UNIVERSITY OF THE WITWATERSRAND

Monetary Policy Reaction Function and Transmission Effectiveness: Evidence from Full-Fledged Inflation Targeting Sub-Saharan African Countries.

By

Abdul-Aziz Iddrisu

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University of the Witwatersrand

Supervisor: Professor Imhotep Paul Alagidede

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ABSTRACT

The relevance of monetary policy rules in providing a framework for policy coherence, stability and optimality has long been acknowledged. The eventual impact of optimal monetary policy response on the real economy, dependent on the effectiveness of the channels of transmission of monetary policy impulses, is even more crucial. Much as empirical literature on monetary policy rules and transmission effectiveness abound, substantial limitations still persist. The continuous focus on linear policy rules in the face of observed asymmetry in monetary policy behaviour; the dilemma and constraints posed to monetary policy responses by rising public debt levels; the direct approach to transmission channel exposition that is far from theoretical prescription; the assumption of homogeneity in prices that confront all agents in an economy which is far from reality; and the egregious neglect of the stabilizing effect of monetary policy on food prices despite the colossal role of the latter in the overall inflation dynamics of developing and poor economies are important research gaps in the monetary policy rule and transmission literature. Meanwhile, appropriate policy characterization and succinct comprehension of the dynamics of transmission are critical in shaping optimal and welfare-enhancing monetary policy. This thesis is centred on four thematic areas, with each considering an important gap (as a distinct essay) relating to monetary policy characterization and transmission.

The first essay considers a nonlinear Taylor rule for the characterization of the monetary policy responses of the only two full-fledged inflation targeting central banks in Africa (Bank of Ghana and the South African Reserve Bank) and whether the said responses are constrained by rising public debt levels. With the aid of the sample splitting and threshold estimation technique, we find asymmetric reaction to inflation and output gaps when inflation falls below or exceeds our

estimated optimal thresholds of 16.4% and 5.2% for Ghana and South Africa respectively, with the South African Reserve Bank being relatively more aggressive in its response to inflation gap above the threshold. The Bank of Ghana is not responsive to output gap on either side of the threshold. Importantly, we find that the monetary policy behaviour of the two central banks is far from the linear characterization and parametrization so common in the literature. For Ghana, we question the logic behind the prevailing upper and lower bounds given the evidence to the contrary. In respect of debt constraint on monetary policy, our estimated threshold level of debt to GDP ratio for Ghana and South Africa are respectively 35.1% and 33.7%. For Ghana, although policy response to inflation gap exhibits relative aggression above the estimated debt to GDP threshold of 35.1%, the extent of response is woefully disproportionate, a key indication of debt constraint and inflation accommodation. For South Africa, we find that the policy response in the low debt regime to inflation gap is negative, on the back of accommodative monetary policy when inflation exceeded the upper limit of the announced target in the midst of challenging growth path. Although the response to inflation gap in the high debt regime is positive, it is substantially constrained.

The extent to which monetary policy decisions exact the desired results in the real economy is essentially a function of the effectiveness of the channels of monetary policy transmission. Comprehending the architecture and dynamics of the workings of these channels is thus critical for the monetary policymakers, as it helps them to determine how and when their decisions eventually impact the real economy and the nature of instruments to adopt. We revisit, in the second essay, the workings of the interest rate and bank lending channels in an indirect and systematic approach anchored on the theoretical prescriptions and a major departure from empirical literature. With the aid of the three stage least square technique (3SLS) in a system of equations, we find that the interest rate and the lending channels are operative in Ghana and South Africa. We find that whiles the lending channel is more effective relative to the interest rate channel in South Africa, the reverse is the case in Ghana.

The fact that different regions/provinces have different economic structures and endowments is an ample reason to expect that price developments in these regions/provinces and their responses to monetary policy would necessarily be distinct. Literature has largely assumed homogeneity in the prices that confront economic agents with dire consequences for welfare. The third essay, therefore, looks at asymmetric effect of monetary policy on regional and provincial inflation in Ghana and South Africa. Using wavelet-based quantile regression for the first time in this strand of the literature, we provide a multi-layered asymmetric exposition on regional inflation-monetary policy relationship. We find that regions/provinces respond differently to changes in monetary policy. For Ghana, we find that for Central, Eastern, Greater Accra, Northern and Western regions, a restrictive monetary policy exacts mixed effect. Whiles monetary policy delivered stability across distinct quantiles in some scales, it fueled inflationary momentum in other scales, especially the higher scales or longer horizons. The responses are also distinct across scales and quantiles for each of the regions and across regions. In the case of Ashanti, Brong Ahafo and Volta regions, we find that a restriction in monetary policy only destabilizes prices across quantiles and in distinct scales. For South Africa, we find that whiles restrictive monetary policy delivers stability in the prices of Gauteng, Mpumalanga and North West provinces, it is destabilizing for prices in Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape provinces. For Free State province, the effect of a restrictive monetary policy on prices is mixed, depending on the horizon and the quantile involved.

Food prices continue to play an important role in the overall inflation dynamics of many countries. For inflation targeting central banks and monetary policymakers in developing and low-income countries in particular, food prices pose even more challenges both from the perspective of achieving inflation targets and the welfare of the many poor households in these economies. In the fourth essay, we look at the stabilizing effect of monetary policy on food inflation in Ghana and South Africa using the quantile regression analysis. For Ghana, we find that monetary policy exerts positive effect on food prices across all the quantiles but the said effect is only statistically significant at the 25th quantile. For South Africa, monetary policy positively influences prices of food and the effect is significant across all the quantiles and prominently at the right tail. Thus, rising food prices in these countries are destabilized even further when monetary policy response is restrictive.

On policy front, the relative inflation accommodation on the part of these central banks is deleterious to their credibility and disastrous for anchoring expectations of inflation which is exacerbated by the observed debt constraint. The findings on the operations of the bank lending and interest rate channels provide policy directions for the authorities to exact the required impact on the real economy and inflation in particular. Such policy directions are enhanced by the invaluable information on the heterogeneous regional responses to policy and the colossal role played by food prices in the African setting.

Key words: Monetary policy rule, debt constraint, monetary policy transmission, regional inflation, food inflation, wavelet-based quantile regression, sample splitting, threshold estimation.

DECLARATION

I, Abdul-Aziz Iddrisu with student identification number 2069155, declare that this PhD thesis titled "Monetary Policy Reaction Function and Transmission Effectiveness: Evidence from Full-Fledged Inflation Targeting Sub-Saharan African Countries" is my own research work. Articles and materials, representing the works of others, used for this research have been duly referenced and acknowledged. This research work has not been presented before for examination leading to an award of any degree either to this university or any other.

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Abdul-Aziz Iddrisu (2069155)

October 5, 2020

DEDICATION

To my late father (Alhaji Iddrisu Mahama) and my mother (Hajia Safuratu)

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I thank Almighty ALLAH for the opportunity to pursue a PhD, the understanding of the subject area, the strength to see it through, the gift of an incredible supervisor and the favour of completion of the PhD programme at one of the world's best universities and the pride of Africa. *Alhamdulillah daa'iman wa abadan.*

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
BCEAO	Banque Centrale Des Etats De L'Afrique De L'ouest
CPI	Consumer Price Index
DFID	Department for International Development
DNA	Deoxyribonucleic Acid
DSGE	Dynamic Stochastic General Equilibrium
DWT	Discrete Wavelet Transform
FAO	Food and Agriculture Organization
FAVAR	Factor Augmented Vector Autoregression
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HP	Hodrick-Prescott
IMF	International Monetary Fund
IT	Inflation Targeting
MENA	Middle East and North Africa
MODWT	Maximal Overlap Discrete Wavelet Transform
MPC	Monetary Policy Committee

PP	Phillips-Perron
REER	Real Effective Exchange Rate
SARB	South African Reserve Bank
SVAR	Structural Vector Autoregression
VAR	Vector Autoregression
VIF	Variance Inflation Factor
WDI	World Development Indicators
3SLS	Three Stage Least Squares

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Output growth, price stability and sustainable development remain the preoccupation of policy makers in every economy of the world, regardless of their stage on the development continuum. The persistent budget deficits in many countries across the world, fiscal indiscipline and the culminating failure of fiscal policy to provide stability in various economies (due largely to political exigencies) have meant that monetary policy has assumed a critical role in delivering the needed stability in these economies (Laureys & Meeks, 2018; and Mishkin, 1996). Meanwhile, the instability that characterized the great depression is largely attributed to monetary mistakes and excess money (Taylor, 2017) and especially when monetary policy decisions are based on discretion.

These blips, on the part of central banks, led to a clarion call for policy rules to guide policy-making and provide a framework for stability in a manner that averts shocks to money, insulate the economy from other shocks and avert hyperinflation (Taylor, 2017). The most popular amongst these policy rules in theory and practice is the Taylor (1993) rule, following its phenomenal success in characterizing the Federal Reserve Bank's policy behaviour. Some modifications were later made to the Taylor rule to include the forward-looking behaviour of central banks (Woodford, 2001 and Clarida et al, 1999). A number of augmentations such as exchange rate (Caporale et al, 2018; Daude et al, 2016; Ghosh et al, 2016) and asset price index (Naraidoo & Paya, 2012) have also been made to the rule.

A burgeoning paradigm in the policy rule literature is the argument that monetary policy behaviour of central banks is not necessarily linear, raising doubts about the famous linear Taylor (1993) rule. Variations in business cycles (Liu et al, 2018), nonlinear relationship between macroeconomic variables (Caporale et al, 2018; and Dolado et al, 2005) and the differences in the objectives and preferences of monetary policy authorities (Ahmad, 2016; Martin & Milas, 2013; and Castro, 2011) are ample reasons why policy behaviour is not linear. Indeed, some authors (Hasanov & Omay, 2008; Surico, 2007; and Blinder, 1998) assert that asymmetry in monetary policy behaviour can be attributed to political pressures on central banks. Their argument is that when a central bank tightens monetary policy to dampen inflation, it may come under immense political pressure as compared to when it loosens policy to buoy employment.

Furthermore, literature acknowledges that rising public debt is a serious source of dilemma and concern for central banks, particularly the inflation targeting central banks (Mitra, 2007; and Dornbusch, 1996). The inflationary effect of rising public debt levels would necessitate an increase in the policy rate to curb the inflationary momentum. Such a prudent policy step is, however, not straightforward in practice especially with less independent central banks. Taking a contractionary monetary policy stance in the face of rising public debt heightens the interest service liability of the fiscal authorities, feeding into worsening fiscal deficits and deteriorating the debt stock even further and inflationary momentum eventually. Meanwhile, keeping interest rates low amidst rising inflation is even more ruinous in the context of inflation targeting, as the publicly announced inflation target would not only be missed, but it collapses an important foundation of public trust and endangers the very survival of the inflation targeting framework on anchoring inflation expectations. This represents a serious dilemma to central banks, a phenomenon termed by Mitra (2007) and Dornbusch (1996) as 'debt constraint on monetary policy'. Surprisingly, empirical investigation into this phenomenon remains egregiously limited.

The policy decisions of monetary authorities, either in response to deviations of macroeconomic fundamentals from their targets or systematic policy changes meant to achieve a macroeconomic outcome, may or may not generate the desired goals depending on the effectiveness of the channels of monetary policy transmission to the real economy. Imperatively, therefore, policymakers require a succinct appreciation of the architecture and dynamics of the workings of these channels to be able to evaluate the timing and extent of impact of their decisions on the real economy (Cevik & Teksoz, 2012; and Boivin et al, 2010). Theoretically, the impulses of monetary policy are transmitted to the real economy through channels such as interest rate, credit, exchange rate and asset prices with an important role for components of aggregate demand to play in the transmission process (Boivin et al, 2010; and Mishkin, 1996). The interest rate channel, for instance, works in a manner such that changes in monetary policy affects interest rates, then investment, then aggregate output or inflation. The same systematic transmission applies to the other channels (see Mishkin, 1996; and Boivin et al, 2010 for the theoretical prescriptions). Invariably, the effect of monetary policy on output or inflation is necessarily indirect through other intermediaries.

A large amount of the literature on monetary policy-inflation nexus are premised on the notion that all economic agents are confronted with homogeneous prices in the economy (Fielding & Shields, 2006) and thus situate the relationship in the context of national aggregates. Such national inflation aggregates are necessarily averages of the different prices observed in different regions of the same country. As noted by Fielding & Shields (2006), Ceglowski (2003), Cecchetti et al (2002) and Engel & Rogers (2001), different people, and for that matter different cities in a country face different prices. In this regard, situating the monetary policy-inflation nexus in the context of the national aggregates then masks the heterogeneous prices faced by different economic agents in different regions of the same country. Fielding & Shields (2006) observe that where heterogeneity exists in the prices that confront economic agents in the same economy, it presents significant ramifications for the conduct of monetary policy. Arnold & Kool (2004) argue that inflation rate differentials in different regions has implications for monetary policy that is conducted at the national level because a restrictive monetary policy may be felt differently in different regions. While it may be mildly restrictive for some regions, it may be severely restrictive for others. Indeed, such a monetary policy stance may even be accommodative for some other regions.

Anagnostou & Gajewski (2019) reckon that the effect of monetary policy, although intended to manifest at the country level, would not be the same for different locations in the same country. Regions will respond differently to changes in monetary policy as a result of differences in the structure of economies of these regions. The patterns of consumption in these regions, their industrial mix, the level of development of their respective financial sectors, performance of enterprises and the differences in demography necessarily inform the differences in the structure of these regions and for which reason monetary policy changes should not be expected to have a uniform impact across these regions (Anagnostou & Gajewski, 2019). Carlino & DeFina (1998) had made similar observations that much as monetary policy is meant to exact an effect on the whole economy, the reality is that the country is made up of different regions with differences in their responses to shocks from macroeconomic variables. Differences in the large-small firm mix across regions and the extent of their dependence on bank loans, differences in the sensitivity of industries in these regions to interest rates, and differences in banks' abilities to change their statements of financial position in the various regions are ample reasons why their respective responses to changes in monetary policy would differ. Moreover, differential responses of regions to changes in monetary policy may also result from differences in capacities of production, technological differences, differences in region-specific factors, differences in the economic agents' behaviour and differences in the economic policy implementations in these regions, especially in countries where governance is largely decentralized (Anagnostou & Papadamou, 2016).

Importantly, Carlino & DeFina (1998) point out that the nature of the theories on transmission of monetary policy themselves give an indication that different regions may be affected differently by changes in monetary policy. In the interest rate channel for instance, different firms and industries have different sensitivities to interest rates and different regions have different industrial mix. The credit channel, following the works of Bernanke & Blinder (1988) and Kashyap et al (1996), also suggest that some firms depend more on loans from banks than other firms and regions have different mix of industries and firms. Indeed, some banks have the capacity to shield their loan portfolios more than other banks (Kashyap & Stein, 1995) following restrictions on reserves through monetary policy, and banks are heterogeneous across regions. Theoretically, authors such as Gros & Hefeker (2002) and De Grauwe (2000) have demonstrated that when monetary policy rule disregards regional differentials in the face of transmission asymmetry, welfare losses would be the natural consequences (Fielding & Shields, 2006). Fratantoni & Schuh (2003) argue that for monetary policy efficiency, recognizing differences across regions are of great importance.

The effect of food prices on the overall inflation dynamics of countries is well acknowledged in the literature (Hammoudeh et al, 2015; Catao & Chang, 2015; Anand et al, 2015). For inflation targeting central banks in particular, food prices pose a problem not only for the overall inflation but also dents the forecasting accuracy meant to inform policy stance (Šoškić**,** 2015). As a result, central banks that target inflation give a considerable attention to food price evolution (Catao & Chang, 2015). However, literature recognizes that the extent of the impact of food inflation on the overall inflation dynamics is a function of income levels of countries (Pourroy et al, 2016), and the proportion of food in the consumption basket of the country (Catao & Chang, 2015). For developing and low income economies where food occupies a significant portion of the consumption basket and where expenditure on food takes a substantial portion of the already meagre income, rising food prices is important not just for the current inflation but also underpins future inflation through expectations and wage negotiations (Pourroy et al, 2016; and Anand et al, 2015). Importantly, Hanif (2012) reckons that because expenditure on food by households in low income economies is enormous (based on Engel's law), rising food prices is inimical to their welfare.

A critical question that has been posed in the literature is whether food inflation should inform monetary policy stance. The argument is that because food price effects are ephemeral, driven by supply side shocks and exhibit extreme volatility (Alper et al, 2016; Anand et al, 2015; Šoškić**,** 2015; Moorthy & Kolhar, 2011; and Anand & Prasad, 2010), it falls beyond the control of monetary policymakers. A counter argument in the literature has been that demand side factors such as income (Pourroy et al, 2016; and Šoškić, 2015) can also drive up prices of food and for which aggregate demand moderation (within the remit of central banks) can prove to be an effective panacea. In addition, to consider only the direct and contemporaneous effect of food prices is to underestimate its lethal second round impact on the other constituents of the CPI basket and the overall inflation eventually (De Gregorio, 2012). Hammoudeh et al (2015) reckon that to the extent that prices of commodities contain information regarding possible upward or downward inflation momentum, they become an important consideration that should inform the stance of monetary policy, a recognition made earlier by Bernanke & Gertler (1999).

An important consensus in the literature is that because expenditure on food in low income economies is a behemoth and the fact that food dominates their consumption baskets, to ignore food price inflation in such countries is to erroneously estimate the living cost and the prices that ordinary households encounter in these countries (Alper et al, 2016). Prices of food is therefore very prominent in the inflation dynamics and policy stance of central banks in these countries, especially the inflation targeting central banks. Indeed, the theoretical literature (Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015) posit that monetary policy can only deliver true welfare maximization in low income economies and those with dominance of food in the consumption basket by targeting headline inflation (that includes food). While theoretical literature

(Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015; Soto, 2003; and Aoki, 2001) provide the foundation for optimal monetary policy to impact food inflation, empirical investigation into this nexus remains limited (Bhattacharya & Jain, 2019).

1.2 The Problem Statement

We provide the problem statement along the four blocks captured in the introduction. They are *monetary policy rule and debt constraints; channels for transmission of monetary policy; monetary policy effect on regional/provincial prices; and monetary policy and food inflation.* We discuss them as follows:

1.2.1 Monetary Policy Rule and Debt Constraints

In spite of the overwhelming evidence of asymmetry in the monetary policy behaviour of central banks, (Caporale et al, 2018; Liu et al, 2018; Ahmad, 2016; and Hasanov & Omay, 2008)), the monetary policy rule literature is still inundated with linear expositions anchored on the famous Taylor (1993) rule. Much as literature on nonlinear monetary policy rule is growing, fundamental limitations still linger. As argued by Liu et al (2018) and Caporale et al (2018), a large number of these nonlinear studies use models such as regime switching and structural change which exhibit characteristics of structural breaks across regimes. Meanwhile, in the short term, monetary policymakers seldom engage in adjustments of monetary policy rule on a large scale (Liu et al, 2018). Getting the policy characterization right is as critical as the adoption of the policy rule itself. Furthermore, the dearth of research on nonlinear monetary policy rules on Africa (Ncube & Tshuma, 2010; Naraidoo & Raputsoane, 2011; Naraidoo & Paya, 2012; Baaziz et al, 2013; and

Baaziz & Labidi, 2016) is worrying. Following the argument in the literature that when monetary policy is optimal in each country, the global monetary policy space become optimal on the aggregate (Taylor, 2017), then monetary policy optimality of central banks in Africa is certainly part of the story as it is one of the continents with the largest number of countries and invariably the largest number of central banks.

Remarkably, while these policy rule studies have sought to capture policy responses to macroeconomic fundamentals, whether the said responses are constrained by rising public debt levels remain empirically unexplored. Meanwhile, literature acknowledges that rising public debt is a serious source of dilemma and concern for central banks, particularly the inflation targeting central banks (Mitra, 2007; and Dornbusch, 1996). The study by Mitra (2007) on the Bank of Canada, to the extent that we know, is the sole empirical study across the monetary policy rule literature that has considered debt constraint on monetary policy (interest rate setting) behaviour. A fundamental drawback of that study, as Mitra (2007) acknowledges, is the failure to provide the confidence interval for the threshold estimate. As the author used sample debt observations to infer about the population, and in particular for policy purposes, the inability to provide confidence intervals raises questions of uncertainty about the accuracy and precision of the estimates and could be fundamentally different from the actual population debt threshold. Meanwhile, such empirical exercises are supposed to inform policy. Taking policy decisions on the basis of estimates whose accuracy cannot be ascertained only jeopardizes soundness of policy paths and the credibility of the policymakers. The current study therefore makes a number of contributions to the policy rule literature and the debt constraint discourse. First, the study captures nonlinearity appropriately, as that has been the major limitation in the policy characterization literature, by employ the sample splitting and threshold estimation technique developed by Hansen (2000). Second, the study enlarges the literature on Africa where the most neglect has been pervasive in both the academic and policy making circles. Third, the study extends our knowledge of the extent of debt constraint on monetary policy behaviour by overcoming the inherent limitations in the previous studies.

