggests that it is appropriate to consider a model with $m = 1$or $m = 2$, since these location parameters allow for more commonly encountered types of variation in the series. Following this approach, we estimated the PSTR Model by allowing for one location parameter ($m = 1$) to be associated with each transition function. Table 2 reports the test statistics for panel heterogeneity, considering a panel of all the 15 ECOWAS countries over the period 2008:M1-2019:M12.

Table 2: Linearity and no remaining non-linearity tests (ECOWAS)

Hypothesis	Test	Statistics	P-value
H_0: $(r = 0)$; H_1: $(r = 1)$	Wald Test (LM)	50.158	0.000
	Fisher Test (LMF)	12.726	0.000
	LRT Tests (LRT)	50.754	0.000
H_0: $(r = 1)$; H_1: $(r = 2)$	Wald Test (LM)	61.628	0.000
	Fisher Test (LMF)	15.663	0.000
	LRT Tests (LRT)	62.531	0.000
H_0: $(r = 2)$; H_1: $(r = 3)$	Wald Test (LM)	52.034	0.000
	Fisher Test (LMF)	13.139	0.000
	LRT Tests (LRT)	52.675	0.000

Lagrange multiplier-Wald (LM); Lagrange multiplier -Fischer (LMF); and Likelihood ratio (LR) tests. The null hypothesis of linearity H_0: linear model; H_1: PSTR model with at least one threshold. The null hypothesis of no remaining non-linearity H_0: PSTR model with one threshold; H_1: PSTR model with at least two thresholds.
Source: Authors' computations

The probability values of the test statistics show strong rejection of the null hypothesis of panel homogeneity. Further test of any remaining heterogeneity involving testing the null hypothesis of PSTR model with one threshold or two regimes against the alternative hypothesis of a PSTR model with at least two thresholds, which indicates strong rejection of the null hypothesis. Similarly, the results further reject the null hypothesis of the existence of two thresholds or three regimes against a PSTR model with at least three threshold values or four regimes. It implies that additional test for remaining heterogeneity could be conducted using a PSTR model with three threshold values or four regimes. However, considering the short length time series employed (12 years), it is not practical to estimate a PSTR model with more than two transition functions (see Wang, Hao, and Yao, 2017). This is because estimating a model with more than two transition functions would lead to the degeneration of the first two transition functions (Jude, 2010).

Following the determination of nonlinearity between inflation and RPV, we estimate a PSTR associated with a three-regime inflation threshold variable and two location parameters. Table 3 presents the parameters obtained from the estimated PSTR model for ECOWAS over the study period. Results show strong threshold effects of inflation on RPV, with the inflation-RPV linkage exhibiting three different inflation regimes for ECOWAS. The estimated location parameters of inflation threshold variable suggest a low- inflation regime for the ECOWAS region (β_0), characterized by inflation rate below 7.1 percent per annum; a moderate/intermediate regime ranging from 7.1 percent to 8.3 percent per annum; and high inflation regime(β_2), when inflation exceeds the upper threshold of 8.3 percent per annum. The results show that the effects of the various components of inflation on RPV: expected inflation, negative inflation surprise and *ex ante* inflation uncertainty depend on the different inflation regimes. To interpret the results, one should consider only the signs or directions of the estimated coefficients and level of significance, since the parameters of the PSTR Model cannot be directly interpreted (Colletaz and Hurlin, 2006; Jude, 2010).