1.2.2 Channels for Transmission of Monetary Policy

Whether monetary policy decisions exact the desired results in the real economy hinges on the effectiveness of the channels of monetary policy transmission. Imperatively therefore, policymakers require a succinct appreciation of the architecture and dynamics of the workings of these channels to be able to evaluate the timing and extent of impact of their decisions on the real economy (Cevik & Teksoz, 2012; and Boivin et al, 2010). The monetary economics literature, unsurprisingly, is inundated with empirical research on the channels of monetary policy transmission (see for example, Anwar & Nguyen, 2018; Afrin, 2017; Chen et al, 2017; Mandler et al, 2016; Amar et al, 2015; Fernald et al, 2014; and Cevik & Teksoz, 2012), with inconclusive results (see Senbet, 2016; Cevik & Teksoz, 2012; and Sims, 1992). The results are sensitive to the countries being studied, the span of data and the model used for estimation.

We argue that the inconclusiveness in the literature can largely be attributed to fundamental flaws in the approaches to transmission channel exposition. Literature has tended to consider a direct effect of monetary policy impulses on the real economy using estimation techniques such as the vector error correction and the generalized method of moments in a single equation context (Tran, 2018; and Matousek & Solomon, 2018). Meanwhile, the theoretical prescriptions of the workings of the channels of monetary policy transmission are far from a direct monetary policy-real economy relationship. Theoretically the interest rate channel, for instance, works in a manner such that changes in monetary policy affects interest rates, then investment, then aggregate output or inflation. The same systematic transmission applies to the other channels (see Mishkin, 1996; and Boivin et al, 2010 for the theoretical prescriptions). To consider a direct relationship, as in the existing literature, is to obfuscate the underlying dynamics of the transmission mechanisms.

Furthermore, the very nature of the theoretical prescriptions of the transmission mechanism implies a significant role for the components of the aggregate demand in delivering the monetary policy impulses to the real sector of the economy. Investment, a component of aggregate demand, is key in the interest rate and credit channels, with import and exports also phenomenal in the exchange rate channel of monetary policy transmission. Surprisingly, empirical literature assume away such roles and stack a typical vector autoregressive (VAR) model or its variants with variables representing monetary policy, interest rate, output, inflation, exchange rate, asset prices and credit. They then report the impact of monetary policy on say interest rate (in pairs) and then the impact of interest rate on output or inflation as the interest rate channel (see for example, Anwar & Nguyen, 2018; Kim & Lim, 2018; Tran, 2018; Afrin, 2017; Chen et al, 2017; Zhang & Huang, 2017; Mandler et al, 2016; Senbet, 2016; Amar et al, 2015; Belke & Beckman, 2015; Fernald et al, 2014; Jain-Chandra & Unsal, 2014; Cevik & Teksoz, 2012; and Koivu, 2012 for different channels). Meanwhile, the theory is far from such over simplification. Although few studies exist on the impact of monetary policy on some components of aggregate demand such as Owusu-Sekyere (2017), Koivu (2012), and Ncube & Ndou (2011) on consumption; Yang et al (2017) and

Ndikumana (2016) on investment; Vithessonthi et al (2017) on corporate investment; Mukherjee & Bhattacharya (2011) on consumption and investment; Sariola (2009) on imports and exports and Aron et al (2014) on imports prices, but how such effects of monetary policy on these components eventually reflect in the ultimate variables of output and inflation remain unexplored. Inspired by the theoretical prescriptions of the dynamics of monetary policy transmission channels, the current study explores the systematic and indirect transmission of policy impulses to the real economy.

1.2.3 Monetary Policy Effect on Regional/Provincial Prices

Notwithstanding the apparent heterogeneity in the prices that confront economic agents in distinct parts of an economy, empirical literature on monetary policy-inflation nexus continue to assume homogeneity of prices for all economic agents. This is problematic and may elicit sub optimality in monetary policy conduct and the overarching objective of welfare maximization. Theoretically, authors such as Gros & Hefeker (2002) and De Grauwe (2000) have demonstrated that when monetary policy rule disregards regional differentials in the face of transmission asymmetry, welfare losses would be the natural consequences (Fielding & Shields, 2006). Fratantoni & Schuh (2003) argue that for monetary policy efficiency, recognizing differences across regions are of great importance.

Although literature on monetary policy and asymmetric regional responses exist, they are largely focused on differential regional output responses to monetary policy shocks (Anagnostou & Gajewski (2019); Anagnostou & Papadamou (2016); Ridhwan et al (2014); and Carlino & DeFina

(1998, 1999). Other contexts include monetary policy and regional housing equity and refinancing of mortgages in the United States (Beraja et al, 2017); monetary policy, credit availability and cost in the regions of the United Kingdom (Dow & Montagnoli, 2007); monetary policy and regional housing market in the United States (Fratantoni & Schuh, 2003); monetary policy and general macroeconomic variables (Fraser et al, 2014; and De Lucio & Izqueirdo, 1999); monetary policy and employment (Svensson, 2012); and monetary policy and real variables (Xiaohui & Masron, 2014). However, studies on monetary policy and responses of regional inflation remain limited in the empirical literature. Meanwhile, differential responses of regional inflation to monetary policy pose a critical challenge in the context of inflation targeting countries where such differences could potentially undermine the achievement of the publicly announced national target with dire consequences for credibility of policymakers.

Few studies, such as Fischer et al (2018), Aastveit & Anundsen (2017), Yang et al (2010) and Del Negro & Otrok (2007) have considered monetary policy and regional prices but only in the context of housing prices as opposed to total regional consumer prices. Meanwhile, the prices that confront economic agents in the various regions of the country go beyond just the housing prices. Beck et al (2006) studied factors that explain inflation at the regional levels of selected countries in the Euro area but fell short of an explicit relationship between monetary policy and these regional prices. Choi et al (2015) considered the effect of the adoption of inflation targeting framework on regional inflation in South Korea as opposed to the impact of changes in monetary policy on regional inflation. Nagayasu (2010) studied factors that explain regional prices in China but not the heterogeneous responses of regional inflation to monetary policy changes. Alagidede et al

(2014) considered persistence in regional and sectoral inflation in Ghana as opposed to the responses of regional inflation to changes in monetary policy.

To the extent that we know, the only two studies that have looked at responses of regional prices (inflation) to changes in monetary policy are Fielding & Shields (2006) in the context of South Africa and Fielding & Shields (2007) in the context of the United States. These studies are, however, limited in a number of ways. Fielding & Shields (2006) considered a hypothetical monetary policy as opposed to actual monetary policy changes with the limitation that the results obtained may be far from reality in terms of actual policy dynamics. Fielding & Shields (2007) considered the context of law of one price and how monetary policy itself contribute to the heterogeneity in regional prices. Moreover, the authors studied cities in the United States as opposed to full-fledged regions.

In addition, while these studies underscore the policy and welfare fatality of assuming homogeneity in the effect of monetary policy on the inflation of regions of a country, they surprisingly assume that the relationship between each region’s inflation and monetary policy is symmetric throughout the distribution of the former. Thus, while they capture heterogeneity between regions, they overlook the heterogeneity in the relationship between monetary policy and each region’s inflation. Meanwhile, the fact that monetary policy behaviour and effect, and indeed macroeconomic variables, exhibit asymmetry is well known in the literature (Liu et al, 2018; Caporale et al, 2018; Ahmad, 2016; Martin & Milas, 2013). Moreover, the economic processes of the regions are not static over time nor simplistic to expect that each region’s inflation response to monetary policy remains the same across time. Importantly, if recognition of heterogeneity between regions in respect of their responses to monetary policy is crucial for policy coherence and welfare maximization, then capturing the appropriate relationship between monetary policy and each region's inflation is even more critical.

Moreover, these studies have been conducted in pure time domain that overlooks the fact that the objectives of central banks differ across long- and short-term horizons and these objectives simultaneously operate at varying scales. As argued by Aguiar-Conraria et al (2008), different economic agents take various actions with varying objectives over different horizons and it is these varying actions and objectives that inform various economic processes. As a result, time series data on various macroeconomic variables are necessarily an amalgamation of these varying objectives and horizons of economic agents. Consequently, the effect of monetary policy, for instance, would naturally differ across different horizons and frequencies. Such intricate relationship between monetary policy and other macroeconomic variables may be difficult to unearth with econometric methods that are either exclusively frequency-domain or exclusively time-domain (Aguiar-Conraria et al, 2008). Significantly, Aguiar-Conraria et al (2018) reckon that the effect of monetary policy across various horizons and particularly the cyclical frequencies should be of interest to policymakers as social welfare may be affected differently when fluctuations occur across distinct frequencies.

We make significant contributions to the monetary policy-regional inflation nexus. We consider a multi-faceted approach to capturing asymmetry in the effect of monetary policy on regional inflation in Ghana and South Africa as we unearth not just the relationship across time and frequency but also across distinct quantiles of the distributions of the respective regional inflation using the wavelet-based quantile regression technique for the first time in the literature on monetary policy and regional inflation.

1.2.4 Monetary Policy and Food Inflation

While theoretical literature (Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015; Soto, 2003; and Aoki, 2001) provide the foundation for optimal monetary policy to impact food inflation, empirical investigation into this nexus remains limited (Bhattacharya & Jain, 2019). A considerable amount of the empirical literature (Hammoudeh et al, 2015; Scrimgeour, 2014; Anzuini et al, 2010; and Akram, 2009) have looked at monetary policy and commodity price index. Few studies (Hammoudeh et al, 2015; and Akram, 2009) have gone beyond the commodity price index to look at the effect of monetary policy on disaggregated components such as food and oil. Even so, the focus has been the context of the United States and a selected advanced and emerging economies (Bhattacharya & Jain, 2019; Hammoudeh et al, 2015; Scrimgeour, 2014; Akram, 2009; and Frankel, 2008).

Meanwhile Africa, where poverty levels are high and with dominance of food in the consumption basket, remains unexplored empirically. In Sub Saharan Africa, food constitutes 40% of the consumption basket as compared to 15% in the advanced economies (Alper et al, 2016). Additionally, the prevalence of poverty in Africa means that food is a major priority and a colossus in the overall expenditure of households. Out of the 736 million extremely poor individuals across the world, as many as 413 million (more than half) lived in Sub-Saharan Africa alone as at 2015 (World Bank, 2018, 2019). In addition, out of the 28 countries regarded as poorest in the world, as many as 27 countries (representing 96.4%) are located in Sub-Saharan Africa (World Bank, 2018, 2019). Understanding the monetary policy-food price nexus in the context of Sub-Saharan Africa could not be more critical. While studies by Alper et al (2016) and Rangasamy (2011) in the context of Africa provide important insights on food inflation and its dynamics, they failed to explicitly model the impact of monetary policy on food inflation.

Importantly, the few studies on monetary policy and food inflation in the context of advanced and emerging countries are fraught with considerable limitations. These studies used the vector autoregressive (VAR) technique or the structural VAR. Although the VAR models have been a workhorse for studies on monetary policy, the right approach for the identification of monetary policy innovations in VARs remains a critical point of disagreement in the literature. In view of such disagreements, empirical results have tended to differ significantly (Bernanke et al, 2004). In addition, the VAR methodology only captures the impact of surprise (Bernanke et al, 2004) in monetary policy as opposed to the invaluable impact of a more systematic monetary policy decisions. Significantly, the use of VAR in these studies on countries such as New Zealand, Canada, Chile, Mexico, India and UK (Bhattacharya & Jain, 2019; Frankel, 2008) which are all inflation targeting countries is problematic. We argue that, in inflation targeting regimes where policy transparency is a sine qua non of the policy framework, the widespread usage of VARs which captures only policy surprises is counterintuitive. Surprises in monetary policy contradicts the need for credibility, transparency and anchoring inflation expectations which are the bedrocks of inflation targeting framework.

Furthermore, the argument in the literature that food inflation exhibits extreme volatilities especially when driven by extreme weather and other supply side shocks (Alper et al, 2016; Anand et al, 2015; Šoškić, 2015; Moorthy & Kolhar, 2011; and Anand & Prasad, 2010) implies that food price distribution necessarily exhibits tail dynamics which mean-based approaches such as VAR would naturally be incapable of capturing. Meanwhile, such tail dynamics are likely to exert substantial effect on the overall inflation trajectory and pose enormous risk to the achievement of the inflation targets. An approach that is more robust to tail dynamics would prove to be invaluable. Notably, the use of VAR in these studies is an explicit assumption of symmetry in the monetary policy-food inflation nexus. Meanwhile, the fact that monetary policy behaviour and effect, and indeed macroeconomic variables, exhibit asymmetry is well known in the literature (Liu et al, 2018; Caporale et al, 2018; Ahmad, 2016; Martin & Milas, 2013). Given the dominant role of food prices in the trajectory of inflation in the African context and those targeting inflation in particular, getting the relationship right between monetary policy and food inflation is critical not just for the credibility of the monetary policymakers, but the resulting policy coherence is invaluable in alleviating the devastating effect of food prices on the welfare of the poor on the continent. We study the monetary policy-food inflation nexus in the African context for the first time in the literature. We depart from the existing literature by employing an estimation technique that captures the apparent asymmetry in the monetary policy-food inflation nexus.

1.3 Research Questions

Following from the research problem statements, this study seeks to answer the following research questions:

a) Does a non-linear Taylor rule appropriately characterize the policy behaviour of the South African Reserve Bank and the Bank of Ghana? Is the behaviour constrained by spiralling public debt levels?

b) How effective are the interest rate and bank lending channels of monetary policy transmission when the theoretically prescribed role of aggregate demand components are accounted for?

c) How differently does monetary policy affect regional/provincial prices across different horizons and distinct quantiles?

d) To what extent is food inflation stabilized by monetary policy?

1.4 Research Objectives

This study's primary objective is the characterization of monetary policy behaviour of the only two full-fledged inflation targeting countries in Sub-Saharan Africa and how monetary policy impulses are transmitted to the economy. The study specifically looks at monetary policy rule and debt constraints; transmission effectiveness of monetary policy; monetary policy and regional/provincial inflation; and then monetary policy and food inflation. Specific objectives are:

1. Ascertain whether the monetary policy behaviour of the South African Reserve Bank and the Bank of Ghana is appropriately characterized by a linear or nonlinear Taylor rule and whether rising public debt levels constrain this behaviour.
2. Examine the effectiveness of interest rate and bank lending channels of monetary policy transmission by accounting for the role of aggregate demand component (investment). The

objective considers an indirect approach to transmission channel exposition that captures the theoretical prescriptions of the transmission dynamics.

3. Assess the response of prices of different regions/provinces to a homogenous monetary policy. The objective seeks to unearth the heterogeneity in price responses across different regions/provinces, over different time horizons and across distinct quantiles.
4. Examine the extent to which monetary policy provides stability in food prices in view of the dominance of food in the inflation dynamics of poor and developing economies.

1.5 Justification and contribution to the literature

Literature on monetary policy rule has largely been based on linear Taylor rule in the face of overwhelming evidence of asymmetry in the monetary policy behaviour of central banks. The few that have explored nonlinearity in monetary policy rule suffer a number of limitations. Meanwhile, getting the policy behaviour characterization right is as critical as the adoption of monetary policy rules themselves. Significantly, the nature of monetary policy response is acknowledged to be substantially influenced by public debt levels in what has been termed as debt constraint on monetary policy (Mitra, 2007; and Dornbusch, 1996). Surprisingly, not only is empirical evidence on this phenomenon egregiously dearth, the only study in the literature suffers fundamental limitations. The current study thus estimates monetary policy rules for Ghana and South Africa by exploring asymmetry in the policy behaviour using the Hansen (2000) sample splitting and threshold estimation technique which captures nonlinearity appropriately. The study then examines the extent of constraint on the policy behaviour of the South African Reserve Bank and the Bank of Ghana imposed by rising public debt levels. While there is no nonlinear monetary policy rule on Ghana to the best of our knowledge, the few non-linear studies on South Africa have used models that fail to account for nonlinearity appropriately. We overcome the limitations of the only study on the debt constraint phenomenon and therefore make an important stride in this strand of the policy rule literature.

In terms of transmission channel effectiveness, literature is replete with conflicting findings. A potential source of this impasse is the approach in the literature where authors have assumed away the workings of intermediate variables such as the components of aggregate demand and rather put proxies for the various channels in a VAR model. The current study contributes to literature by examining the interest rate and bank lending channels and accounting for the role of investment (aggregate demand component) which is at the heart of the workings of these channels. The study considers a more systematic approach to unearthing the workings of these channels in line with theoretical prescriptions.

Although economic agents in various parts of an economy are confronted with heterogeneous prices, empirical literature assume price homogeneity in studying monetary policy-inflation nexus with dire welfare consequences. An effort by the central bank to stabilize general price level in the economy may not be optimal in welfare maximization if it fails to understand how prices in different regions (a measure of living cost) are affected by its decisions or actions. Not only is literature scant on how monetary policy affects regional prices, the few available are based on the United States and limited to the prices of houses in various regions. The only study two studies, to the extent that we know, that have considered the heterogeneous effect of monetary policy on regional inflation are by Fielding & Shields (2006) in the context of South Africa and Fielding &

Shields (2007) in the context of the United States. These studies are, however, limited in a number of ways. Fielding & Shields (2006) considered a hypothetical monetary policy as opposed to actual monetary policy changes with the limitation that the results obtained may be far from reality in terms of actual policy dynamics. Fielding & Shields (2007) considered the context of law of one price and how monetary policy itself contribute to the heterogeneity in regional prices. Moreover, the authors studied cities in the United States as opposed to full-fledged regions. In addition, while these studies underscore the policy and welfare fatality of assuming homogeneity in the effect of monetary policy on the inflation of regions of a country, they surprisingly assume that the relationship between each region's inflation and monetary policy is symmetric throughout the distribution of the former. Meanwhile, the fact that monetary policy behaviour and effect, and indeed macroeconomic variables, exhibit asymmetry is well known in the literature (Liu et al, 2018; Caporale et al, 2018; Ahmad, 2016; Martin & Milas, 2013). Moreover, the economic processes of the regions are not static over time nor simplistic to expect that each region's inflation response to monetary policy remains the same across time. The current study makes significant contributions to the monetary policy-regional inflation nexus. We consider a multi-faceted approach to capturing asymmetry in the effect of monetary policy on regional inflation in Ghana and South Africa as we unearth not just the relationship across time and frequency but also across distinct quantiles of the distributions of the respective regional inflation using the wavelet-based quantile regression technique for the first time in the literature on monetary policy and regional inflation. Such multi-layered asymmetric exposition provides a far more nuanced information that are invaluable in informing monetary policy stance.

Much as theoretical literature (Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015; Soto, 2003; and Aoki, 2001) provide the foundation for optimal monetary policy to impact food inflation, empirical investigation into this nexus remains limited. A handful of studies (Bhattacharya & Jain, 2019; Hammoudeh et al, 2015; and Akram, 2009) have looked at the effect of monetary policy on food prices. Even so, the focus has been the context of the United States and a selected advanced and emerging economies. Meanwhile Africa, where poverty levels are high and with dominance of food in the consumption basket, remains unexplored empirically. While studies by Alper et al (2016) and Rangasamy (2011) in the context of Africa provide important insights on food inflation and its dynamics, they failed to explicitly model the impact of monetary policy on food inflation.

Importantly, the few studies on monetary policy and food inflation in the context of advanced and emerging countries are fraught with considerable limitations. These studies used the vector autoregressive (VAR) technique or the structural VAR. Although the VAR models have been a workhorse for studies on monetary policy, it suffers identification problems, captures only unexpected changes in monetary policy, unable to capture tail dynamics given volatilities in food prices and assumes symmetry in the relationship between monetary policy and food prices. We study the monetary policy-food inflation nexus in the African context for the first time in the literature. We depart from the existing literature by employing an estimation technique that captures the apparent asymmetry in the monetary policy-food inflation nexus and capable of dealing with tail dynamics in view of the known volatilities in food prices.