Table 3: PSTR model estimation (ECOWAS)

	β_0	β_1	β_2
Location (threshold) parameter (c)	7.0933		8.2656
Slope parameter (γ)	0.0227		3.5054
Lagged expected inflation	0.0001 **	-0.0002*	0.0003**
	(0.0000)	(0.0001)	(0.0001)
Lagged positive unexpected inflation	0.0001	-0.0010	0.0015
	(0.0002)	(0.0014)	(0.0014)
Lagged negative unexpected inflation	-0.0001	-0.0012**	0.0012**
	(0.0001)	(0.0005)	(0.0006)
Lagged inflation uncertainty	0.0015***	0.0043***	-0.0041***
	(0.0003)	(0.0010)	(0.0010)
AIC criterion	-11.978		
Schwarz criterion	-11.936		
Number of observations	2145		

Note: ***, **,* denote 1%, 5% and 10 % respectively. Dependent variable-relative price variability (RPV)
Standard errors in parentheses are corrected for heteroscedasticity.
Source: Authors' estimates

In the low-inflation regime, the estimated coefficient on expected inflation (0.0001) is significantly positive. It turns out to be negative and significant at the 10 percent level as inflation increases towards the intermediate range and strongly positive at the high inflation regime. This finding suggests that the distortional effect of expected inflation on RPV is weakest in the intermediate regime, which points to the optimal level of inflation band ranging from 7.1 percent to 8.3 percent per annum. The results appear to provide mixed evidence on the predictions from theoretical models that explain inflation-RPV linkage. Starting with expected inflation, the effects on RPV across the different inflation regimes seem to be consistent with the predictions from the menu-costs and monetary search models. In the low inflation regime, expected inflation is significantly positive, which reflects the argument that the reduction in the optimal stock of price information as inflation increases induce greater variability in relative prices. In the intermediate regime, the coefficient on expected inflation becomes slightly negative (10 percent level) but strongly positive in the high inflation regime. The intuition behind these results is that rising inflation would induce customers to undertake additional search for lower prices in the short-run, due to incomplete information about price distributions (Reinsdorf, 1994). However, RPV increases with increases in expected inflation in the high inflation regime, reflecting more long-run pattern in which increases in inflation triggers expectations about inflation persistence. This discourages further search and generates greater variability in relative prices. The results are qualitatively similar to the findings by Nautz and Scharff (2012) for the euro area. Their study shows that the effect of expected inflation on RPV is strongly positive when expected inflation is too low (at most 0.95 percent) or too high (at least 4.96 percent) per annum.

The outcome suggests that the effect of expected inflation on RPV is nonlinear and takes a U-shape profile. This evidence corroborates previous evidence that suggests a U-shape relationship between expected inflation and RPV (e.g. Fielding and Mizen, 2008; Gu et al, 2016). The empirical literature suggests that the U-shape profile of the inflation-RPV linkage characterizes the sticky price adjustment environments. As discussed, in most ECOWAS countries, private oil importing companies do not immediately undertake upward adjustments in petroleum products prices in

response to increases in crude oil prices in the global markets. It is obvious that some governments influence the price-setting decisions of these companies to avoid complete pass through of increases in global crude oil prices into domestic pump prices. Equally, domestic pump prices appear to be sticky downwards, with private companies sluggishly decreasing prices when global oil prices fall, due to the time lag between importing and marketing of these products in the host countries.

Turning to unexpected inflation, the results indicate that the effect of negative inflation surprise on RPV is significantly negative in the intermediate regime but strongly positive in the high inflation regime. However, positive inflation surprise does not influence RPV across all the different inflation regimes. This outcome does not seem to support the predictions from the extended signal-extraction model, which suggests that the size of shocks and sign of unexpected inflation do not matter in explaining the response of RPV to unexpected inflation. Equally, expected inflation turns out to be strongly positive in both low and high inflation regimes, contrary to the prediction from both versions of the signal-extraction model that expected inflation is not an important driver of RPV.

The result indicates that *ex ante* inflation uncertainty induces greater variability in relative prices in the low and intermediate inflation regimes. The effect on RPV declines in the high inflation regime. It is argued that in a stable inflation environment, low inflation induces more inflation uncertainty, while high inflation creates no more uncertainty than low inflation (Golob, 1994). The strongly positive effects of inflation uncertainty in the low to intermediate inflation regime could be attributed to higher uncertainty induced by commodity supply shocks in the ECOWAS region, particularly food and energy in the short run, which generate greater variability on relative prices. On the contrary, the negative effect of inflation uncertainty at high inflation could be explained by changes in macroeconomic policies that influence both inflation and RPV in the long run. Overall, the findings indicate that the Authorities should set an inflation target within the moderate/intermediate inflation regime where the impact of expected inflation on RPV is minimised.

5.2.1 PSTR estimation results (WAMZ countries)

As indicated above, the first step is to explore the existence of nonlinearity between inflation and RPV in WAMZ countries. Table 4 presents the results of the test statistics to determine whether the inflation-RPV nexus is nonlinear in the WAMZ and associated number of inflation thresholds or regimes that characterizes the relationship. The test procedure clearly shows the existence of nonlinearity in explaining inflation-RPV nexus. Like the rest of ECOWAS, the results suggest that the inflation-RPV linkage can be captured by estimating a PSTR model with two thresholds or three regimes.

Table 4: Linearity and no remaining non-linearity tests in the WAMZ

Hypothesis	Test	Statistics	P-value
H_0: $(r = 0)$; H_1: $(r = 1)$	Wald Test (LM)	21.919	0.000
	Fisher Test (LMF)	5.541	0.000
	LRT Tests (LRT)	22.163	0.000
H_0: $(r = 1)$; H_1: $(r = 2)$	Wald Test (LM)	31.589	0.000
	Fisher Test (LMF)	8.000	0.000
	LRT Tests (LRT)	32.098	0.000
H_0: $(r = 2)$; H_1: $(r = 3)$	Wald Test (LM)	9.958	0.041
	Fisher Test (LMF)	2.457	0.044
	LRT Tests (LRT)	10.008	0.040

Lagrange multiplier-Wald (LM); Lagrange multiplier -Fischer (LMF); and Likelihood ratio (LR) tests. The null hypothesis of linearity H_0: linear model; H_1: PSTR model with at least one threshold. The null hypothesis of no remaining non-linearity H_0: PSTR model with one threshold; H_1: PSTR model with at least two thresholds.
Source: Authors estimations

Table 5 reports the parameter estimates obtained from the estimation of the PSTR model for the WAMZ. The results clearly indicate that the inflation-RPV nexus in the WAMZ is characterized by a three-regime inflation with the low regime below 7.3 percent per annum, moderate/intermediate inflation regime that ranges from 7.3 percent to 8.3 percent per annum, and a high inflation regime above the threshold value of 8.3 percent per annum.

Table 5: PSTR model estimation (WAMZ)

	β_0	β_1	β_2
Location (threshold) parameter (c)	7.3010		8.2776
Slope parameter (γ)	1.1365		0.0773
Lagged expected inflation	-0.0001	-0.0001	0.0003***
	(0.0001)	(0.0001)	(0.0001)
Lagged positive unexpected inflation	-0.0009	0.0002	0.0011
	(0.0007)	(0.0019)	(0.0018)
Lagged negative unexpected inflation	-0.0003	-0.0009	0.0010
	(0.0004)	(0.0007)	(0.0006)
Lagged inflation uncertainty	0.0024***	0.0034***	-0.0044***
	(0.0006)	(0.0012)	(0.0011)
AIC criterion	-11.511		
Schwarz criterion	-11.433		
Number of observations	1001		

Note: ***, **,* denote 1%, 5% and 10 % respectively. Dependent variable-relative price variability (RPV)
Standard errors in parentheses are corrected for heteroscedasticity.
Source: Authors estimations

The estimated parameter of expected inflation is negative in the low and moderate inflation regimes. It is only when inflation is high above 8.3 percent per annum that expected inflation induces greater variability in relative prices in the WAMZ. The result suggests that distortions of expected inflation on relative prices vanish in the low to intermediate regime, below the threshold level of inflation of 8.3 percent per annum. The finding is consistent with the predictions from the menu-costs model, suggesting sluggish adjustment of nominal prices as inflation erodes real prices and causing an increase in RPV.