1.6 The choice of Ghana and South Africa

Price stability is gradually been accepted by economists as the desirable primary objective that central banks should pursue in the long term (Mishkin, 1996). It is in recognition of this and the failure of monetary targeting that many countries across the world adopted inflation targeting framework for monetary policy. With literature on monetary policy effectiveness rather limited on sub-Sahara Africa, the current study focuses on this region. We pay special attention to countries that practice full-fledged inflation targeting in the region and Ghana and South Africa meet that requirement. Our study is particularly important for these countries as they need to understand how their decisions are translated into real economy to achieve the set targets for inflation and provide them the needed credibility to be able to anchor the public expectation of inflation going forward.

1.7 The structure of the thesis

The thesis encompasses six chapters. In chapter two, the study reviews theoretical and empirical literature on monetary policy rule and debt constraint on monetary policy behaviour. It then provides empirical evidence on the monetary policy behaviour of the South African Reserve Bank and the Bank of Ghana and whether such a behaviour is constrained by rising public debt levels. In chapter three, the study reviews theoretical and empirical literature on the channels of transmission of monetary policy impulses. The chapter then provides empirical evidence by revisiting the interest rate and bank lending channels and accounting for the role of aggregate demand component in an indirect fashion anchored on theoretical prescriptions. Chapter four reviews theoretical empirical literature on monetary policy and regional inflation and provides empirical evidence in the context of Ghana and South Africa. In chapter five, theoretical and empirical literature on monetary policy and food inflation are reviewed. It then provides an empirical evidence on the monetary policy-food inflation nexus. The conclusion, policy ramifications and recommendations for further studies are contained in chapter six.

CHAPTER TWO

MONETARY POLICY BEHAVIOUR AND DEBT CONSTRAINTS

2.1 Introduction

Monetary policy rules have long been advocated for in the wake of economic instabilities and prolonged inflationary episodes that were thought to have been occasioned by monetary mistakes (Taylor, 2017). Some of these rules include Friedman's (1948, 1960) fixed percentage rule, McCallum's (1988) feedback rule and the Taylor (1993) interest rate rule. Of all these rules, the Taylor (1993) rule has enjoyed enormous popularity in the literature and in practice, largely as a result of its phenomenal success in characterizing the policy behaviour of the Federal Reserve Bank of the United States particularly between 1987 and 1992. Some modifications were later made to the Taylor rule to include the forward-looking behaviour of central banks (Woodford, 2001 and Clarida et al, 1999). A number of augmentations such as exchange rate (Caporale et al, 2018; Daude et al, 2016; Ghosh et al, 2016) and asset price index (Naraidoo & Paya, 2012) have also been made to the rule.

A burgeoning paradigm in the policy rule literature is the argument that monetary policy behaviour of central banks is not necessarily linear, raising doubts about the famous Taylor (1993) linear rule. Variations in business cycles (Liu et al, 2018), nonlinear relationship between macroeconomic variables (Caporale et al, 2018; and Dolado et al, 2005) and the differences in the objectives and preferences of monetary policy authorities (Ahmad, 2016; Martin & Milas, 2013; and Castro, 2011) are ample reasons why policy behaviour is not linear. Indeed, some authors

(Hasanov & Omay, 2008; Surico, 2007; and Blinder, 1998) assert that asymmetry in monetary policy behaviour can be attributed to political pressures on central banks. Their argument is that when a central bank tightens monetary policy to dampen inflation, it may come under immense political pressure as compared to when it loosens policy to buoy employment.

Although literature on nonlinear monetary policy rule is growing, fundamental limitations still linger. As argued by Liu et al (2018) and Caporale et al (2018), a large number of these nonlinear studies use models such as regime switching and structural change which exhibit characteristics of structural breaks across regimes. Meanwhile, in the short term, monetary policymakers seldom engage in adjustments of monetary policy rule on a large scale (Liu et al, 2018). Getting the policy characterization right is as critical as the adoption of the policy rule itself.

Furthermore, the dearth of research on nonlinear monetary policy rules on Africa is worrying. We observed that not only are studies on Africa limited, they are largely based on linear policy rules. The nonlinear studies, to the best of our knowledge, across the whole of Africa are Ncube & Tshuma (2010), Naraidoo & Raputsoane (2011), Naraidoo & Paya (2012) and Baaziz et al (2013) for South Africa and then Baaziz & Labidi (2016) for Egypt and Tunisia. Following the argument in the literature that when monetary policy is optimal in each country the global monetary policy space become optimal on the aggregate (Taylor, 2017), then monetary policy optimality of central banks in Africa is certainly part of the story as it is one of the continents with the largest number of countries and invariably the largest number of central banks. Importantly, the few studies on Africa have a number of limitations. For instance, Naraidoo & Raputsoane (2011) used 3-month

Treasury bill rate as monetary policy variable instead of the repo rate which is the policy instrument used by the South African Reserve Bank. Naraidoo & Paya (2012) focused more on forecasting interest rate but again they also used 3-month Treasury bill rate as the policy variable instead of the repo rate. Ncube & Tshuma (2010), Baaziz et al (2013) and Baaziz & Labidi (2016) used logistic smooth transition regression which, as argued by Liu et al (2018) and Caporale et al (2018), are limited in capturing nonlinear characteristics of monetary policy behaviour.

Remarkably, while these policy rule studies have sought to capture policy responses to macroeconomic fundamentals, whether the said responses are constrained by rising public debt levels remains empirically unexplored. Meanwhile, literature acknowledges that rising public debt is a serious source of dilemma and concern for central banks, particularly the inflation targeting central banks (Mitra, 2007; and Dornbusch, 1996). The inflationary effect of rising public debt levels would necessitate an increase in the policy rate (restrictive policy stance) to curb the inflationary momentum. Such a prudent policy step is, however, not straight forward in practice especially with less independent central banks. Taking a contractionary monetary policy stance in the face of rising public debt heightens the interest service liability of the fiscal authorities, feeding into worsening fiscal deficits and deteriorating the debt stock even further and inflationary momentum eventually. Meanwhile, keeping interest rates low amidst rising inflation is even more ruinous in the context of inflation targeting, as the publicly announced inflation target would not only be missed, but it collapses an important foundation of public trust and endangers the very survival of the inflation targeting framework on anchoring inflation expectations. This represents a serious dilemma to central banks, a phenomenon termed by Mitra (2007) and Dornbusch (1996) as ‘debt constraint on monetary policy’. Surprisingly, empirical investigation into this phenomenon remains egregiously limited. The study by Mitra (2007) on the Bank of Canada, to the extent that we know, is the sole empirical study across the monetary policy rule literature that has considered debt constraint on monetary policy (interest rate setting) behaviour. A fundamental drawback of that study, as Mitra (2007) acknowledges, is the failure to provide the confidence interval for the threshold estimate. As the author used sample debt observations to infer about the population, and in particular for policy purposes, the inability to provide confidence intervals raises questions of uncertainty about the accuracy and precision of the estimates and could be fundamentally different from the actual population debt threshold. Meanwhile, such empirical exercises are supposed to inform policy. Taking policy decisions on the basis of estimates whose accuracy cannot be ascertained only jeopardizes soundness of policy paths and the credibility of the policymakers.

The current study therefore makes a number of contributions to the policy rule literature and the debt constraint discourse. First, to capture nonlinearity appropriately, as that has been the major limitation in the policy characterization literature, we employ the sample splitting and threshold estimation technique developed by Hansen (2000). This model, in addition to an accurate threshold effect estimation, also unravels the varying effects of output and inflation gaps on the policy rate when inflation exceeds or falls below the optimal threshold. Furthermore, the functional form of nonlinearity or otherwise that the relationship between the regressors and the policy variable take is not assumed or superimposed *a priori* by our model. Indeed, an important virtue of our estimation technique is the fact that it empirically provides the confidence intervals for the threshold's statistical significance with the aid of the asymptotic theory. The model approximates, asymptotically, the distribution of the threshold parameter's estimate, a feature that distinguishes it from the other threshold models. Additionally, the resulting asymptotic distribution of the threshold parameter's estimate is devoid of nuisance parameters that other threshold models suffer (Hansen, 2000). Finally, the approach does not require a predetermination of the threshold value as this is done by the model itself.

Second, we help enlarge the literature on Africa where the most neglect has been pervasive in both the academic and policy making circles. The nonlinear policy rule estimation for Ghana in our work becomes the first of its kind in Ghana. Importantly and in the context of inflation targeting, we become the first in the literature to consider the two full-fledged inflation targeting countries in Africa at the same time.

Third, given the policy relevance of empirically examining the extent of debt constraint on monetary policy, particularly for inflation targeting central banks, our focus on the South African Reserve Bank and the Bank of Ghana represents an important stride in the literature in view of the limited studies. Importantly, our study could not be more critical in view of the fact that the debt to GDP ratios of South Africa and Ghana over their respective inflation targeting periods have witnessed an upward trajectory. In the case of South Africa, the debt to GDP ratio reached 53% in 2017 and an estimated 55.7% in 2018 from as low as 26.5% in 2008. For Ghana, the debt to GDP ratio rose from 31% in 2007 when the full-fledged inflation targeting began to 70.2% in 2014 and 72.2% in 2015 necessitating an IMF intervention in 2015 with a credit facility of USD 918 million under a three-year programme meant to engender restoration of sustainability of debt, provide stability to the macro economy and enhance economic growth (IMF, 2015). These developments pose a significant upside risk to inflation and indeed inflation in both countries over the respective high debt periods has largely been above the publicly announced targets. Notably, we provide evidence in the context of Africa where high levels of debt and fiscal licentiousness continue to fuel not just inflation but also constrain the fiscal space and deny the countries the needed developmental projects.

Fourth, to overcome the limitations of the work of Mitra (2007), we make use of Hansen (2000) sample splitting and threshold estimation technique that provides confidence intervals at 95% confidence level on the basis of asymptotic theory. Significantly, the fact that we are considering an African context makes the need to determine debt threshold with considerable confidence level the more critical as lack of precision could spell even more misery in terms of policy coherence and credibility.

We find, in the case of monetary policy rule characterization, that policy reaction to inflation gap is asymmetric when inflation falls below or exceeds our estimated optimal thresholds of 16.4% and 5.2% for Ghana and South Africa respectively, with the South African Reserve Bank being relatively more aggressive in its response to inflation gap above the threshold. Whereas the Bank of Ghana is not responsive to output gap on either side of the threshold, the South African Reserve Bank is responsive to output gap above the threshold. The findings are robust to variations in model specifications. Importantly, we find that the monetary policy behaviour of the two central banks is far from the linear characterization and parametrization so common in the literature. Surprisingly, we find considerable accommodation of inflation on the part of these central banks that are supposed to be targeting inflation. For Ghana, we question the logic behind the prevailing upper and lower bounds given the evidence to the contrary.

On debt constraint and monetary policy, we find, for Ghana, that although policy response to inflation gap exhibits relative aggression above the estimated debt to GDP threshold of 35.1%, the extent of response is woefully disproportionate, a key indication of debt constraint and inflation accommodation by a central bank that is supposed to be targeting inflation. We also find the Bank of Ghana to be unresponsive to output gap below and above the threshold. For South Africa, we find that the policy response to inflation gap in the high debt regime (above the estimated threshold debt to GDP ratio of 33.7%) is substantially constrained. The extent of inflation accommodation is even more pronounced on the back of a challenging growth trajectory. This is reflected in the rather high weights placed on the output gap below and above the debt threshold. The findings are robust to different specifications. We discuss key policy ramifications for monetary policy effectiveness under a targeting regime.

Section 2.2 focuses on the developments of monetary policy in South Africa and Ghana. This is followed by macroeconomic developments and monetary policy response in both countries in section 2.3 and review of the relevant literature in section 2.4. The methodology is covered in section 2.5. We then present the empirical results and analysis in section 2.6 and conclusion in section 2.7.

2.2. The Development of Monetary Policy in Ghana and South Africa

2.2.1 The case of Ghana

Drawing from Addison (2001), we provide the evolution of monetary policy in Ghana. The transformation of the financial system in Ghana that accompanied the Economic Recovery Programme of 1983 triggered numerous modifications in the conduct of monetary policy, particularly in respect of the instruments deployed, although the ultimate objective continues to be the stability of the price level. From a controlled environment in terms of conduct of policy and the deployment of direct instruments, the deregulation of the financial system provided the impetus for shift to the utilization of indirect instruments in a more market oriented system during a period where steering of monetary aggregates were considered the intermediate target with the intuition that it had a direct bearing on the ultimate objective of stability of the price levels. Before 1983, the Bank of Ghana had used M1 as the intermediate target but modified it over time as financial innovation continued to confound what constituted money. Following the growth in savings and time deposits and their substitutability for current account deposits, the Bank of Ghana replaced M1 with M2 as the new intermediate target. As deposits denominated in foreign currency also grew faster in the commercial banks, there was the policy need to bring these deposits under the surveillance of the regulator since they posed additional risk to exchange rate movements and inflation. As a consequence, the Bank of Ghana in 1997 moved to M2+ to include these deposits as the intermediate target. However, the expected relationship between these intermediate targets and inflation waned as innovation and technology in the financial sector became more pervasive and continuously changed the boundaries of the definition of money. The country's inflation outcomes deteriorated on the back of the weakened monetary aggregate-inflation relationship. The Bank of Ghana had to then transition to the use of interest rate as instrument for policy and eventually adopted inflation targeting framework. This became possible following the passage of the Bank of Ghana Act (2002) that granted an operational independence to the central bank and the power to adopt its own policy instruments.

2.2.2. The case of South Africa

Drawing on Casteleijn (2001) and Aron & Muellbauer (2000), we provide a historical account of the evolution of monetary policy in South Africa. The policy in the 1960s up to the beginning of 1980 was one of quantitative control of both credit and interest rate under a system based on liquid asset ratio. Under this framework, the central bank used liquid asset requirement for the control of money where commercial banks were made to keep certain liquid assets as a minimum ratio of the deposits they have and very limited role was given to interest rate to play. The intuition behind this was that by making the commercial banks to keep these liquid assets, it curtails their lending ability and growth of money supply. The discontentment with this framework and the De Kock Commission's recommendations, ushered in a new framework in 1985 based on cost of cash reserves. Under this framework, the reserve bank announced annually an explicit target for monetary growth (M3) between 1986 and 1998. These explicit targets of M3 were then to be realized through the use of interest rates, making interest rates (discount rate) an important policy instrument. With structural changes and liberalization of the financial system in the 1990s, the link between money supply growth, prices and output altered significantly and limited the relevance of targets of money supply, leading the Reserve Bank to complements these monetary targets with wider indicators such as asset prices, exchange rates, balance of payments, output gap, fiscal stance, total credit extension and wage settlements. Towards the start of March 1998, the Reserve Bank started tenders of liquidity on daily basis through repurchase transactions as a new monetary accommodation. Inflation was still a challenge due to the growing weakness of the link between monetary aggregates and inflation. To help anchor inflation expectations, obtain credibility and deliver more transparent policymaking, the Reserve Bank began to set guidelines for M3 growth for a period of three years from March 1998 with an informal target of inflation set for the first time to range between 1% and 5%. By 2000, the Reserve had migrated to a formal and an explicit inflation targeting framework with inflation target range of 3% and 6% and remain the same target range for inflation in South Africa.

2.3 Macroeconomic Developments and Monetary Policy Response

The monetary policy stance at any point in time in any country is informed by the developments within and outside the economy. To put our study in context, we provide the changes in policy stance and the underlying factors in these two countries by relying on the monetary policy committee statements and annual reports issued at various times by the two central banks.

2.3.1 The case of Ghana

Full-fledged inflation targeting was launched in Ghana on the 21st of May 2007 with a publicly announced target range of 7% and 9%. With global crude oil price hikes in the year 2007 (which reached $99 per barrel) and its impact on domestic prices in Ghana that led to double upward review of petroleum prices in the country, the rising food prices resulting from increasing cost of distribution of food, the irregular supply of energy, utility tariff hikes, widening deficit of the budget and the strengthening demand in the economy, inflation in Ghana exceeded the announced target and reached 12.8% at the end of 2007. Indeed, the year started with a rate of inflation of

10.9% which was already higher than the upper limit of the announced target band. In response, the monetary policy stance was one of tightening as the monetary policy rate was reviewed upwards to 13.5% in November 2007. Similar to 2007, the year 2008 witnessed rising global crude oil and food prices on the back of the global economic meltdown that fed into local prices in Ghana. In addition, fiscal deficit deteriorated to 13.92% of GDP against a target of 6.1% of GDP for the year. Output in 2008 grew by 7.3% up from 6.7% in 2007. These developments presented an upside risk to inflation and inflation did rise to 18.4% in June from 12.8% in January. Although it dropped to 17.3% in October 2008, it closed the year at 18.1% against the inflation target of 6% to 8% for 2008. In response, the monetary policy committee of the Bank of Ghana adjusted the policy rate upwards three times in the year from 13.5% in January to reach 17% in July.

The factors that fueled inflation momentum in 2008 were deemed to still linger in the early part of 2009 thereby necessitating a policy tightening in February 2009 to 18.5% but reduced to 18% in November as inflation declined from 20.7% by middle of 2009 to 15.9% by December 2009 on the back of subdued economic activities (output growing at 4%) and improved inflation outlook. The year 2010 saw a massive policy easing as inflation dropped to a single digit. Inflation declined from 15.9% at the end of 2009 to 9.5% in June 2010 and further down to 8.6% by the end of the year. The stability of the local currency, enhanced production of food and sluggish global economic recovery underpinned the decline in inflation. The monetary policy rate was cut down from 18% to 13.5% by July 2010. Ghana started oil production on commercial scale in 2011 which helped to boost output in the year as it grew by 14.4%. With improved output performance, an increase in petroleum prices in January 2011 and rising non-food inflation, overall inflation rate increased from 8.6% at the end of 2010 to 9.2% in February 2011. However, with food inflation dropping from 4.5% at the end of 2010 to 4.3% in 2011 and the decline in non-food inflation in the second half of the year from 12.4% in June to 11.2% in December, inflation rate declined from 9.2% to 8.6% at the end of 2011. Notably, inflation ranged between 8.4% and 9.2% in 2011 with a target of 9% announced for that year. With single digit inflation in 2011 as well, the policy stance was on the path of easing. The Bank of Ghana, reduced the monetary policy rate from 13.5% to 12.5% by July 2011.

In 2012, the Ghanaian economy grew moderately at 7.9% with the depreciation of the Cedi a major destabilizer of the economy in that year. The cedi weakened against the US dollar by as much as 17.5% in the year compared to 4.9% in 2011 on the back of phenomenal pressures from demand side and speculative attacks. In February 2012, the Bank of Ghana increased the monetary policy rate to 13.5% from 12.5% at the end of 2011 as it considered the weakening cedi, the negative impact of the debt crisis in the Eurozone and the upsurge in fiscal spending to pose a significant upside risk to inflation outlook in Ghana. In addition to these factors, the economy witnessed strong domestic demand and improved economic activities towards the second quarter of 2012 leading the Bank of Ghana to review the policy rate upwards to 14.5% in April. The increasing financing of the fiscal deficit domestically, the continued weakening of the cedi and the increasing non-food inflation which reached 12.5% by August 2012 from 11.2% in December 2011 posed additional risk to inflation and the policymakers reviewed the policy rate upwards to 15% in June 2012. Although policy stance was one of tightening in 2012, increasing by 2.5% on the aggregate, inflation surged to 9.5% in July 2012 from 8.6% by the end of 2011 but closed the year at 8.8% within the announced target range of 6.5% and 10.5%. Inflation momentum picked up in 2013 on the back of a number of increases in petroleum prices and related products, hikes in utility tariffs, the weakening cedi, the increasing fiscal deficit and the surging non-food inflation. Inflation rose from a single digit of 8.8% at the end of 2012 to 13.5% in 2013. In response, the Bank of Ghana reviewed the policy rate upwards by 1% from 15% in 2012 to 16% in May 2013.