Looking at inflation variability, the effects on RPV across the different inflation regimes show a qualitatively similar pattern like the results obtained for the ECOWAS. The effect of uncertainty on RPV is significantly positive as inflation increases from low to moderate regime but becomes

significantly negative as explained above. The results do not suggest any significant effect of neither the positive nor the negative inflation surprise on RPV.

The results show mixed evidence on the inflation regime in which the inflation-RPV relationship is weakest. The coefficient on expected inflation suggests that its effect on RPV is not significant in the low to moderate inflation regime, while inflation uncertainty, reveals that the effects decline in the high inflation regime. Comparing the inflation thresholds of the WAMZ and those obtained for the wider ECOWAS region, the results reveal that it is desirable to set an inflation target within the low to moderate inflation regime below the inflation threshold of 8.3 percent per annum. Across the ECOWAS region, the distortionary impact of expected inflation on RPV are moderated in the intermediate inflation regime from 7.1 percent to 8.3 percent. From these findings, a useful extension of the analysis is to determine whether the inflation threshold that minimizes RPV in the WAMZ is different from the inflation threshold of the WAEMU countries. The next sub-section analyzes the inflation-RPV linkage in WAEMU countries.

5.2.2 PSTR estimation results (WAEMU countries)

Table 6 below presents the results of the test procedure to determine whether the relationship between inflation and RPV is nonlinear in the WAEMU. To conduct the test, we excluded 48 largest observations (4.2 percent) to eliminate outliers in the data. Results show strong rejection of the null hypothesis of homogeneity but failed to reject the alternative hypothesis of the presence of one threshold function or a two-regime function. In effect, the test suggests that the inflation-RPV relationship in WAEMU can be characterized by a two-regime PSTR relationship.

Table 6: Linearity and no remaining non-linearity tests in WAEMU

Hypothesis	Test	Statistics	P-value
H_0: $(r = 0)$; H_1: $(r = 1)$	Wald Test (LM)	42.505	0.000
	Fisher Test (LMF)	10.934	0.000
	LRT Tests (LRT)	43.351	0.000
H_0: $(r = 1)$; H_1: $(r = 2)$	Wald Test (LM)	6.972	0.137
	Fisher Test (LMF)	1.722	0.143
	LRT Tests (LRT)	6.994	0.136

Lagrange multiplier-Wald (LM); Lagrange multiplier -Fischer (LMF); and Likelihood ratio (LR) tests. The null hypothesis of linearity H_0: linear model; H_1: PSTR model with at least one threshold. The null hypothesis of no remaining non-linearity H_0: PSTR model with one threshold; H_1: PSTR model with at least two thresholds.
Source: Authors estimations

Results from the estimation of a two-regime PSTR model are presented in table 7. This model estimates an inflation threshold of 5.5 percent per annum, which distinguishes between the low inflation regime below the threshold level and high inflation regime for all inflation levels above the threshold. In the low inflation regime, the coefficient on expected inflation is negative and not significant, but it has a positive effect on RPV in the high inflation regime. The result suggests that inflation expectations may only influence the variability of relative prices in WAEMU countries

under a high inflation regime. As the effect of expected inflation on RPV fades out in the low inflation regime, it is desirable for WAEMU countries to set an inflation target below this threshold. As explained above, the result is consistent with the predictions from the menu costs theory. Like the inflation-RPV nexus in WAMZ countries, the result suggests that the effect of inflation expectations on RPV exhibits a U-shape profile.

Turning to inflation uncertainty, we find significantly positive effect on RPV in the low inflation regime. The coefficient associated with the high inflation regime is positive but not statistically significant. This is consistent with the argument that in a stable inflation environment, low inflation is associated with higher inflation uncertainty compared to a high inflation regime. This induces greater variability in relative prices in the low inflation regime.

Table 7: PSTR model estimation (WAEMU)

	β_0	β_1
Location (threshold) parameter (c)	5.4596	
Slope parameter (γ)	5.6777	
Lagged expected inflation	-0.0001	0.0004***
	(0.0001)	(0.0001)
Lagged positive unexpected inflation	0.0003	-0.0002
	(0.0002)	(0.0003)
Lagged negative unexpected inflation	0.0002 *	-0.0009*
	(0.0001)	(0.0004)
Lagged inflation uncertainty	0.0015***	0.0002
	(0.2041)	(0.0009)
AIC criterion	-12.866	
Schwarz criterion	-12.820	
Number of observations	1096	

Note: ***, **,* denote 1%, 5% and 10 % respectively. Dependent variable-relative price variability (RPV)
Standard errors in parentheses are corrected for heteroscedasticity.
Source: Authors estimations

Turning to inflation surprises components, results suggest that the effect of negative unexpected inflation is weakly positive in the low inflation regime but turns out to be negative in the high inflation regime. However, positive unexpected inflation does not show any significant effect on RPV in both inflation regimes.

Overall, the results indicate the existence of different inflation thresholds between countries in WAMZ and WAEMU. The estimated inflation thresholds show that across the ECOWAS region, inflation expectations do not seem to distort relative prices in the intermediate inflation regime ranging from 7.1 percent to 8.3 percent per annum. In the WAMZ, the distortionary impact of expected inflation on relative prices is moderated in the low to intermediate inflation regime below the threshold of 8.3 percent per annum. For the WAEMU, countries would be able to mitigate the undesirable relative price dispersion induced by expected inflation in the low inflation regime below an inflation threshold of 5.5 percent per annum. These empirical insights provide clear guidance on the appropriate inflation rate that would allow central banks to anchor inflation expectations and enhance credibility in the conduct of monetary policy in these Zones. The findings suggest that there are different levels of inflation tolerance between the WAMZ and WAEMU as shown by the different inflation thresholds in these Zones. It implies that above the

established inflation thresholds for both Zones, the undesirable effects of high inflation on welfare would be amplified.

5.2 Robustness

To verify the robustness of our results, we use the core inflation measure to assess the nonlinear and threshold effects of inflation on RPV. As noted above, we employ one-period lag of headline inflation as the threshold variable, and all components of inflation to mitigate the problem of endogeneity. As discussed, the core inflation measure excludes volatile components of inflation associated with energy and food supply shocks, which, in effect mitigates simultaneity bias.

Table 8 reports the tests for nonlinearity using a sample of all the ECOWAS countries, which shows strong evidence of a nonlinear relationship between inflation and RPV. In line with the above analysis, the test results suggest the estimation of a PSTR model with two transition functions or three different inflation regimes.

Table 8: Linearity and no remaining non-linearity tests (ECOWAS)

Hypothesis	Test	Statistics	P-value
H_0: $(r = 0)$; H_1: $(r = 1)$	Wald Test (LM)	40.359	0.000
	Fisher Test (LMF)	10.194	0.000
	LRT Tests (LRT)	40.749	0.000
H_0: $(r = 1)$; H_1: $(r = 2)$	Wald Test (LM)	35.123	0.000
	Fisher Test (LMF)	8.815	0.000
	LRT Tests (LRT)	35.418	0.000
H_0: $(r = 2)$; H_1: $(r = 3)$	Wald Test (LM)	15.380	0.004
	Fisher Test (LMF)	3.817	0.004
	LRT Tests (LRT)	15.437	0.004

Lagrange multiplier-Wald (LM); Lagrange multiplier -Fischer (LMF); and Likelihood ratio (LR) tests. The null hypothesis of linearity H_0: linear model; H_1: PSTR model with at least one threshold. The null hypothesis of no remaining non-linearity H_0: PSTR model with one threshold; H_1: PSTR model with at least two thresholds.
Source: Authors estimations

The parameter estimates for the resulting three-regime PSTR model are displayed in Table 9. The results clearly show the variation in the effect of expected inflation and other components of inflation across the different inflation regimes. The coefficient on expected inflation is positive but not significant in the low inflation regime. It turns out negative and statistically significant in the intermediate inflation regime, which ranges from 4.9 percent to 6.1 percent per annum. Above the core inflation threshold of 6.1 percent per annum, expected inflation induces greater variability in relative prices. Considering this measure of inflation, the results reveal a tighter range of inflation to minimize distortions in relative prices, compared to headline inflation associated with an intermediate inflation regime ranging from 7.1 percent to 8.3 percent per annum. This is expected given the exclusion of volatile food and energy components of CPI in core inflation. Looking at this range, suggests that the distortions on relative prices would be minimized in the intermediate regime from 4.9 percent to 6.1 percent per annum.