Growth slowed down in 2014 reaching 4% compared to 7.3% recorded in 2013. The weakening of the cedi, soaring utility tariffs, hikes in petroleum prices, swelling public sector wages and debt servicing fed into inflation. Inflation rose to 17% at the end of 2014 from 13.5% at the end of 2013. In response, the policy stance was tightened with policy rate increased from 16% in 2013 to 21% by November 2014. As the weakening of the cedi was becoming more pronounced over the past years, 2014 saw the issuance of new regulations on foreign exchange by the Bank of Ghana. In 2015, growth shrunk further to 3.7% as the challenges in the energy sector had a toll on the industry and enhanced cost push factors that fed into inflation. In addition, utility tariff hikes, increases in petroleum prices and the depreciating cedi reinforced inflation momentum with inflation rising to 17.7% at the end of 2015 well above the target range of 6% and 10%. This led to another round of policy tightening with policy rate increasing from 21% to 26% by November 2015. The story was not very different in 2016 with hikes in utility tariffs, increasing petroleum prices and the associated high cost of transportation reinforcing the high inflation outlook and expectations. The situation was compounded by high debt servicing and the resulting fiscal pressures. Inflation rose from 17.7% to 19% at the start of 2016 and further to 19.2% in March. As a result, policy stance remained tightening at 26% for the first three quarters of 2016. However, with low food prices and the decline in non-food inflation from 23.3% at the end of 2015 to 18.2% towards the end of 2016, overall inflation fell to 15.4% in December 2016 from the 19.2% recorded in March 2016. Following this development, the policy rate was reduced by 50 basis points to close the year at

25.5%. Growth picked up in 2017 on the back of oil and gas sector to reach 8.5% compared to the 3.7% recorded in 2016. The fiscal consolidation drive in 2017, relative stability of the cedi in 2017 and the declining non-food inflation dampened inflation expectations. In addition, the improved confidence in the economy in 2017 and the stable power supply provided a significant downside risk to inflation. Consequently, inflation dropped to 11.8% at the end of 2017 from 15.4% at the end of 2016 although it was still above the target range of 6% and 10%. Policy rate reduced from 25.5% to 20% by the end of 2017. Fiscal consolidation continued in 2018 and the domestic currency remained stable. In addition, food inflation fell leading to a fall in inflation to 9.4% at the end of 2018. On the back of these developments and the downwards trend in inflation, the Bank of Ghana reduced the policy rate from 20% to 17% by May 2018.

2.3.2 The case of South Africa

Relying on the annual reports and monetary policy decisions of the SARB over the years, we provide an insight into the macroeconomic developments and policy responses. South Africa announced its inflation targeting framework on February 23, 2000 with a medium-term target range of 3% and 6% by 2002 but remains the target range. Although factors such as rising crude oil prices on the international market, hikes in food prices, weakening rand and increasing monetary aggregates posed an upside risk to inflation in 2000, significant downside risk to inflation also existed. The slow growth of the economy, low per unit cost of labour as well as fiscal and monetary discipline provided the impetus for disinflation. As a result, the greater part of the year 2000 saw a stable monetary policy stance as the repo rate was kept at 11.75% until October when it was reviewed upwards by 25 basis points to reach 12% at a special meeting. The upward review was occasioned by the continuous weakening of the rand, increasing petroleum prices and current account deficit by the third quarter of 2000 which posed an upside risk to inflation and endangered the prospects of achieving the medium-term target by 2002. The repo rate remained the same at 12% throughout the last quarter of 2000 up to the second quarter of 2001 when it was reviewed downwards by 1% to 11% in June 2001 and further down to 9.5% in September 2001. The global economy was experiencing sluggish growth and the growth trajectory in South Africa was not different. The period also saw enhanced commitment to fiscal and monetary discipline as well as an overall reduction in domestic credit extension. Inflation trended down by the first quarter of 2001 reaching 6.1% and further down to 6% in August 2001 on the back of moderation in the increases of energy and food prices, declining per unit cost of labour for two consecutive years and reversal of current account deficit to surplus. These developments then informed the softening of policy stance in 2001. The monetary policy stance in 2002 was one of tightening. The repo rate was reviewed upwards cumulatively to 13.5% by September following the sharp weakening of the rand, increasing prices of food, fuel and services, current account deficit and increasing credit to the private sector which posed risk to inflation. By July, inflation had reached 9.9%.

In the year 2003, the increases in prices of food moderated, the rand staged a recovery, the current account recovered to surplus position, the growth of money and credit extension softened, the continued fiscal discipline and the less than potential output in the economy set the tone for a disinflation process. Yearly inflation declined to 4% by December 2003 although the average for the year was 6.8% down from average of 9.3% recorded for 2002. In response, the reserve bank reduced the repo rate considerably by 5.5% cumulatively from 13.5% in 2002 to 8% by December 2003. The path of disinflation continued in 2004 on the back of developments similar to those in 2003. There were some developments such as increases in crude oil prices and movements in exchange rate that posed an upside risk to inflation during the year and inflation did increase briefly to 5% in June. However, with declining inflation expectations, fiscal discipline, low credit extension to the private sector, low capacity utilization especially in manufacturing, inflation trended downwards and reached 3.7% in December 2004. As a result, the greater part of the year saw policy rate remaining the same at 8% with a marginal downward review by 0.5% in August to 7.5% following the declining inflation expectations. Inflation remained within the target range, declining further to 3.1% in February 2005 as fuel prices in the economy were reduced considerably. Additionally, due to slow rate of growth of food prices, the decline in service prices and the favourable inflation outlook, the reserve bank reduced the policy rate by 0.5% to reach 7% in April 2005. However, inflation subsequently increased to 4.8% in August on the back of fuel price hikes in the economy but dropped to 4.4% in October following a decline in the prices of food and other consumer goods and services. With inflation expected to remain within the target range of 3% and 6%, the repo rate remained the same at 7% by December 2005.

The developments in 2006 dampened the hitherto benign inflation trajectory. The country experienced widening current account deficit, growing extension of credit to the private sector feeding into robust consumer demand, improved productivity in the manufacturing sector and increasing prices of petroleum products. These developments worsened the inflation expectations and the reserve bank responded with repo rate increase of 50 basis points to 7.5% in June. The bleak inflation outlook was compounded by increasing prices of food and weakening rand. By June, inflation had reached 4.8% up from 3.7% in April. Worse still, the forecast of inflation by the reserve bank had indicated an upward trajectory. Such upside risk to inflation then necessitated another increase in the repo rate by 0.5% in August to 8%. Furthermore, the increasing economic activities, strengthened domestic demand that was underpinned by growing credit to the private sector, widening deficit in the current account and the weakening rand triggered a further uptick in inflation which reached 5% in October. The repo rate was thus adjusted further upwards to 8.5% in October. The upside risk to inflation still lingered as the economy continued on the path of improved economic activities and rising food inflation. Concerned about the deteriorating inflation outlook, the reserve bank tightened monetary policy further by increasing the repo rate to 9% in December 2006. The inflation momentum continued in 2007 with inflation going beyond the target range to reach 7.3% by October on the back of hikes in prices of food, crude oil prices feeding into prices of petroleum, weakening rand and hikes in utility prices. The increasing momentum of inflation triggered a policy tightening in 2007, with the repo rate increased by 2% on the aggregate from 8% to 11% by December 2007.

By February 2008, inflation had reached 9.4% on the back of year-on-year increases in food and petroleum prices. With surging labour cost, rand depreciating by 16% at the start of 2008, electricity price hikes and crude oil price, the outlook of inflation deteriorated further. The reserve bank decided in April to increase the repo rate by 50 basis points to 11.5%. From 9.4% in February, inflation trended upwards to 10.1% in March and then to 10.4% by April as food and petroleum price hikes continue. With inflation outlook expected to deteriorate further, the repo rate was again reviewed upwards in June by 0.5% to 12%. Towards the last quarter of the year, the inflation outlook saw signs of moderation despite the surge in the third quarter. From 10.4% in April, inflation increased to 13.6% by August (as food and petroleum prices increased year-on-year by 17.2% and 31% respectively) but began to wane, reaching 13% in September and further down to 12.4% by October as the effect of the global economic meltdown began to manifest in the South

African economy as well as the sharp decline in crude oil prices. These developments provided a boost to the anchoring of inflation expectations by the reserve bank. The repo rate was, as a result, reduced by 0.5% to 11.5% in December 2008 as inflation dropped to 10.3%. In 2009, economic growth slowed down further with the effect of the global economic crisis still lingering. Crude oil prices as well as food inflation were equally moderate thereby boosting the inflation outlook. The repo rate was reduced in February 2009 by 1% to 10.5% as inflation had dropped further to 8.1% in January. The favourable inflation outlook led to a further reduction in the repo rate in March 2009 by 1% to 9.5%. At the same time, the extent of volatility of the exchange rate was moderating and the consumer demand and extension of credit to the private sector were on the decline. In May 2009, the reserve bank reduced the repo rate twice. The repo rate was first reduced by 1% to reach 8.5% on May 4 and then further down to 7.5% on May 29. Output contraction continued with capacity utilization in the manufacturing sector falling from 84.4% in the prior year to 78%. Consumer demand and extension of credit continued to be on the decline. Inflation dropped to 6.9% by June and although prices of food and petroleum continued to pose high risk to inflation, the overwhelming downside risk emanating from output contraction led the reserve bank to reduce the repo rate in August by 50 basis points to 7%. The start of the year 2010 saw a decline in inflation to 5.7% within the target range as the rand strengthened, output growth still softened and inflation outlook better. The reserve bank reduced the repo rate in March by 0.5% to 6.5%. As demand conditions in the domestic economy continued to wane, the protracted output contraction on the back of fragility in the global economic space placed even further downward inflationary pressure and with the strengthening rand reinforcing the favourable inflation outlook, inflation dropped further by July to reach 3.7% from 4.6% recorded in May 2010. The reserve bank reduced the repo rate in September by 0.5% to 6% and further down to 5.5% in November as inflation dropped to 3.2% by September 2010. The year 2011 witnessed some economic recovery in the domestic economy although considerable fragility still existed. Inflation momentum picked up in the year, rising to 5.7% by September. Prices of food and petroleum remained key contributing factors to the inflation momentum although other factors such as weakening rand, transport and utility played significant roles. However, the monetary policy stance remained the same from November 2010 throughout the year 2011 as the repo rate remained at the 5.5% level in the whole of 2011. With inflation rising continuously in 2011, a policy tightening would have been expected. However, the reserve believed that the factors driving inflation upwards were cost push in nature and that the softened domestic demand, fragility in the recovery of the economy and the Eurozone debt crisis offered a counter downside inflation risk to keep the outlook balanced.

Inflation outlook at the start of 2012 deteriorated further with prices of petroleum, food and exchange rate volatility leading the pack of underlying factors. Inflation reached 6.1% in April. There were however downside risk factors as well such as the contagion effect of the Eurozone debt crisis on domestic growth fragility. Indeed, the slowing domestic economy resulting from sluggish global economic growth fed into lower inflation expectations and inflation actually dropped to 5.5% by June 2012. The continued favourable inflation outlook informed a downward review of the repo rate by 0.5% in July to 5%. The favourable inflation outlook continued in 2013 with inflation falling within the target range by October. The widening current account deficit as well as the prolonged depreciation of the rand posed a significant upside risk to inflation in 2013. Indeed, inflation remained close to the upper band of 6% throughout the year. Despite the inflationary pressures, the country was still experiencing weak growth prospects which was compounded by prolonged stoppages of work within the sector for motor vehicles and the negative impact it had on exports for that year. Concerned about the rather sluggish economic growth, the reserve bank kept the repo rate at 5% throughout 2013 in the face of growing inflation momentum.

Following the reduction in the quantitative easing programme by the Federal Reserve which signaled an improvement in the US economy, a number of developing and emerging economies suffered exchange rate volatility in the short to medium term as the reduction in the quantitative easing came with it significant capital flight out of these emerging countries. The rand suffered from these developments and posed an upside inflation risk. The volatility of the rand came under more pressure with widening deficit of the current account and falling terms of trade. South Africa's problems were compounded by protracted labour disputes. The forecast for inflation indicated a bleak outlook. In response, the repo rate was reviewed upwards in January 2014 by 0.5% to 5.5%. While growth continues to slow down, inflation was on the ascendancy. The prolonged strike actions in sectors such as manufacturing and mining negatively impacted the already fragile economy. Meanwhile, inflation had reached 6.6% by May 2014 above the target range on the back of increasing wages, wage demands, weakening rand and increasing prices of food. In July 2014, the reserve bank decided to increase the repo rate by 0.25% to 5.75% and remained so for the rest of 2014. Despite the decline in inflation to 4% in March 2015, the inflation momentum picked up again with inflation increasing to 4.5% the following month and a medium-term inflation forecast of 6.8% by March 2016 (first quarter). The rising utility (electricity) prices, weakening rand, food price hikes and power supply challenges underpinned the rising inflation expectations. Indeed, the monetary policy committee of the reserve bank in their May 2015 sitting was divided as to the policy stance although the majority inclined towards stability with two members calling for tightening by 0.25%. However, inflation outcomes and expectations deteriorated further with inflation rising in June to 4.7%. In the subsequent meeting in July, the committee in response raised the repo rate by 0.25% to 6% although two members dissented. Although inflation was 4.7% by October, the outlook remained bleak as the weakening of the rand continued and the nation was hit by devastating drought that has the potential to impact prices of food. The repo rate was increased further by 0.25% to 6.25% in November 2015.

Post policy tightening in November 2015, the outlook for inflation significantly worsened on the back of weak rand and rising prices of food resulting from the impact of the drought with inflation forecasted to hit 7% by 2017. At the end of 2015, inflation had reached 5.2%. The reserve bank thus reviewed the repo rate upwards by 0.5% in January 2016 to 6.75%. Thereafter, worsening prices of food as a result of the drought as well as prices of fuel pushed inflation above the target range and expected to continue above the target for a longer time. From 5.2% in December 2015, inflation reached 6.2% the following month in 2016. Meanwhile, the rand continued to be volatile although it had moderately recovered. On a balance of precarious growth prospects and the worsening inflation outlook, the reserve bank in March 2016 opted to safeguard its commitment to inflation targeting, raising the repo rate by 25 basis points to 7%. Following the stability and gradual decline in prices of food in 2017, the outlook for inflation improved remarkably. In addition, crude oil prices had trended downwards and the rand had put up a tremendous resilience. Inflation dropped to 5.1% by June 2017. The reserve bank, in July 2017, reduced the repo rate by 0.25% to 6.75% and remained the same for the remainder of 2017. There was improved outlook for inflation in early 2018 with inflation dropping to 4% by February and staying within the target range. The improvement in inflation outlook was largely driven by a number of factors such as the strengthening of the rand which appreciated by 4.8% in contrast to the dollar, reasonable wage levels and the waning impact of prices of food. As a consequence, the repo rate was reduced in March 2018 by 0.25% to 6.5%. However, the outlook for inflation over the longer term began to worsen. The rand started to weaken and oil prices were on the ascendancy. By October, inflation had increased to 5.1%. With upward inflation trend, the reserve bank in November 2018 increased the policy rate back to 6.75% by 0.5%.

2.4 Literature Review

2.4.1 Monetary Policy Rule: Theoretical Perspectives

Primarily, monetary policy rule is a framework or contingency strategy that informs the way monetary policy decision is to be carried out (Taylor & Williams, 2010). The concept of rules of monetary policy was first contemplated by Adam Smith (1776) in his book the 'Wealth of Nations' where he argued that, compared to pure commodity standard, regulating paper money well comes with enormous benefits by enhancing stability and economic growth (Taylor, 2017; and Taylor & Williams, 2010).

At the beginning of the nineteenth century, monetary policy guided by rules was advocated for by David Ricardo (1824) and Henry Thorton (1802) following an economic crisis that was thought to have been induced by monetary factors (Taylor, 2017; and Taylor & Williams, 2010). Knut Wicksell (1907) and Irvin Fisher (1920) also advocated for monetary policy rules at the start of the twentieth century as a way of curbing excess money that fueled massive inflation after the first world war and the era of great depression (Taylor, 2017; and Taylor & Williams, 2010).

Furthermore, the monetary mistakes that characterized the great depression motivated Milton Friedman (1948, 1960) to propose a policy rule in the form of a constant rate of growth rule primarily to avert such blips (Taylor, 2017; and Taylor & Williams, 2010). The rather instability in both output and inflation witnessed in the 1960s and 1970s led to various propositions of monetary policy rules such as the Taylor (1993) rule.

Economists agree that policy rules do not necessarily imply a fixed framework for instruments of policy (Taylor, 1993). Taylor (1993) argues that a policy rule should not necessarily be captured mechanically as a formula but can be executed or made operational in a more informal way with greater recognition for the fact that some judgment is required with clear understanding of the underpinnings of the policy rule in respect of the responses of the policy instruments. In distinguishing between rules and discretion, Taylor (1993) posits that under discretion, the policy makers would always have to begin from the scratch anytime they are determining the instruments for policy without a well-spelt out framework for future contingencies. Key monetary policy rules in the literature include the following:

2.4.1.1 The Fixed Percentage Rule by Friedman

Friedman (1948, 1960) recommended a fixed increase in money supply from time to time. The rationale is that the real variables of the economy will, in the long term, revert to their natural level without monetary policy. Variables such as unemployment, interest rate and real output depend on technology in the long run and are therefore supply related. Meanwhile, monetary policy relates to demand but can only affect these real variables in the short term since in the long run these variables will reverse. Friedman argues that the rate of growth of money supply should be done in a manner that would keep price levels constant (Salter, 2014).

2.4.1.2 The Feedback Rule by McCallum

Developed by McCallum (1988), it is a rule that focuses on supply of money just like the rule proposed by Friedman and it is also similar to Taylor rule in terms of specificity in how it guides policy makers to vary target variable in reaction to changes in macroeconomic variables (Salter, 2014). Setting the base for his proposition, McCallum argues that the fixed growth rate advanced by Friedman which hinges on hope that there will be real income and velocity stability resulting in no inflationary effect is unworkable. McCallum posits that velocity changes frequently just as income albeit income changes infrequently compared to velocity. McCallum thus incorporated the possibility that velocity and income can change. The rule proposed by McCallum, which focuses on monetary base, took the form:

$g^B = gy^* - gV^B + \gamma(\ln Py^* - \ln Py)$ where B is monetary base, the velocity of monetary base is given by V^B, trend rate of output is given as gy^*, the target value of nominal income is given as Py^* while the recent nominal income is denoted as Py and the parameter which indicates the required change in the supply of money when nominal income departs from the target level is represented by γ which is supposed to be equal to 0.25 (Salter, 2014).

2.4.1.3 The Taylor rule

The Taylor rule, compared to the constant growth rate proposed by Friedman is relatively complicated and remains one of the widely deliberated policy rules even in recent times (Salter, 2014). It is a rule that states that the central bank adjusts interest rates in response to variations in output and inflation from their target levels. According to Salter (2014), one of the key positives of the Taylor rule is the fact that it provides specificity by guiding central banks as to the exact response to provide by way of interest rates adjustments with changing economic situations. The very specificity and simplicity of the Taylor rule is the source of the criticism of the rule since striking a balance in terms of the magnitudes to be assigned to output gap and inflation tend to be difficult (Salter, 2014).

Taylor (1993) provided one of the famous monetary policy rule characterization by developing a linear model that sought to describe or characterize the adjustment of monetary policy by the Federal Reserve Bank in response to changes in inflation and output gaps. Taylor's (1993) rule was effective in capturing the behaviour of interest rate and the monetary policy reaction in the United States. Taylor (1993) developed a representative policy rule of the form:

$$r = p + 0.5y + 0.5(p-2) + 2$$

where he defined r as federal funds rate, p is the last four quarters rate of inflation and y is the percentage of real GDP's deviation from its target. According to Taylor (1993), the nature of the policy rule means that an increase in the real GDP beyond its trend or a rise in inflation beyond two percent will cause the federal funds rate to increase. In other words, monetary authorities would only increase the federal funds rate when both output and inflation deviate from their targets. According to the author, this representative policy rule captures or describes well the policy performance of the United States. The Taylor (1993) interest rate rule has enjoyed phenomenal popularity in the literature and our work is grounded in same. As a result, our focus in the subsequent sub sections of the literature review would be on the Taylor rule.

2.4.2 Linear Monetary Policy Rule: Empirical Evidence

2.4.2.1 The Global Perspective

Taylor (1993) provided one of the foundations of rule-based monetary policy by formulating a linear model that adequately describes the monetary policy behaviour of the Federal Reserve Bank. A later study by Orphanides (2003) on the United States lent a strong support for the Taylor rule. Stuart (1996) finds that over the period that the United Kingdom (UK) was a member of the Exchange Rate Mechanism and even up to 1992-1993, actual interest rates in the UK were closely tracked by the Taylor rule. Gerlach & Schnabel (2000) demonstrate that except for the 1992 – 1993 exchange market eccentricity, the Taylor rule appropriately characterized the policy behaviour within the European Monetary Union between 1990 and 1997.

In an assessment of seven policy rules for Canada, Côté et al (2004) observed that in a certain class of models, the Taylor rule with output gap coefficient of 0.5 and inflation gap coefficient of 2 appeared to have performed better than the remaining simple rules albeit it was not robust. Osterholm (2005) applied the Taylor rule to data on Sweden, Australia and the United States and finds that there is weak evidence that the Taylor rule best characterizes monetary policy behaviour.