Table 9: PSTR model estimation (ECOWAS)

	β_0	β_1	β_2
Location (threshold) parameter (c)	4.8607		6.0836
Slope parameter (γ)	1.9582		0.0593
Lagged expected inflation	0.0001	-0.0006***	0.0004***
	(0.0001)	(0.0001)	(0.0001)
Lagged positive unexpected inflation	0.0002	-0.0010***	0.0011***
	(0.0001)	(0.0003)	(0.0004)
Lagged negative unexpected inflation	0.0001	0.0016*	-0.0020**
	(0.0001)	(0.0009)	(0.0009)
Lagged inflation uncertainty	0.0017***	0.0053***	-0.0035***
	(0.0003)	(0.0012)	(0.0012)
AIC criterion	-11.965		
Schwarz criterion	-11.922		

Note: ***, **,* denote 1%, 5% and 10 % respectively. Dependent variable-relative price variability (RPV)
Standard errors in parentheses are corrected for heteroscedasticity.
Source: Authors estimations

6.0 Conclusion and policy implications

Research on RPV in the ECOWAS region has neglected the nonlinear inflation-RPV linkage, despite its relevance to the conduct of monetary policy. This paper examined the response of RPV to the different inflation regimes within the ECOWAS region during 2008-2019. By implication, it explored the inflation thresholds that would minimise the distortionary impact of expected inflation on RPV in the WAMZ, WAEMU and wider ECOWAS region. The interest in this relationship was driven by the belief that policymakers would be able to determine appropriate inflation targets to anchor inflation expectations and enhance credibility to monetary policy across the wider ECOWAS region.

To exploit the heterogeneity in inflation across countries, this paper applied the PSTR approach to explore the threshold effects of inflation on RPV over the period 2008:M1-2019:M12. The results show remarkably strong evidence of variations of the effects of expected inflation on RPV across the different inflation regimes in the ECOWAS region. In the WAMZ, the paper finds that the distortionary effects of expected inflation on relative prices fade out in the low to moderate inflation regimes below the inflation threshold of 8.3 percent per annum. This finding shows that it is desirable for WAMZ countries to set headline inflation target below 8.3 percent per annum. It implies that above this threshold, the undesirable effects of inflation on welfare will be amplified. Considering the WAEMU, the distortions of expected inflation on RPV are minimized if inflation is below the threshold of 5.5 percent. Across the ECOWAS region, countries would be able to achieve lower RPV in the intermediate inflation regime associated with headline inflation rate ranging from 7.1 percent to 8.3 percent per annum. This finding implies that the inflation target for the wider ECOWAS region should be set within this band to minimise the undesirable effects of inflation on welfare. The core inflation measure shows the intermediate inflation regime ranging from 4.9 percent to 6.1 percent per annum, suggesting a relatively tighter inflation target for the region.

The study has important implications for the conduct of monetary policy across countries in the ECOWAS region. The results show the existence of different inflation thresholds between WAMZ and WAEMU countries. The established inflation thresholds are consistent with the single-digit inflation convergence criterion set by ECOWAS countries. This finding suggests that it is probably currently not desirable to set a single inflation criterion of 5.0 percent per annum proposed by ECOWAS for both Zones. This is because countries in the WAMZ would still minimize distortions in relative prices at inflation levels above this threshold, but below 8.3 percent per annum for headline inflation. It is not the case for WAEMU countries, where such distortionary effects on welfare are magnified if headline inflation is above the threshold of 5.5 percent per annum. The outcome implies that there are differences in levels of inflation tolerance between these Zones, which reflect the differences in institutional and policy environments between them.

Given the differences in the inflation thresholds between these Zones, one policy option would be to adopt a two-tier inflation compliance strategy with inflation targets clearly defined within the established thresholds for these Zones. Considering that WAMZ countries are exposed to various shocks because of the adoption of a flexible exchange rate regime, structural reform measures should be adopted to reduce inflation below the established threshold of 8.3 percent per annum. Regarding the inflation threshold of 5.5 percent per annum in the WAEMU Zone, it is currently desirable for these countries to comply with the ECOWAS convergence criterion on inflation of 5.0 percent per annum.

Alternatively, the ECOWAS Member States should strengthen policy processes to foster the implementation of a common monetary policy framework. The determination of appropriate inflation targets in line with these thresholds in both Zones would pave the way for the adoption of an IT regime to anchor inflation expectations and enhance credibility of monetary policy actions across the wider ECOWAS region. However, the authorities should support efforts to harmonise CPI statistics across the ECOWAS region before migration to an IT framework.

There are, however, some shortcomings of the paper that are worth noting. The estimated models did not capture the persistence of variability in relative prices in explaining the inflation-RPV linkage. This requires the estimation of dynamic panel threshold models, which were not applied given the relatively small size of countries in each Zone to allow us to establish separate inflation thresholds. Future research should determine which components of the CPI strongly drive RPV in the ECOWAS region. It would be difficult, however, to undertake this research across the ECOWAS region in the absence of a harmonized CPI framework.

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Appendix

Appendix 1: Variable description

Variable	Description	Source
RPV	Relative price variability is measured as the weighted sum of squared deviations of the individual commodities price changes (π_{ijt}) around the average inflation for each country i (π_{it}): $$RPV_{ijt} = \sum_{j=1}^{n} w_{ijt}(\pi_{ijt} - \pi_{it})^2$$	Own calculations. Data on CPI was sourced from Central Banks and National Statistics Offices.
$\pi_{i,t}^{e}$	Expected inflation is derived as the absolute value of the series obtained using the GARCH (1 1) model of inflation estimated with seasonal effects.	Own calculations
$\pi_{i,t}^{ue}$	Unexpected inflation obtained as the difference between actual inflation (π_{it}) and expected inflation ($\pi_{i,t}^{e}$).	Own calculations
$\pi_{i,t}^{ue+}$	Positive unexpected inflation obtained using the formula: $\pi_{i,t}^{ue+} = \begin{cases} \pi_{i,t}^{ue} & if\ \pi_{i,t}^{ue} \geq 0 \\ 0, & otherwise \end{cases}$	Own calculations
$\pi_{i,t}^{ue-}$	Negative unexpected inflation measured as the absolute value of the series obtained using the formula: $$\pi_{i,t}^{ue-} = \begin{cases} \pi_{i,t}^{ue} & if\ \pi_{i,t}^{ue} \leq 0 \\ 0, & otherwise \end{cases}$$	Own calculations
$\pi_{i,t}^{uncer}$	Inflation uncertainty is measured as the square root of the conditional variance of inflation obtained from the estimation of the GARCH (1 1) model of inflation over a 12-month forecast horizon.	Own calculations

Appendix 2: GARCH (1 1) estimates for both expected inflation and ex-ante inflation uncertainty in ECOWAS

Variables	
Inf_constant	5.9019***
	(0.0669)
L.ar	0.9645***
	(0.0422)
L2.ar	0.1186**
	(0.0470)
L3.ar	-0.0237
	(0.0298)
L4.ar	-0.0630***
	(0.0211)
L.ma	0.0642*
	(0.0349)
L12.ma	-0.5230***
	(0.0141)
L.arch	0.0978***
	(0.0049)
L.garch	0.8966***
	(0.0042)
Constant	0.0039***
	(0.0006)
Observations	2,160

Note: '*', '**' and '***' indicate significant parameters at 10 %, 5% and 1%, respectively.