In studying new entrants into the European Union, Ghatak & Moore (2011) demonstrate that the policy instruments (short term interest rate) of countries such as Slovenia, Slovakia, Poland and Czech Republic react more to exchange rate deviations. The authors argue that despite the relative success of the Taylor rule in the United States and its adoption in other advanced economies, applying it wholesale to transition countries is questionable as exchange rate play an important role in these countries.

Hofmann & Bogdanova (2012) estimated the linear Taylor rule using quarterly data on seventeen emerging countries and eleven advanced countries spanning from 1995Q1 to 2012Q1. They found that the monetary policy rates in these countries were below the rate suggested by or consistent with the Taylor rule proposition, particularly since the year 2000. They found further that the deviations of the policy rates from that suggested by the Taylor rule was quite acute for the emerging countries. Lee et al (2013) estimated a meta Taylor rule for both Australia and the United Kingdom (UK) and found that monetary policy in Australia and UK are well characterized by the linear meta Taylor rule.

Ferga (2016) estimated the linear Taylor rule to characterize monetary policy behaviour of the Bank of England. The author used data from October 1992 to December 2014 and a cointegration approach. The author found the Bank of England not to follow the Taylor rule. Li & Liu (2017) used quarterly data from the second quarter of 1996 to the last quarter of 2015 to estimate three different forms of rules for monetary policy in China. The aim was to find out the monetary policy rule that is supported by China's data using the Bayesian Dynamic Stochastic General Equilibrium model. The results show that China's data favours the expanded Taylor rule. That is a Taylor rule that incorporates both interest rate and growth rate of money. While the authors found money to play a critical role in the monetary policy behaviour of China, they conclude that monetary policy behaviour of China cannot be described by the basic or interest rate rule propounded by Taylor.

2.4.2.2 The African Context

To East Africa, Rotich et al (2007) found the central bank of Kenya to follow a linear policy rule in combating inflation with repo rate and monetary aggregates playing critical roles especially post liberalization between the period 1997 and 2006. Wamalwa (2018) explored policy reaction function for Kenya. The author finds that the central bank responds more to deviations of output growth and interest rates from set targets. Using the Bayesian DSGE approach, Mwabutwa et al (2012) found that Malawi's monetary authorities respond more to higher inflows of foreign aid.

To North Africa, Allegret & Benkhodja (2015) used Bayesian DSGE for Algeria and found linear policy rule which focuses on core inflation to best characterize the policy behaviour of the central bank of Algeria especially from 1990 to 2010. Chaouche & Toumach (2016) also found that the Taylor rule offers a close characterization of the policy behaviour of Algeria's central bank. For Egypt, Elshamy (2012) applied both the basic Taylor rule and one augmented with characteristics of open economy to Egypt. The author found both rules to characterize the policy behaviour of the central bank of Egypt. Going to Tunisia, Sghaier (2012) found that the linear Taylor rule appropriately characterizes the policy behaviour of Tunisia's central bank. Chaouech (2015) also found that the monetary policy behaviour of Tunisia's central bank was best characterized by the dynamic version of the Taylor rule.

To West Africa, Shortland & Stasavage (2004) demonstrate that BCEAO, the central bank of the West African Economic and Monetary Union reacts to foreign exchange position along with output gap, inflation and the borrowings of government in the short run. The authors also augmented the Taylor rule with foreign interest rate. Agu (2011) found that Nigeria's central bank follows the linear Taylor rule. Yaaba (2013) formulated a linear policy rule for the central bank of Nigeria with focus on index of monetary condition. The author found the index to characterize the behaviour of the central bank over the period of the study. Although Ghana is part of West Africa, we deal with it separately as one of the countries within our study. To Southern Africa, we observe that all the studies are on South Africa which we deal with separately as one of the countries we study.

2.4.2.3 The case of Ghana and South Africa

Boamah (2012) explored a linear Taylor rule for Ghana in an attempt to describe policy behaviour and reaction function of Bank of Ghana. The author found the Taylor rule unsuitable in predicting the behaviour of interest rate in Ghana. Bleaney et al (2018) also estimated a linear Taylor rule for Ghana using ordered probit and ordered logit. They found that exchange rate, inflation and output gap are positive and statistically significant.

For South Africa, Aron & Muellbauer (2000) modelled the Taylor rule for the Reserve Bank. They found strong negative response of interest rate to inflation. In addition to interest rate responding to output gap, the also found interest rate in South Africa to respond positively to treasury bill rate of the United States. They then included excess growth of money which improved their results and considerably reduced the negative response of interest rate to inflation. They observed that the policy variable (money stock or M3) targeted the stability of output as opposed to inflation (Kabundi & Ngwenya, 2011). Ortiz & Sturzenegger (2007) estimated a linear policy rule for the South African Reserve Bank using the DSGE model and found it to be stable and much similar to the rules for New Zealand, Australia, UK and Canada. After augmenting the Taylor rule with conditions in the market for labour as well as expectations of inflation, Bold & Harris (2018) found the Taylor rule to characterize the monetary policy behaviour of the Reserve Bank of South Africa.

2.4.3 The Non-Linear Monetary Policy Rule Argument

Over time and with conflicting results in the literature, some authors turned to nonlinearity in the Taylor rule. Baaziz et al (2013) argue that the conduct of monetary policy is mostly characterized by surprises, uncertainties and unexpected eventualities but yet a large amount of the literature still use simple policy rules such as the Taylor rule. Baaziz et al (2013) argue further that the linear Taylor rule is not suitable in capturing the actual characteristics of policy behaviour, particularly for countries that have liberalized their financial markets and in the face of economic crisis that tend to make central banks adopt different behaviour.

Monetary policy behaviour is not fixed and has been observed to exhibit asymmetric characteristics over time. Some authors such as Olmo & Sanso-Navarro (2015), Kim et al (2004) and Svensson (1999) have argued that monetary policy rules may not necessarily be static but may be asymmetric and exhibit inertia over some period of time. According to them, while policy makers may be inclined to tolerate deflation, their behaviour would be entirely different when inflation bites. Similar arguments have been made by Ma (2016). In the case of inertia, regular adjustments will only be carried out by policy makers during periods when deviations of economic variables from their set targets at a particular range occur.

Liu et al (2018) argue that because monetary authorities tend to tolerate lower inflation as compared to higher inflation, there will be smaller correlation between inflation and interest rate during periods of low inflation. In addition, the authors argue that variations in business cycle also causes monetary policy rules to change. For example, Liu et al (2018) observed that while China has witnessed significant fall in growth of output and inflation since 2014, its rate of interest in nominal terms remained high leading the authors to argue that monetary policy rule may not necessarily be linear and can thus exhibit non-linear feature. The authors also observed that while the Federal Reserve Bank embarked on interest rates that were zero lower bound following the subprime mortgage debacle, both output and inflation witnessed substantial fluctuations implying that the relationships between economic variables and interest rates are not stable.

Authors such as Dolado et al (2005) as well as Robert-Nobay & Peel (2003) assert that such possible non-linearities in monetary policy rule can be attributed to the non-linear relationship between macroeconomic variables (Caporale et al, 2018). Other authors such as Ahmad (2016), Martin & Milas (2013) and Castro (2011) believe that such non-linearities in monetary policy rule can be attributed to the differences in the objectives and preferences of monetary authorities (Caporale et al, 2018).

Moreover, Ma (2016) argues that an implementation of a linear rule when inflation and output gap trade-offs are non-linear yields spurious results. The author argues further that a policy rule that is nonlinear is appropriate or better represents the behaviour of central banks and monetary authorities in the economies of emerging markets because it aids in taking into account the time varying, discontinuous and asymmetric characteristics of monetary policy in many of these countries.

2.4.4 Non-Linear Monetary Policy: The Empirical Evidence

2.4.4.1 The Global Perspective

Dolado et al (2004) explored non-linearity in monetary policy rule in the United States and found that post 1983, non-linear policy rule best characterized monetary policy in the United States. A later study by Petersen (2007) who used smooth transition regression to explore non-linearity in the policy behaviour of the Federal Reserve Bank confirmed the findings of Dolado et al (2004). The author found the Federal Reserve's policy behaviour to be characterized by the non-linear Taylor rule, particularly between 1985 and 2005. The author also found that it is between 1960 and 1979 that the Federal Reserve's policy behaviour was better characterized by the linear Taylor rule. Surico (2007) also found asymmetric behaviour in the monetary policy preferences of the Federal Reserve Bank although that was only prior to 1979. That is, while the Fed reacted more aggressively to output slump, the response to an output boom of equal measure was less proportionate. Using multiple regime smooth transition model, Ahmad (2016) observed asymmetry in the monetary policy behaviour of the Federal Reserve Bank and the fact that the Fed did not also follow the Taylor during the 2007 financial crisis as well as certain periods in the era of great moderation.

For the United Kingdom, Martin & Milas (2004) found monetary policy behaviour to be asymmetric since 1992 as the response of policymakers is more aggressive to inflation overshooting as compared to undershooting. Taylor & Davradakis (2006) also found that the interest rate setting by the Bank of England is characterized by a nonlinear behaviour. Kharel et al (2010) explored non-linear policy rule in the United Kingdom with a focus on how monetary policy makers react to real exchange and its misalignment. They found that it is rather the misalignment in real exchange rate that policy makers respond to as opposed to actual real rate of exchange.

Turning to countries within the Eurozone, Dolado et al (2005) established the nonlinear monetary policy behaviour for Bundesbank of Germany, Banque de France, the European Central Bank and Banco de Espana (Spain). They however did not find such evidence for the Federal Reserve Bank of the United States. Garcia-Iglesias et al (2013) studied whether there is asymmetry in the European Central Bank's policy behaviour. They found that it is impossible to confirm that the European Central Bank's policy reaction function exhibited asymmetric characteristics, especially between 1999 and 2008.

Some studies have looked at countries in both Europe and Americas at the same time. Comparing the policy behaviour of the European Central Bank, the Federal Reserve Bank and the Bank of England, Castro (2011) established that the policy behaviour of the Bank of England as well as the European Central Bank can best be characterized by a nonlinear policy rule while that of the Fed is well captured by a linear Taylor rule. The author augmented the Taylor rule with financial condition index that captures different asset prices. The author found that while the Bank of England and the Fed do not react to this index, the European Central Bank does. Caglayan et al (2016) found asymmetric preferences in the behaviour of monetary policy authorities of Canada and the UK. The authors argue strongly for the need to augment the Taylor rule with exchange rate when studying open economies.

For emerging economies, Hasanov & Omay (2008) found that the reaction function of the central bank of Turkey exhibited a nonlinear characteristic. According to the authors, periods of economic boom saw mild policy reaction compared to the reactions in periods of economic downturn. Using quantile regression, Miles & Schreyer (2012) found that monetary policy behaviour in Thailand, Malaysia, Korea and Indonesia is nonlinear.

Caporale (2018) argue that the existing studies which have sought to establish non-linearity in monetary policy rules, have mostly used models of markov regime switching which is limited in terms of facilitating transmission between regimes smoothly. As a result, Caporale et al (2018) in studying non-linearity in monetary policy rule adopted a non-linear Taylor rule with threshold autoregressive model for five inflation targeting emerging countries namely Turkey, Korea, Indonesia, Thailand and Israel. Using GMM for estimation, they found that the non-linear augmented Taylor rule accurately captures monetary authorities' behaviour in the five emerging economies.

On the basis of a similar argument to that of Caporale et al (2018), Liu et al (2018) studied the non-linear relationship between policy rules and business cycles in the United States and China using a model of multiple thresholds as well as the latent threshold time varying parameter VAR. The authors found that depending on the stage of the business cycle, the preferences of the monetary policy makers differed. In addition, adjustments in nominal interest rates in the United States and China are hardly regime-switching and tend to rather be gradual. In a micro foundation environment using Bayesian Dynamic Stochastic General Equilibrium and data from 1998 to 2008, Ma (2016) found the Central Bank of China to follow a non-linear Taylor rule.

2.4.4.2 The case of Africa

We found very few studies on nonlinear monetary policy rule in Africa. The first is the work of Ncube & Tshuma (2010) who explored non-linear Taylor rule and employed quarterly data between 1976 and 2008. The authors used the logistic smooth transition regression and found that the policy behaviour of the South African Reserve Bank is best characterized by a non-linear Taylor rule.

The second is the work of Naraidoo & Raputsoane (2011) who used monthly data from 2000 to 2008 and a GMM technique to study how monetary policy in South Africa responds to departure of output and inflation from their respective targets and considered nonlinearity in the policy behaviour. While they found the SARB’s response to deviations in inflation to remain the same whether it undershoots or overshoots the set target range, they found asymmetric response in the case of output deviations.

The third is the work of Naraidoo & Paya (2012) who examined whether the decision involving the setting of interest rate by the South African Reserve Bank is also influenced by asset prices. They explored non-linearity in the Taylor rule and conducted an in-sample and out-of-sample forecasting of the interest rate in South Africa. The authors considered share prices, housing prices and exchange rate (collectively as asset prices). Their data covered the period from 1986 to 2008.

The authors found that in setting interest rate in South Africa, asset prices are considered. They also found that the rule for monetary policy in South Africa exhibited non-linear characteristics.

The fourth is the work of Baaziz et al (2013) who considered nonlinear Taylor rule for South Africa using quarterly data from the third quarter of 1995 to the last quarter of 2011. The authors adopted logistic smooth transition regression model and found that the monetary policy in South Africa is better characterized by a nonlinear Taylor rule. That is, there is nonlinearity in the reaction function of SARB's monetary policy.

The fifth is the work of Baaziz & Labidi (2016) who explored nonlinear policy rule using quarterly data from the last quarter of 1998 to the second quarter of 2013 and adopting the logistic smooth transition regression. They found that nonlinear policy rule of the Taylor-type best characterizes the behaviour of central banks of Egypt and Tunisia.

2.4.5 Debt Constraint on Monetary Policy

Seigniorage provides an important theoretical relationship between monetary policy and debt. Increasing levels of debt trigger debt monetization which in turn fuels high inflation levels (Mitra, 2007). High and increasing debt is said to fuel high inflation and are mostly orchestrated to shrink the real value of these debts and the associated debt service burden. Even though significant debt levels may not have been intended to rope in inflation, it poses enormous challenge to effective monetary policy making (Dornbusch, 1996). Dornbusch (1996) posits that long tenured debt can be significantly eroded by an unanticipated high level of inflation. On the basis of rational expectations however, Dornbusch (1996) argues that because investors understand the impact of rising debt on inflation, they incorporate it into their future expectation of inflation and the acceptable interest rate. For short term debt that are rolled over therefore, although inflation would rise in response to high levels of debt, the resulting inflation would not necessarily erode the debt as interest rates would necessarily rise to neutralize the effect of inflation on the value of the debt they hold. However, Dornbusch (1996) reckons that even when interest rate increases in response to increasing inflation, short term debts could still be wiped out by inflation that is explosive.

Mitra (2007) observed that interest rate also serves as an important theoretical connection between monetary policy and debt. Interest rate can be kept at lower levels to lessen the interest service burden of the fiscal authorities and debt accumulation eventually. At very high levels of debt, an increase in interest rate increases the debt service burden of the central government, feeding into additional expenses, potential deficits and additional borrowing. As a result, interest rate can be kept low to ease such debt service burden but that would then mean accommodating more inflation than the central bank would ordinarily have done. The central bank becomes less aggressive to rising inflation due to high debt levels. For inflation targeting central banks, this has serious consequence for the publicly announced inflation target, commitment to achieving it and detrimental to public confidence and the requirement to anchor expectations of inflation.

However, a prudent monetary policy tightening too in the face of rising debt only increases debt burden and the stock of debt eventually. By increasing the debt burden, it also increases the budget deficit. Policy tightening also slows down the economy, reduces government revenues and the cycle of deficit and debt continues (Dornbusch, 1996). As government and monetary policymakers are supposed to be independent entities, the tightening of monetary policy that slows the economy down may elicit an opposite response from the fiscal authorities who may embark on an expansionary fiscal policy (particularly on political grounds) to spur on economic activities and thereby widening the deficit further. With these counter fiscal policies by the fiscal authorities and the eventual effect on inflation that the monetary authorities would want to fight, it places the latter in a difficult situation and can affect their credibility if the inflation targets are not achieved. The policymakers are then torn between accommodating higher inflation now to lessen debt burden of the government to avoid the vicious cycle of debt spirals in the future and the accompanying inflationary effect or take a sterner stance now to force discipline on fiscal authorities. As a result, monetary policymakers may take tightening stance but the extent of the tightening could be far less than what is required (Dornbusch, 1996).

An important point that complicates the dilemma of the monetary policy authorities is whether an accommodation of inflation now would not rather deteriorate the situation further as fiscal authorities may rather see the accommodation as extra fiscal space to spend more, especially when driven by political agendas and campaign promises. This is a serious concern and dilemma to many central banks.

The literature on monetary policy responses and behaviour abound, particularly following the phenomenal success of the Taylor (1993) rule in capturing the Federal Reserve Bank's behaviour. Further dimensions to the Taylor rule such as the fact that policymakers react to future macroeconomic developments (Woodford, 2001) enriched the policy rule discourse. The nonlinear policy rule paradigm (Caporale et al, 2018; Liu et al, 2018 and Ahmad, 2016) raised serious doubts about the linear Taylor rule and ushered in a new strand of the policy rule literature. However, what is fundamentally missing in all of these is the neglect of the constraint that high debt levels pose to monetary policymakers in the very response that these previous studies sought to capture. The work of Mitra (2007) is the only empirical study, to the best of our knowledge, which has considered debt constraint in a typical policy rule estimation. Mitra (2007) estimated a threshold model for Canada to ascertain whether high levels of debt pose a constraint to monetary policymakers. The author employed a dummy variable iteratively in a GMM estimation technique. With monthly data from November 1991 to December 2000, the author established that high debt levels constrained monetary policy. Specifically, the author found policy response to inflation to reduce by 0.99% above the debt threshold relative to the response when there is no debt constraint. However, the work of Mitra (2007) is fundamentally weak as the author concedes that the estimated debt threshold was not accompanied by a confidence interval to ascertain the precision of the said estimate. Meanwhile, such estimations are supposed to inform policy decisions. We situate our study in the context of overcoming this limitation by deploying a robust model that delivers an accurate threshold estimate accompanied by confidence interval at 95% confidence level. We also situate our work in the context of extending the literature on debt constraint – monetary policy discourse in view of the worrying paucity.

2.5 Methodology

As we look at policy characterization and the nature of debt constraint on the policy behaviour, our methodology addresses two related issues with subheadings clearly identifying the aspect being addressed at every point in time.

2.5.1 Monetary Policy Characterization

2.5.1.1 Data and Data Sources

We used monthly data for all the series from April 2000 to June 2018 for South Africa and from January 2007 to June 2018 for Ghana. The start of the data from 2000 for South Africa is in line with the start of explicit inflation targeting in that country and the same applies to Ghana for the choice of 2007. For Ghana, we obtained the data on all the variables from the website of Bank of Ghana (under monetary time series). In the case of South Africa, we obtained data on all the variables except inflation from Datastream. Inflation data was obtained from the quarterly bulletins of the South African Reserve Bank.

2.5.1.2 Description of Variables

In estimating the nonlinear Taylor rule for the respective countries, we used output and inflation gaps and monetary policy instrument.

***Monetary policy instrument*:** this is represented by the repo rate for South Africa as that is the official monetary policy instrument. For Ghana, we used the monetary policy rate which is also the policy instrument in the country.

Inflation gap**:** For South Africa, we measured inflation gap as the difference between the year-on-year change in inflation rate and the midpoint of South African Reserve Bank's inflation target. This is similar to the work of Naraidoo & Raputsoane (2011). With the same procedure, we estimate the inflation gap for Ghana as the difference between the year-on-year change in inflation rate and the midpoint of Bank of Ghana's inflation target which is similar to the work of Bleaney et al (2018). We expect that the two central banks would react more aggressively to positive inflation gap than negative inflation gap. More specifically, monetary policy authorities of the two countries would respond positively to increasing inflation gap.

Output gap**:** Data on gross domestic product (usually used as proxy for output) is not available in monthly series, forcing us to rely on an alternative measure of output or economic activities. For South Africa we used the coincident business cycle indicator in line with Naraidoo & Raputsoane (2011) and so we measure the output gap as percentage change in the log of coincident business cycle indicator from its trend. For Ghana, we used the composite index of economic activity compiled by the Bank of Ghana as a measure of output in line with Bleaney et al (2018) and therefore the output gap becomes the percentage change in the log of composite index of economic activity from its trend. The trend is calculated using a univariate structural time series model that decomposes the output series into the cycle and trend components as per the work of Koopman et al (2009). Following Koopman et al (2009) and for the purpose of our decomposition, the model is specified as follows:

$$y_t = \mu_t + \omega_t + \epsilon_t \qquad \epsilon_t \sim NID(0, \sigma_\epsilon^2), t = 1 \dots\dots T \qquad (1)$$

such that y_t represents output, μ_t denotes the trend component, with the cyclical component denoted by ω_t and the irregular component is represented by ϵ_t. The estimation is done by way of Maximum Likelihood. Previous studies (Naraidoo & Raputsoane, 2011; Ma, 2016; Liu et al, 2018; and Caporale et al, 2018) had used the filter of Hodrick & Prescott (1997) popularly known as the HP filter. However, the HP filter suffers from various inadequacies. The HP filter requires a prior determination of the parameter (λ) that penalizes smoothness versus fit, the choice of which is usually arbitrary (Alvarez & Gomez-Loscos, 2018). Additionally, for series that have a classical spectral shape, the HP filter is said to engender spurious cycles (Alvarez & Gomez-Loscos, 2018). Moreover, the HP filter behaves poorly in respect of observations or periods that are most recent (Caporale et al, 2018; Alvarez & Gomez-Loscos, 2018; and Shortland & Stasavage, 2004). Furthermore, the HP filter may erroneously specify the structure of the economy as the values put forward by the filter are idiosyncratic to the United States' economic setting (Caporale et al, 2018; and Sarikaya et al, 2005). For emerging markets and Africa in particular, the volatility of output is an inherent characteristic and therefore the use of HP filter for trend estimation may suffer greater variability (Caporale et al, 2018). Our model-based technique of decomposing trend and cycle has the virtue that because the model implicitly defines the filters, these filters exhibit optimality and are consistent not just with each other but also with our data (Harvey & Trimbur, 2003). Indeed, the said mutual consistency is observed both at the start and end of the output series. Thus, they adapt automatically to the ends of our sample. Importantly, because the model is capable of estimating the parameters, the properties of our output series are consistent with the accompanying filters (Harvey & Trimbur, 2003).

Table 2.1: Summary Statistics

Ghana	**MPR**	**INF**	**OUTPUT**
Mean	17.67571	13.34971	334.9969
Maximum	26.00000	20.70000	1148.830
Minimum	12.50000	8.390000	14.60000
Std. Dev.	4.237260	3.744857	119.0975
Skewness	0.662517	0.321194	2.146463
Kurtosis	2.360419	1.725088	16.93870
Observations	140	140	140
South Africa	**MPR**	**INF**	**OUTPUT**
Mean	8.054688	5.657589	98.89777
Maximum	13.50000	14.30000	108.9000
Minimum	5.000000	0.600000	82.80000
Std. Dev.	2.540385	2.345062	7.707962
Skewness	0.684974	0.892761	-0.830473
Kurtosis	2.138900	5.035583	2.244992
Observations	224	224	224

Notes: MPR is monetary policy rate, INF is inflation rate.

The average inflation rate in Ghana over the period is 13.35% which is 3.35% above the upper limit of 10% of the inflation target range, as per the descriptive statistics in Table 2.1. Indeed, for most part of the period, Ghana’s inflation has well been above the upper limit of 10%, with inflation reaching as high as 20.7% in June 2009. Even though the country enjoyed single digit inflation between June 2010 and 2012 and more recently between April and August 2018, the country is yet to achieve the midpoint target of 8%. The closest the country had come is 8.39% in July 2011 and the lower band of 6% has since eluded the country. For South Africa, the average inflation over the period is 5.66% which is very close to the upper band of 6% of the inflation target range. Although there has been periods of higher inflationary episodes with inflation exceeding the upper band and reaching 14.3% in November 2002, South Africa has, for most of the period since the inception of inflation targeting in 2000, kept inflation within the target band of 3%-6%. Indeed, inflation had gone down below the lower band of 3% in South Africa in many cases, particularly between October 2003 and October 2004.

The average monetary policy rate over the period for Ghana is 17.68% compared to 8.1% for South Africa. The vast difference in the policy rates of both countries unearths the huge dichotomy in the levels of development of their financial systems. South Africa, undoubtedly boasts of a relatively sophisticated financial system much akin to those of the advanced economies. Indeed, the higher policy rate in Ghana relative to South Africa is also a manifestation of the unpalatable policy stance that the Bank of Ghana has had to endure in curbing the staggering inflationary episodes. The average economic activity index of Ghana is 335 compared to South Africa's 98.9 over the period under review. Ghana's economic activities and growth credentials over the period have largely been more promising relative to South Africa albeit with greater variability.

In Figures 2.1 and 2.2 we present the line graphs of monetary policy and inflation for Ghana and South Africa respectively. In both figures, we see that monetary policy and inflation have tended to move together with occasional drift. It is an indication that indeed these two countries have been targeting inflation.

Figure 2.1: Ghana's monetary policy rate and inflation

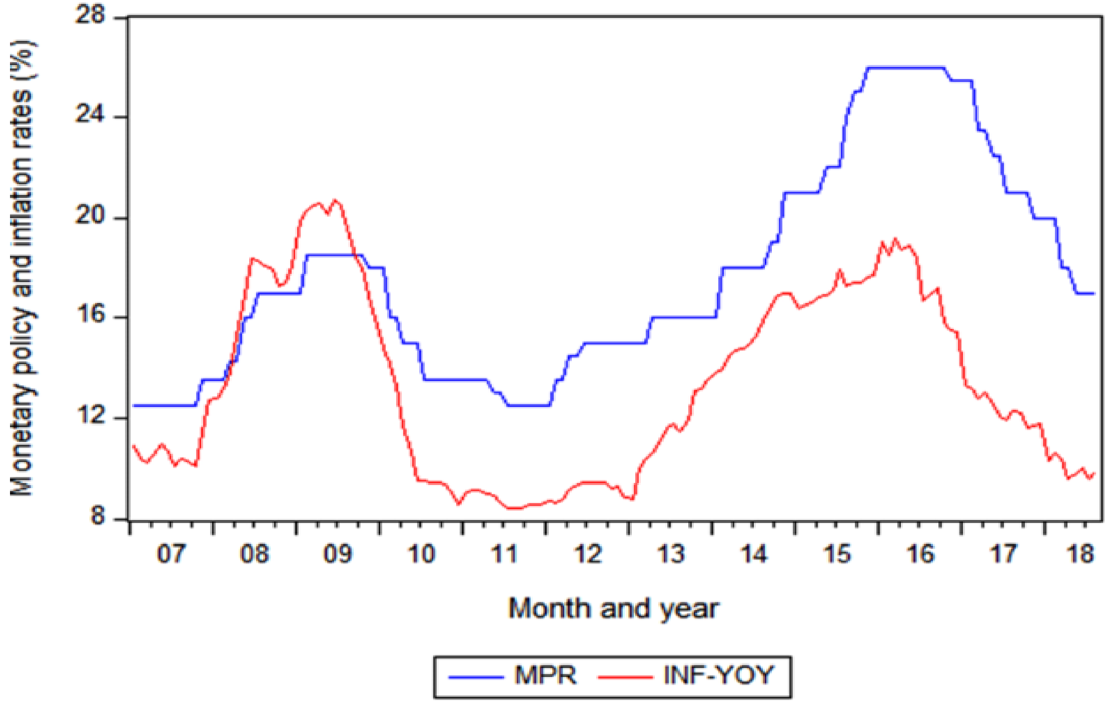
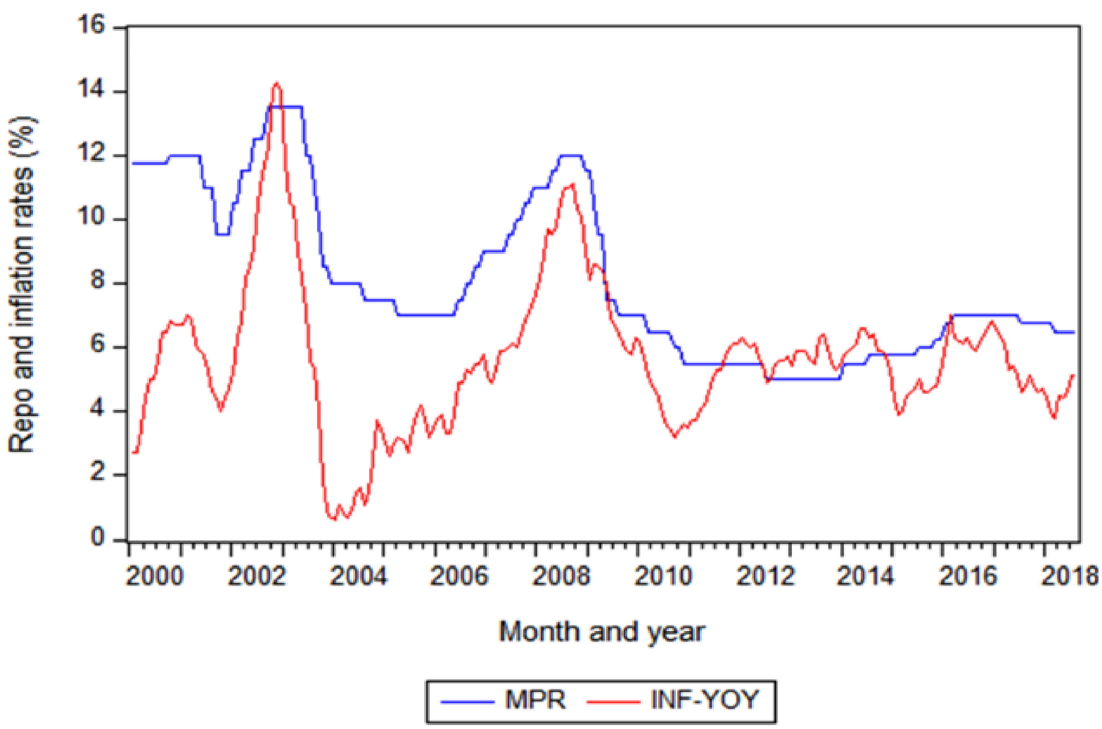


Figure 2.2: South Africa's monetary policy rate (repo rate) and inflation



We ascertain the stationarity properties of our series using the Phillips Perron (PP) test developed by Phillips & Perron (1988) and the Augmented Dickey-Fuller (ADF) test by Dickey & Fuller (1981). In both the ADF and the PP tests, we include intercept and trend. The results are presented in Table 2.2. In the case of Ghana, all the variables except the output gap are stationary after the first difference. Output gap is stationary at the level. For South Africa, just like Ghana, only the output gap is stationary at the levels using ADF test with the rest of the variables being stationary after the first difference. The variables that are not stationary at the levels enter the model after the first difference.

Table 2.2: Stationarity Test

		ADF TEST		PP TEST	
		Level	**First Diff**	**Level**	**First Diff**
Ghana	mpr_t	-2.901	-3.5034 ***	-1.0991	-11.9768 ***
	$y_{t+k} - y_t^*$	-10.9932 ***	-7.7712 ***	-10.9970 ***	-127.5025 ***
	$\pi_{t+k} - \pi_t^{tg}$	-2.7513	-3.9890 ***	-1.6813	-8.5265 ***
South Africa	mpr_t	-2.7149	-4.7408 ***	-2.2389	-14.1742 ***
	$y_{t+k} - y_t^*$	-3.1855 *	-4.9429 ***	-2.9566	-9.1924 ***
	$\pi_{t+k} - \pi_t^{tg}$	-2.4894	-5.8046 ***	-3.0499	-8.4711 ***

Note: For the ADF and the PP Tests, we include both the intercept and trend at both the levels and first difference. ***, ** and * indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root.

2.5.1.3 Empirical Approach

A typical threshold analysis would normally involve a prior imposition of a quadratic term on the threshold variable. However, not only is that questionable, but such an approach also fails to capture the mediation role that the initial values of the threshold variable would play in the threshold effect (Alagidede et al, 2018; and Ibrahim & Alagidede, 2018). Our estimation technique, in addition to an accurate threshold effect estimation, also unravels the varying effects of the regressors on the policy rate when inflation exceeds or falls below the optimal threshold. The study uses the Sample Splitting and Threshold Estimation developed by Hansen (2000) to unearth the nonlinearity in the policy behaviour of the Reserve Bank of South Africa and the Bank of Ghana. The Sample Splitting and Threshold Estimation technique employs least square technique in the parameter estimation and this is more intuitive and superior compared to an a priori quadratic term imposition.

The functional form that the relationship between the regressors and the policy variable take is not assumed or superimposed *a priori*. Indeed, an important virtue of our estimation technique is the fact that not only does it not impose the form of nonlinearity, but it also empirically provides the confidence intervals for the threshold's statistical significance based on the asymptotic theory. The approach does not require a predetermination of the threshold value as this is done by the model itself. The observations are split into regimes below and above the threshold and determines the nature of response of the policy rate to the inflation gap, output gap and exchange rate movements across the two regimes.

Our linear model is expressed as:

$$mpr_t = \beta_0 + \beta_1\left(E_t\left[\pi_{t+k} - \pi_t^{tg}\right]\right) + \beta_2(E_t[y_{t+k} - y_t^*]) + \varepsilon_t \qquad (2)$$

such that the monetary policy rate is represented by mpr_t, inflation is represented by π_{t+k} while target inflation is represented by π^{tg} and therefore the inflation gap is represented by $\pi_{t+k} - \pi_t^{tg}$. Then $y_{t+k} - y_t^*$ represents the output gap, and ε_t is the error term. The E_t in the specification represents expectations. As indicated earlier, the incorporation of expectation in our model specification is in line with the argument that policy makers respond to future or expected inflation and output gaps (Woodford, 2001 and Clarida et al, 1999). As a result, the data on inflation gap and output gap are two-month lead variables. The choice of two-month period lead is informed by the fact that the Monetary Policy Committees of both the South African Reserve Bank and Bank of Ghana meet every two months to decide on the policy rate (thus a total of six times in a year).

From the above equation, representing the dependent variable by g and the regressors by x, then the set $\{g_{i,}, x_i, \vartheta_i\}_{i-1}^{n}$ represents the observed sample such that x_i denotes an m-vector while g_i and ϑ_i are real-valued. Meanwhile, ϑ_i, which denotes the threshold variable and given by $\vartheta_i = \pi_{t-2}$ has a continuous distribution. The lag of inflation is the threshold variable in line with Caporale et al (2018) with the intuition that policy makers aggressively react more to the overshooting of inflation than the undershooting of inflation and particularly as we are dealing with inflation targeting central banks.

Our estimation of threshold is specified as follows:

$$mpr_t = (\beta_{11} + \beta_{21}\left(E_t\left[\pi_{t+k} - \pi_t^{tg}\right]\right) + \beta_{31}(E_t[y_{t+k} - y_t^*]))d_i\{\vartheta_i \leq \theta_i\} + (\beta_{12} +$$

$$\beta_{22}\left(E_t\left[\pi_{t+k} - \pi_t^{tg}\right]\right) + \beta_{32}(E_t[y_{t+k} - y_t^*]))\, d_i\{\vartheta_i > \theta_i\} + \varepsilon_t \qquad (3)$$

such that an indicator variable denoted by $d_i\{.\}$ is a dummy which has a value of 1 when the condition in the indicator function is fulfilled, otherwise it is 0. Meanwhile, θ represents the threshold value.

Prior to the threshold estimation, we begin with the test for linearity and our null hypothesis is that $\beta_{i1} = \beta_{i2}$ against $\beta_{i1} \neq \beta_{i2}$.

We reduce equation (2) to $g_i = \beta' x_i + \partial_i' x_i(\theta) + \varepsilon_i$ (4)

such that $\partial_n = \beta_{i2} - \beta_{i1}$, where $\partial_n = \beta_{i2} - \beta_{i1}$ denotes the threshold effect. Importantly, the solution is provided by $\partial_n \rightarrow 0$ when $n \rightarrow \infty$ with β_{i2} held constant such that when $n \rightarrow \infty$, $\beta_{i1} \rightarrow \beta_{i2}$ with the virtue that the resulting asymptotic distribution of $\hat{\theta}$ is devoid of nuisance parameters that other threshold models suffer (Hansen, 2000).

Putting equation (4) into a matrix form with an $n \times 1$ vectors of ε_i and g_i through the stacking of both and then $n \times m$ matrices $X \: and \: X_\theta$ through the stacking of the vectors X_i' and then $X_i(\theta)'$ it yields the following equation:

$$Y = X\beta + X_\theta \partial_n + \varepsilon_i \qquad (5)$$

The parameters of interest that we estimate are $\beta, \partial \: and \: \theta$ by way of least squares. The least squares estimates $\hat{\beta}, \hat{\partial} \: and \: \hat{\theta}$ then minimize the Sum of Squared Errors (SSE) in equation (5) given as $SSE_n(\beta, \partial, \theta) = (Y - X\beta + X_\theta \partial_n)'(Y - X\beta + X_\theta \partial_n)$ (6)

Meanwhile, the threshold value is confined to a bounded set $[\underline{\theta}, \overline{\theta}] = \overline{\varphi}$ for the purpose of minimization. The approach then uses the concentration technique to obtain the least square estimates $\hat{\beta}, \hat{\partial} \: and \: \hat{\theta}$ such that $SSE_n(\theta)$ is minimized by the value $\hat{\theta}$ and is determined uniquely by

$$\hat{\theta} = \underbrace{argmin}_{\theta \in \overline{\varphi}} SSE_n(\theta)$$

such that $\overline{\varphi}_n = \overline{\varphi}_n \cap \{\theta_1, \theta_2, \dots \dots \dots \dots \theta_n\}$ and we estimate the slopes as $\hat{\beta} = \hat{\beta}(\hat{\theta}) and \: \hat{\partial} = \hat{\partial}(\hat{\theta})$.

We use the Likelihood Ratio test to test the hypothesis H_0: $\theta = \theta_0$ which is given by $LR_n(\theta) = n \frac{SSE_n(\theta) - SSE_n(\hat{\theta})}{SSE_n(\hat{\theta})}$

For large values of $LR_n(\theta)$, the null hypothesis H_0 is rejected. To determine the reliability of θ, we examine where it lies within the asymptotic confidence interval for θ given the Likelihood Ratio $LR_n(\theta)$ that is expressed as $\hat{\hat{\varphi}}$ = { θ: $LR_n(\theta) \leq$ c} as developed by Hansen (2000) and is superior to confidence intervals resulting from the Wald and t-statistic inversion (Ibrahim & Alagidede, 2018). The model approximates, asymptotically, the distribution of the threshold parameter's least square estimate ($\hat{\theta}$), a feature that places this model above the other threshold models.

2.5.2 Debt Constraint on Monetary Policy

2.5.2.1 Data and Data Sources

For the debt constraint on monetary policy discourse, we employ data in quarterly frequency from quarter three of 2000 to quarter two of 2018 for South Africa and from the third quarter of 2007 to the last quarter of 2017. Starting the data from 2000 and 2007 respectively for South Africa and Ghana is in tandem with the start of the full-fledged inflation targeting framework in these countries. For South Africa, data on all the variables except inflation and debt to GDP ratio are sourced from Datastream. Inflation data is obtained from the quarterly bulletins released by the South African Reserve Bank (SARB). For Ghana, data on inflation and the monetary policy rate are obtained from the monetary time series database of the Bank of Ghana. The real GDP data (in 2006 prices) is obtained from the Ghana Statistical Service. For both countries, we obtained the debt to GDP ratio data from the IMF database which is originally in annual series but converted to quarterly series using interpolation. For the respective observations of the annual series, the interpolation technique provides a local quadratic polynomial estimation. It then utilizes the accompanying polynomial to give the corresponding quarterly observations for each year. The technique forms the quadratic polynomial by taking from the annual data some adjacent points that are in sets of three to estimate the quadratic in such a manner that the sum or the average of the resulting quarterly series match the actually observed annual series (IHS Global, 2017). For all the variables other than debt to GDP ratio, data in monthly frequency is available. However, converting the debt to GDP ratio from annual series to monthly series to match the frequency of the other variables would mean losing important properties of the debt to GDP ratio data. We therefore decided to use the readily available quarterly frequency for all the other variables to match the converted debt to GDP series.

2.5.2.2. Description of Variables

For the purposes of our estimations, the variables that go into the model are monetary policy instrument, debt level, inflation gap and output gap.

***Monetary policy instrument*:** The policy instrument in Ghana is the monetary policy rate set by the Bank of Ghana and we use same for the purposes of our work. For South Africa, we used the repo rate as that is the policy instrument used by the South African Reserve Bank (SARB).

***Inflation gap*:** The medium target inflation range in Ghana is 6% and 10% with a midpoint target of 8%. For South Africa, the target range is 3% - 6% and therefore the midpoint target is 4.5%. Our inflation gap is thus the difference between the rate of inflation and the midpoint target for the respective countries, similar to Bleaney et al (2018) for the case of Ghana; and Naraidoo & Raputsoane (2011) and Naraidoo & Paya (2012) for South Africa. When these central banks respond less aggressively to rising expected inflation above the estimated debt threshold or the restrictive policy stance is far less than required, then there is an indication of debt constraint on monetary policy.

Debt level: This is measured by the ratio of debt to GDP.

***Output gap*:** We represent output by real GDP of both countries. The output gap then is the deviation of the real GDP (in logs) from the estimated trend. We estimated the trend with the aid of Koopman et al's (2009) univariate structural time series model. This technique decomposes the real GDP time series into the trend and cycle components in a manner similar to the specification in equation (1). The rationale for the choice of this model-based technique for decomposition are as provided earlier under section 2.5.1.2.

With the aid of Augmented Dickey-Fuller (ADF) test developed by Dickey & Fuller (1981) and the Phillips Perron (PP) test developed by Phillips & Perron (1988), we test for the stationarity of our variables. The variables that are not stationary at the levels enter the models after first difference.

Table 2.3: Test for Stationarity

		ADF TEST		PP TEST	
		Level	**First Diff**	**Level**	**First Diff**
Ghana	MPR	-3.064	-3.627**	-1.6796	-3.762**
	GDP GAP	-1.957	-14.896***	-6.4265***	-10.8354***
	INF GAP	-2.007	-4.025**	-1.904	-4.1097**
	D/GDP	-1.104	-1.910	-0.837	-3.394**
South Africa	MPR	-3.311*	-4.483***	-2.2905	-4.033**
	GDP GAP	-4.526***		-3.858**	
	INF GAP	-4.818***		-4.7719***	
	D/GDP	-0.117	-2.971**	0.217	-2.882**

Note: ***, ** and * indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root. D/GDP is the ratio of debt to GDP.

2.5.2.3 Empirical Approach

We first estimate a basic linear Taylor (1993) rule. The linear model is specified as follows:

$$r_t = \alpha_0 + \alpha_1(E_t[\theta_{t+k} - \theta_t^t]) + \alpha_2(E_t[y_{t+k} - y_t^*]) + \varepsilon_t \tag{7}$$

where monetary policy rate is given by r_t, θ_{t+k} represents inflation and θ^t is the target inflation. Inflation gap is given as $\theta_{t+k} - \theta_t^t$. Meanwhile, $y_{t+k} - y_t^*$ denotes the output gap, and ε_t is the error term. Expectation is included in the model and is given as E_t to signify the fact that policymakers respond to expected inflation as opposed to current inflation. The data on output and inflation gaps that entered the model are one-period lead. The data is in quarterly series and the fact that the Monetary Policy Committees of these central banks meet every two months to decide on the policy rate makes the choice of one-quarter lead the more appropriate.

To capture the constraint that high debt level places on monetary policy, we resort to a threshold estimation to unearth the level of debt beyond which the interest setting behaviour is constrained.

To do this, we rely on the Hansen (2000) sample splitting and threshold estimation technique which, beyond the threshold value estimation, also provides the confidence intervals for the estimated threshold. In the threshold estimation and the accompanying confidence intervals, our model is devoid of nuisance parameters that tend to be the Achilles heel of other threshold models.

Given equation (7) above, we denote the policy rate by q and then the output and inflation gaps by x so that the set $\{q_{i,}, x_i, \delta_i\}_{i-1}^{n}$ signifies our observed sample with x_i denoting an m-vector, and then q_i and δ_i are real-valued. In the observed sample, δ_i signifies the threshold variable and is expressed as $\delta_i = \theta_{t-1}$ and its distribution is continuous. The lag of debt to GDP ratio is the threshold variable. The resulting threshold model is given by:

$$r_t = (\alpha_{11} + \alpha_{21}(E_t[\theta_{t+k} - \theta_t^t]) + \alpha_{31}(E_t[y_{t+k} - y_t^*]))I_i\{\delta_i \leq \varphi_i\} + (\alpha_{12} + \alpha_{22}(E_t[\theta_{t+k} - \theta_t^t]) + \alpha_{32}(E_t[y_{t+k} - y_t^*]))\, I_i\{\delta_i > \varphi_i\} + \varepsilon_t \qquad (8)$$

where the indicator variable given by $I_i\{.\}$ denotes a dummy with value of 1 following the fulfillment of the condition in the indicator function or 0 if not. The threshold value is given by φ. All the other variables are as defined previously. The use of the lagged debt to GDP ratio as the threshold variable vis-à-vis the measure of the dependent variable (monetary policy rate) as current values helps to eliminate potential endogeneity or feedback problems between the threshold variable and the monetary policy rate. The argument is that whereas previous values of debt to GDP may have an effect on current interest rates, the reverse is not plausible (see Boachie et al, 2018; and Uprety, 2019). Similarly, the expression of the other regressors as one-quarter lead, in view of the fact that policy responds to expectations, makes simultaneity or feedback (if any) between these regressors and the policy variable rather remote.

To proceed with the threshold estimation, we first test the hypothesis of linearity as against threshold as the foundation for threshold estimation. Thus we test if $\alpha_{i1} = \alpha_{i2}$ or $\alpha_{i1} \neq \alpha_{i2}$.

Equation (7) is reduced to $y_i = \alpha' x_i + \gamma_i' x_i(\varphi) + \varepsilon_i$ (9)

where $\gamma_n = \alpha_{i2} - \alpha_{i1}$ and signifies the threshold effect. Significantly, we derive the solution as $\gamma_n \to 0$ when $n \to \infty$. Thus we keep α_{i2} fixed so that as $n \to \infty$, $\alpha_{i1} \to \alpha_{i2}$. Meanwhile, the accompanying asymptotic distribution of $\hat{\varphi}$ does not suffer the weakness of nuisance parameters inherent in other threshold models (Hansen, 2000).

We represent equation (9) in a matrix form using $n \times 1$ vectors of ε_i and q_i as we stack both and then an $n \times m$ matrices $X \; and \; X_\varphi$ by stacking the vectors X_i' and $X_i(\varphi)'$. The resulting matrix form is:

$$Y = X\alpha + X_\varphi \gamma_n + \varepsilon_i \tag{10}$$

Using least squares, we estimate the parameters $\alpha, \gamma \; and \; \varphi$. The Sum of Squared Errors in equation (10) expressed as

$$SSE_n(\alpha, \gamma, \varphi) = (Y - X\alpha + X_\varphi \gamma_n)'(Y - X\alpha + X_\varphi \gamma_n) \tag{11}$$

are then minimized by the least squares estimates $\hat{\alpha}, \hat{\gamma} \; and \; \hat{\varphi}$. The threshold value is then restricted to a bounded set $[\underline{\varphi}, \overline{\varphi}] = \overline{\tau}$ in the minimization process. The concentration technique is invoked to determine the least square estimates $\hat{\alpha}, \hat{\gamma} \; and \; \hat{\varphi}$ so that $SSE_n(\varphi)$ is minimized by the value $\hat{\varphi}$ which is distinctively determined by

$$\hat{\varphi} = \underbrace{argmin}_{\varphi \in \overline{\tau}} SSE_n(\varphi)$$

where $\overline{\tau}_n = \overline{\tau}_n \cap \{\varphi_1, \varphi_2, \dots \dots \dots \dots \varphi_n\}$ with the slopes determined as $\hat{\alpha} = \hat{\alpha}(\hat{\varphi}) and\, \hat{\gamma} = \hat{\gamma}(\hat{\varphi})$.

By employing the Likelihood Ratio test, we test the hypothesis $H_0: \varphi = \varphi_0$ expressed as $LR_n(\varphi) = n\, \frac{SSE_n(\varphi) - SSE_n(\hat{\varphi})}{SSE_n\,(\hat{\varphi})}$

We reject the null H_0 for large values of $LR_n(\varphi)$. To establish the reliability of φ, we determine where it falls in the asymptotic confidence interval for φ given the Likelihood Ratio $LR_n(\varphi)$ defined as $\hat{\hat{\tau}}$ = { φ: $LR_n(\varphi) \leq$ c} as per Hansen (2000).

2.6 Empirical Results and Analysis

2.6.1. The Case of Monetary Policy Characterization

Pursuant to the objective of ascertaining whether it is the linear or nonlinear Taylor rule that best characterizes the policy behaviour of Bank of Ghana and the South African Reserve Bank, we present in Table 2.4 the results of our null hypothesis of linearity against that of the threshold hypothesis. We bootstrapped 5,000 replications for each country at a trimming percentage of 15, and test the significance of the threshold statistically using the p-vales of the bootstrap. The null hypothesis that there is no threshold is rejected for both Ghana and South Africa, given the large Lagrangian Multiplier test statistic.

Table 2.4: Threshold Test

Moderated by	No. of Bootstrap replications	Trimming Percentage	LM-Test of no threshold	Bootstrap p-values
GH Inflation	5,000	15	10.86	0.029
SA Inflation	5,000	15	10.08	0.059

Note: The errors are corrected for heteroscedasticity. GH and SA are Ghana and South Africa respectively.

The bootstrap p-values of 0.029 and 0.059 for Ghana and South Africa respectively is a manifestation that the policy behaviour of Bank of Ghana and South African Reserve Bank is not linear and thus the behaviour of these central banks vary across two different regimes (below and above the threshold values). In Figures 2.3 and 2.4, we present respectively the threshold graphs along with the confidence intervals for Ghana and South Africa of the normalized Likelihood Ratio (θ) which is a function of the inflation threshold based on the Hansen (2000) threshold test.

Figure 2.3: Confidence Interval - Ghana

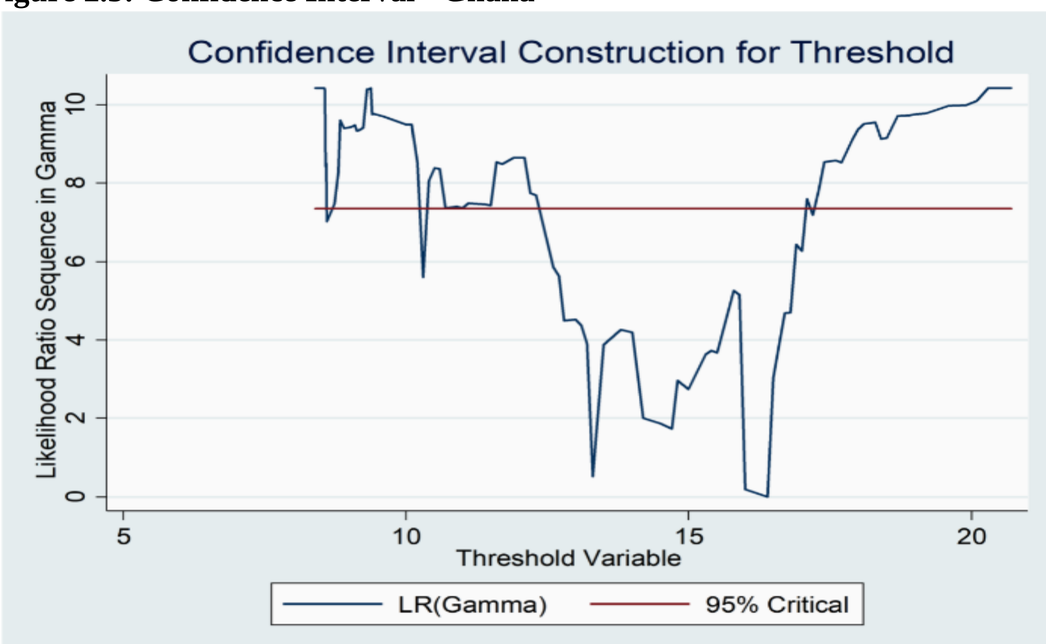
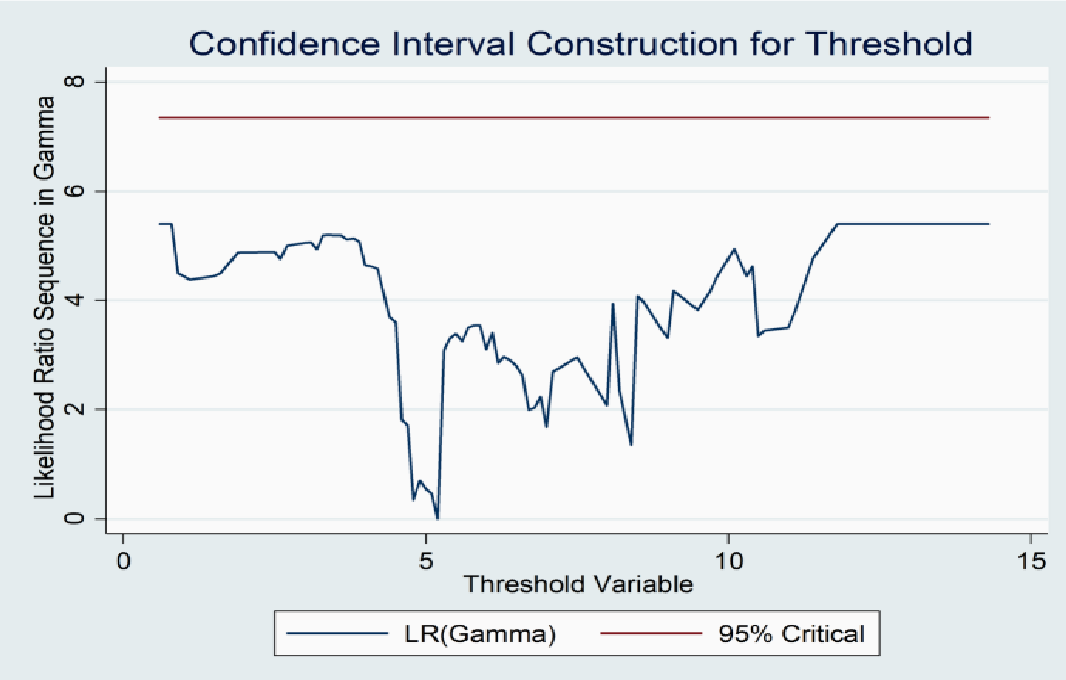


Figure 2.4: Confidence Interval - South Africa



The results indicate a threshold value of 16.4% for Ghana with a confidence interval of [8.6%, 17.2%] and a threshold value of 5.2% for South Africa with a confidence interval of [0.6%, 14.3%]. Putting these optimal inflation values side by side with the publicly announced inflation targets in both countries reveal interesting perspectives especially for Ghana.

For the greater part of the inflation targeting period in Ghana, actual inflation has largely been above the announced inflation targets and the recent target of 8% $\pm$ 2 is not an exception. In 2007 when full-fledged inflation targeting was launched, a target range of 7% and 9% was announced and yet the actual inflation rate at the end of that year was 12.7%. In 2008, a target range of 6% and 8% was announced and yet inflation was 18.1%, more than double of the upper limit. The story was the same in 2009 where although inflation dropped to 15.9%, it was still above the target.

Fast forward, inflation target range announced in 2013 was 7.5% and 11.5% and yet actual inflation was 13.5%. In 2014, the announced target range was 11% and 15% and yet actual inflation was 17%. Since 2015, a medium term target of $8\% \pm 2$ (6% to 10%) was announced and yet actual inflation was 17.7% at the end of 2015, 15.4% at the end of 2016 and 11.8% at the end of 2017. Clearly the targets have fundamentally been missed. It was in 2010, 2011 and 2012 that the targets were met but were even above the midpoint target. Indeed in 2011 when the announced target was 9%, inflation reached 9.2% in February of that year.

The failure to meet the publicly announced targets raises fundamental questions of how the inflation targets in Ghana are arrived at. Whether such targets are supported by the economic fundamentals of the country and if they were subjected to any empirical investigation are questions that deserve further considerations. Meanwhile, a publicly announced inflation target is one that is supposed to be consistent with the economic credentials of the economy and policy optimality. Policy optimality is in turn supposed to be welfare maximizing. It also raises fundamental questions of whether the inflation forecasting by Bank of Ghana is up to scratch to inform policy stance. An important component of the tool box of policy makers in a targeting framework is inflation forecasting based on developments within and outside the economy. Getting the forecasting wrong is an obvious precursor to missing the target. Apart from inflation forecasting, the other prerequisites for a successful inflation targeting such as absence of fiscal dominance, well developed financial markets to aid transmission and reasonably low inflation rate are problematic in Ghana. The fiscal balance in Ghana has persistently been in deficit over the inflation targeting period posing a significant upside risk to inflation and potentially dictating the nature of policy stance indirectly. The Bank of Ghana Act (2002) Act 612 prohibits the country's central bank under section 30(2) from financing more than 10% of the government revenue in any particular fiscal year. This is to deal with issues of policy independence and fiscal dominance. Sadly, in 2008 the Bank of Ghana's financing of the government's fiscal deficit amounted to 10.2% of the total government revenue (including grants). This was even worse in 2012 where the financing by Bank of Ghana amounted to 13.2% of the total government revenue (including grants). It raises questions of whether the central bank is indeed committed to inflation targets. On the issue of financial sector development to aid transmission for a successful inflation targeting, a large number of the country's population do not have access to the banking sector. As at 2017, only 57.7% of the country's population above the age 15 hold bank and mobile money accounts according to the World Bank data. Behind this figure is the stark reality that it is even the mobile money that has more penetration to the rural and informal sector than the bank accounts in Ghana. In addition, the country's financial sector continues to be primary with non-existent secondary markets. The dominant sector is the banking sector which has been plagued by liquidity and solvency issues in the recent past. Indeed, the regulator (Bank of Ghana) had to revoke the banking licenses of two indigenous banks in 2017 on account of insolvency and another five in 2018 on the same grounds to safeguard the stability of the banking system.

Moreover, the structure of the Ghanaian economy raises questions about a single digit inflation target on a sustainable basis. The Ghanaian economy is one that continues to export mainly primary products and imports finished and intermediate goods. The country is a net importer with frequent large current account deficits and its accompanying effect on the currency and upside inflation risk. The agricultural sector in Ghana has long been overtaken by the services sector in terms of contribution to GDP leading to importation of many of the components of the consumption basket with dire consequences for imported inflation and the effect on the country's currency and food prices. Food inflation has been a behemoth in driving inflationary pressures in Ghana and when Ghana experienced single digit inflation for the first time in 2010, it was largely on the back of a significant fall in food inflation from 11.8% in 2009 to 4.5% in 2010. With such an economic structure and susceptibility to external shocks, a single digit inflation on a sustainable basis is naturally questionable. The continuous failure to achieve the set targets (over the period under review) clearly demonstrates that the targets are impractical given the economic fundamentals of the economy and this is detrimental to the credibility of the Bank of Ghana and undermines the intended objective of anchoring inflation expectations with public announcement of the target. Meanwhile, public confidence is an essential building block of the foundations of inflation targeting framework.

Turning to South Africa, the optimal threshold inflation of 5.2% is very close to the upper limit of 6%. Although inflation has, on a number of occasions, been kept within the target band, there has been considerable number of inflationary outcomes that went above the upper limit of 6%. The closest comparison is the 4.56% estimated inflation target obtained by Naraidoo & Paya (2012) for South Africa. While the authors used monthly data from 2000 to 2008, our work has a complement of an expansive monthly data coverage from 2000 to 2018 and that potentially explains the difference.

After assessing the threshold characteristics of inflation, we now present the results in Tables 2.5 and 2.6 on the response of policy to inflation and output gaps across both regimes (below and above the threshold value). In each of the tables, the first part of the results (panel A) represents the linear global ordinary least square results without threshold while the second part (panel B) presents the results of the two regimes (below and above the threshold) for the respective countries.

2.6.1.1 The Linear Model

We find that while the Bank of Ghana responds to only inflation gap in the linear model, the South African Reserve Bank responds to both the output gap and inflation gap. Specifically, we find that a 1% increase in inflation gap induces a 0.23% and 0.06% increase in the monetary policy rate in Ghana and South Africa respectively. Similarly, when output gap surges by 1%, policy rate is increased by 3.17% in South Africa.

Table 2.5: Results on the Linear and Threshold Models for Ghana

Panel A: The Linear Model			**Panel B: The Threshold Model**			
Variables	**Global OLS**		**Regime 1: [ϑ≤θ]**		**Regime 2: [ϑ>θ]**	
Intercept	0.034	(0.049)	-0.059	(0.058)	0.213**	(0.088)
$y_{t+k} - y_t^*$	0.041	(0.074)	0.022	(0.095)	0.095	(0.669)
$\pi_{t+k} - \pi_t^{tg}$	0.226***	(0.076)	0.341**	(0.124)	0.113	(0.072)
Diagnostics (Linear Model)						
Observations		138				
Sum of Squared Errors		45.53				
Residual Variance		0.34				
R Squared		0.06				
Heteroscedasticity Test (p-vale)		0.98				
Diagnostics (Threshold Model)						
Threshold estimate		16.4				
95% confidence interval		[8.6, 17.2]				
Observations				95		43
R Squared				0.12		0.02
Sum of Squared Errors				29.66		12.81
Residual Variance				0.32		0.32
Joint R Squared		0.12				
Heteroscedasticity Test (p-value)		0.98				

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

Table 2.6: Results on the Linear and Threshold Models for South Africa

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [ϑ≤θ]**		**Regime 2: [ϑ>θ]**	
Intercept	-0.091***	(0.026)	0.030	(0.027)	-0.132**	(0.047)
$y_{t+k} - y_t^*$	3.167***	(0.792)	-0.258	(0.689)	3.612***	(0.954)
$\pi_{t+k} - \pi_t^{tg}$	0.055***	(0.012)	0.057 **	(0.021)	0.063***	(0.018)
Diagnostics (Linear Model)						
Observations		219				
Sum of Squared Errors		19.26				
Residual Variance		0.09				
R Squared		0.24				
Heteroscedasticity Test (p-value)		0.000				
Diagnostics (Threshold Model)						
Threshold estimate		5.2				
95% confidence interval		[0.6, 14.3]				
Observations				90		129
R Squared				0.19		0.31
Sum of Squared Errors				3.40		14.5
Residual Variance				0.04		0.12
Joint R Squared		0.29				
Heteroscedasticity Test (p-value)		0.000				

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

2.6.1.2. The Threshold Model

As the null hypothesis of no threshold is rejected, we now look at the results based on the threshold model. We begin with the results in regime 1 which is the response of policy to output and inflation gaps below the inflation threshold. We find that the inflation gap below the threshold for the respective countries is positive and statistically significant, indicating that the two central banks respond to positive inflation gap below the threshold. Specifically, we find responses of 0.34% and 0.06% by the Bank of Ghana and the South African Reserve Bank respectively to 1% rise in expected inflation below their respective thresholds. This is problematic especially as it involves inflation targeting central banks. Much as a one-to-one pass through or response is obviously not expected, a policy response of less than half of the expected inflation increase is a clear indication of inflation accommodation. This is surprising, if not worrying, as a considerable number of the inflation outcomes below the estimated thresholds for Ghana in particular are still above the publicly announced inflation target range. For instance, the estimated threshold inflation of 16.4% for Ghana is 6.4% more than the publicly announced upper limit of 10%. Indeed, out of the 95 inflation observations that are equal to or fall below the estimated threshold of 16.4% in Ghana, as many as 58 of them are above the upper limit of 10% Ghana has set for itself. Only 34 out of the 95 observations fall below the 10% and even so it is instructive to note that all of these 34 observations are between the midpoint target of 8% and the upper limit of 10%. Two inflation outcomes out of the 95 are exactly equal to the 10% upper limit and one observation is equal to 16.4%. For an inflation targeting central bank, this is deleterious to their credibility and raises enormous doubts about their commitment to fighting inflation under a targeting framework. Losing credibility is inimical to the need to earn public trust and anchor their inflation expectations appropriately to achieve announced inflation targets.

The output gap below the threshold for Ghana, although positive, is statistically insignificant, implying that the Bank of Ghana does not respond to output gap below the threshold. Putting this into context, the inflationary process in Ghana and the underlying causes that elicited responses from the central bank over the period under review were factors other than output dynamics. The years 2010 and 2018 for instance were relatively disinflationary and the inflation outcomes in those years did fall below the inflation target (reaching 8.6% in 2010) and by extension the optimal inflation. The accommodative monetary policy stance of the Bank of Ghana in 2010 was in response to better inflation outlook underpinned by stability of the domestic currency, reduction in food inflation from 11.8% in the prior year to 4.5% in 2010 and the sluggish global economic recovery. The monetary policy rate was reviewed downwards from 18% to 16% in February 2010, then to 15% in April and finally 13.5% in July 2010. Similarly, in 2018 where inflation dropped to 9.4%, policy rate was cut by 3% cumulatively from 20% to 17% by May 2018 on the back of fiscal consolidation, strengthening of the domestic currency, falling non-food inflation and to lessen the debt servicing plight of the government to foster the fiscal consolidation drive. Similarly, the output gap below the threshold for South Africa is statistically insignificant.

Having considered monetary policy response below the threshold, we now turn our focus to the response above the respective thresholds (regime 2). We find results similar to that of the lower regime but with different coefficients. The differences in the coefficients across the two regimes is an affirmation that policy behaviour is asymmetric and corroborates the rejection of linearity observed earlier. For inflation gap, we find that the South African Reserve Bank responds relatively more aggressive when inflation exceeds the estimated threshold of 5.2% and farther away from the upper inflation limit of 6% publicly announced in the country. So while the South African Reserve Bank increases the repo rate by 0.057% when inflation gap increases by 1% below the threshold, the Reserve Bank increases the repo rate by 0.063% when inflation gap rises by 1% above the estimated threshold. While this is also a confirmation of asymmetry in policy response, the quantum of response remains significantly small relative to the expected inflation hike and this is uncharacteristic of inflation targeting central banks as they are expected to take sterner monetary policy stance when inflation bites. In a similar fashion, the South African Reserve Bank responds relatively more aggressive to widening positive output gap above the threshold as such increasing economic activities generate inflationary pressures and inflation expectations. The Reserve Bank increases the repo rate by 3.612% when output gap increases by 1% above the threshold. The South African Reserve Bank stabilizes output in addition to the inflation gap. South Africa has had economic growth challenges in the recent past. At various monetary policy committee sittings of the reserve bank, the repo rate had to be left unchanged to prop up economic activities particularly when inflation was within target. Indeed, on numerous occasions, inflation was trending upwards towards the upper limit but policy stance remained unchanged as output growth remained an added priority to the committee. This perhaps explains the inflation accommodation observed earlier in respect of the response to inflation gap.

Turning to Ghana, we find that although the Bank of Ghana responds to inflation gap above the estimated threshold, the said response is statistically insignificant. Indeed, the quantum of response is lower compared to the response below the threshold. While the Bank of Ghana adjusts the policy rate upwards by 0.34% when inflation gap increases by 1% below the threshold, it increases the policy rate by 0.113% when inflation gap increases by 1% above the threshold which is insignificant statistically. The finding is much akin to that of Caporale et al (2018) for Israel, Thailand and Turkey in their panel study where the coefficient of inflation gap in the low inflation regime is higher than the coefficient in the high inflation regime. This is surprising as policy makers are expected to respond more aggressively when inflation soars above the target as was found in the case of South Africa. We observed that the policy responses of the Bank of Ghana to the very high inflationary periods of 2007, 2008, 2009, 2013, 2014, 2015, 2016 and 2017 where inflation exceeded announced targets speak to this policy conundrum. For instance, while inflation in 2007 increased by 2.5% on the aggregate, the accompanying policy tightening was by only 1% on the aggregate. In 2008 when inflation increased by 5.3% on the aggregate from 12.8% to 18.1%, the resulting policy tightening was an increase in policy rate by an aggregate of 3.5%. Notably, when inflation increased by 4.7% on the aggregate in 2013, policy rate was only increased by 1%

on the aggregate. The Bank of Ghana must take a sterner policy stance during inflationary episodes if indeed it wants to rein in inflation and achieve the stated target to help anchor inflation expectations following its inability to meet the stated target for the greater part of the inflation targeting period. For instance, although 43 inflation observations are above the estimated threshold of 16.4%, as many as 102 inflation outcomes out of the total 138 observations are above the upper limit of 10% publicly announced. We also find that the Bank of Ghana does not respond to the output gap above the inflation threshold. While it is true that inflation was driven up in Ghana by factors other than output over the years, the rather volatile output growth should have attracted the attention of the Bank of Ghana in terms of response to stabilize output as in the case of South Africa. For instance, over the period under review, Ghana grew by 7.3% in 2008, then 4% in 2009, 7.7% in 2010, 14.4% in 2011 as oil production came on board, down to 7.9% in 2012, then to 7.3% in 2013, down to 4% in 2014, 3.7% in 2015 and 2016 and then 8.5% in 2017. Meanwhile, the narrow focus on inflation is not yielding the desired results either.

2.6.1.3 Robustness Checks

We vary the specification of our model (for robustness checks) as we augment it with exchange rate of the respective currencies of Ghana and South Africa (Cedi and Rand) to the United States dollar. The choice of exchange rate flows from the intuition that Ghana and South Africa are small open economies and therefore exchange rate plays an important role in the macroeconomic dynamics of these countries. The results, presented in Tables 2.8 and 2.9 for Ghana and South Africa respectively, show that our earlier findings are resilient. We find that the threshold inflation rates are still 16.4% and 5.2% for Ghana and South Africa respectively. The Bank of Ghana is still unresponsive to output gap below and above the estimated threshold. The policy response to inflation gap above the threshold by the Bank of Ghana is still less than the policy response below the threshold, although the response above the threshold is now statistically significant. The case of South Africa is not different. The South African Reserve Bank responds relatively more aggressive to inflation gap above the threshold and the policy response to output gap is largely similar to that of the earlier findings. We find policy response to exchange rate to be rather prominent in Ghana than in South Africa.

Table 2.7: Threshold Test – Robustness Check

Moderated by	No. of Bootstrap replications	Trimming Percentage	LM-Test of no threshold	Bootstrap p-values
GH Inflation	5,000	15	13.48	0.012
SA Inflation	5,000	15	11.47	0.066

Note: The errors are corrected for heteroscedasticity. GH and SA are Ghana and South Africa respectively.

Table 2.8: Controlling for Exchange Rate – Ghana

Panel A: The Linear Model			**Panel B: The Threshold Model**			
Variables	**Global OLS**		**Regime 1: [ϑ≤θ]**		**Regime 2: [ϑ>θ]**	
Intercept	0.036	(0.056)	-0.110*	(0.061)	0.276***	(0.091)
$y_{t+k} - y_t^*$	0.042	(0.074)	0.017	(0.082)	0.503	(0.656)
$\pi_{t+k} - \pi_t^{tg}$	0.227***	(0.077)	0.315**	(0.115)	0.172**	(0.073)
$EXCH_{t+k}$	-0.207	(1.945)	4.489*	(2.459)	-4.628***	(0.830)
Diagnostics (Linear Model)						
Observations		138				
Sum of Squared Errors		45.52				
Residual Variance		0.34				
R Squared		0.06				
Heteroscedasticity Test (p-vale)		0.98				
Diagnostics (Threshold Model)						
Threshold estimate		16.4				
95% confidence interval		[14.2, 16.5]				
Observations				95		43
R Squared				0.15		0.11
Sum of Squared Errors				28.64		11.67
Residual Variance				0.32		0.30
Joint R Squared		0.17				
Heteroscedasticity Test (p-value)		0.98				

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

Table 2.9: Controlling for Exchange Rate – South Africa

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [ϑ≤θ]**		**Regime 2: [ϑ>θ]**	
Intercept	-0.093***	(0.026)	0.037	(0.030)	-0.139***	(0.047)
$y_{t+k} - y_t^*$	3.124***	(0.780)	-0.418	(0.743)	3.424***	(0.950)
$\pi_{t+k} - \pi_t^{tg}$	0.055***	(0.012)	0.056**	(0.03)	0.064***	(0.017)
$EXCH_{t+k}$	0.594	(0.570)	-0.649	(0.547)	1.220	(0.952)
Diagnostics (Linear Model)						
Observations	219					
Sum of Squared Errors	19.15					
Residual Variance	0.09					
R Squared	0.24					
Heteroscedasticity Test (p-value)	0.000					
Diagnostics (Threshold Model)						
Threshold estimate	5.2					
95% confidence interval	[0.6, 14.3]					
Observations				90		129
R Squared				0.20		0.32
Sum of Squared Errors				3.33		14.27
Residual Variance				0.04		0.11
Joint R Squared	0.31					
Heteroscedasticity Test (p-value)	0.000					

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

Figure 2.5: Confidence Interval (Robustness) – Ghana

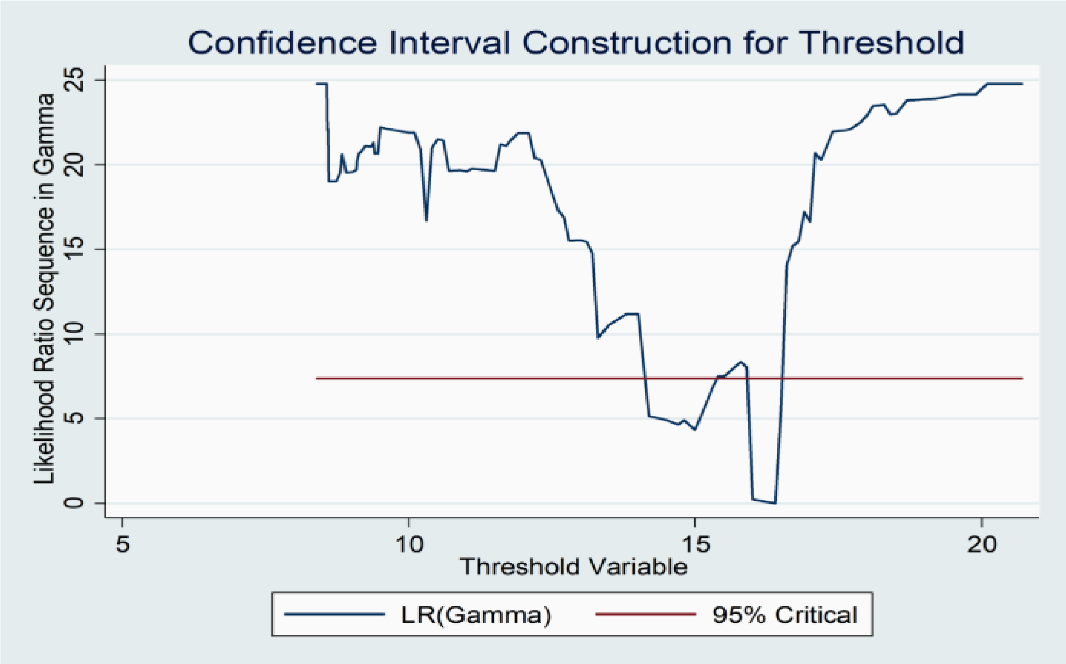
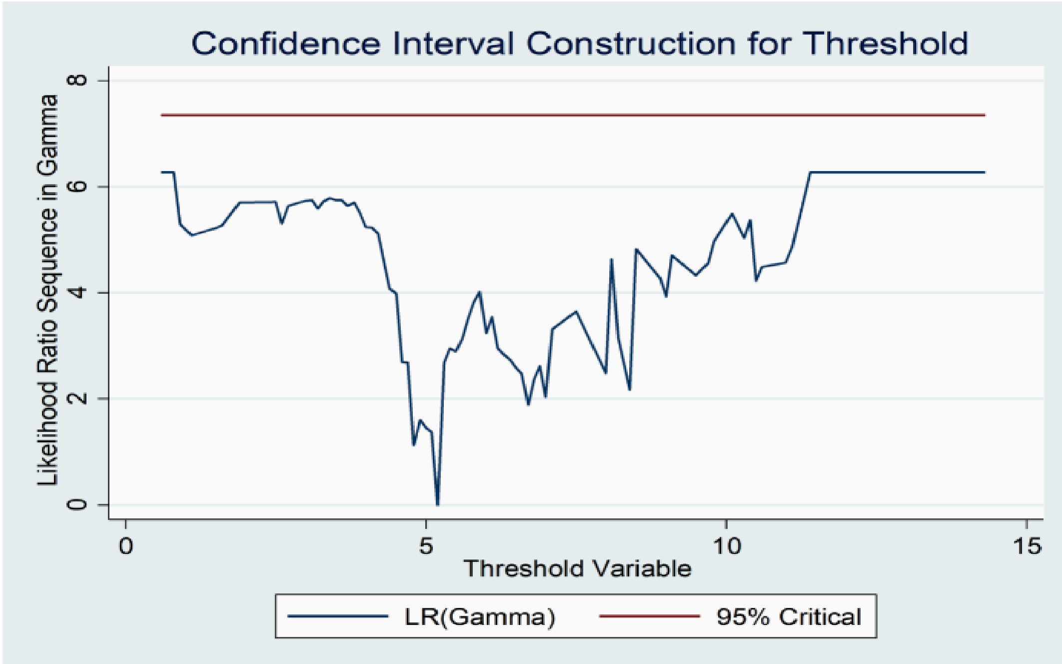


Figure 2.6: Confidence Interval (Robustness) – South Africa



2.6.1.4 Implications for Policy, Current and Future Research

2.6.1.4.1 Policy

The findings in our study carry enormous policy relevance to both central banks. Our model, which underwent 5,000 bootstrap replications indicate that the optimal inflation level for Ghana is 16.4% and the set inflation target of 8% ± 2 is far from the country's economic credentials. Indeed the average inflation of 13.35% over the period and the failure of the Bank of Ghana on a number of occasions to meet the set target over the inflation targeting period lend credence to our assertion. A review of the target is necessary to help anchor inflation expectations properly. Setting an unachievable target is a sure way to reputational damage, confidence derailment and macroeconomic jeopardy. Our finding that the Bank of Ghana is less aggressive during inflationary episodes is a serious policy challenge, if not enigma. The Bank of Ghana would need to ensure policy consistency and deliver appropriate responses when inflation outlook deteriorates and when inflationary outcomes are above the set target if indeed they want to rein in inflation and achieve the set target. The rather volatile growth pattern in Ghana deserves some policy attention. The narrow focus on inflation which the country has struggled to achieve may not be helpful to the growth dynamics of the country.

The quantum of policy response relative to the rise in expected inflation is revealing of the extent of inflation accommodation by these two central banks that are supposed to be targeting inflation. This is perilous to policy credibility and public confidence which shakes the very foundation of inflation targeting framework. The two central banks would need to demonstrate commitment to reining in inflation when it rises by taking sterner policy stance as appropriate. When the public get used to such inflation accommodation and less commitment to fighting it, it becomes very difficult for the central banks to anchor expectations of inflation towards the publicly announced targets in the future. Public confidence is not built only by transparency through the publication of monetary policy committee proceedings and related indicators. Indeed, the level of commitment to fighting inflation and the successes thereof are perhaps more germane to public confidence building.

2.6.1.4.2 Current Research

The current study has an important bearing on policy rule literature and obviously the rule-discretion debate. The rather popular linear policy rule characterization in the literature is questionable as developments in economies are not straightforward where the extent of inflation at one point in time would necessarily be equal to the extent of disinflation at another point to warrant a symmetrical response. Macroeconomic relationships change over time, and preferences of central banks differ depending on changing economic realities. As our study has revealed, nonlinear policy rule characterization best suit such asymmetries in the nature of economies and the interrelationships between their economic fundamentals. The growing nonlinear policy rule research is thus in the right direction. Importantly, the nature of nonlinearity may differ from country to country and it would be counter-intuitive to impose the very nature of the nonlinearity in any country.

On the rule-discretion debate, our results reveal a strong relationship between monetary policy and inflation in both countries and that is largely attributable to the inflation targeting framework which in itself is a form of a rule. Importantly, we find that in relative terms the rule-based policy framework has helped the South African Reserve Bank to achieve stability in the price level as compared to its prior experience. Although Ghana has, for most of the period, not achieved the target inflation, the levels of inflation post adoption of inflation targeting is better compared to high inflationary episodes prior to inflation targeting. Over the inflation targeting period, the highest inflation outcome was 20.7% in June 2009 whereas inflation reached 41.9% in March 2001 prior to the adoption of inflation targeting. Having said that, it is important to mention that while rules may be superior to discretion, the latter is equally indispensable in practical policy making. Indeed, the complexities in a real-world situation may not be exactly captured algebraically and some discretion would be required to deal with special situations and underlying uncertainties in the real-world. The case of South Africa is a classic example where the reserve bank was left in a dilemma on a number of occasions where output was declining but certain other factors were posing significant upside inflation risk and the reserve bank at certain points had to use discretion to prop up economic activities although they are committed to rule-based framework to achieve a certain inflation target that has been publicly announced. Essentially, therefore, an element of discretion is required in a policy rule environment. Importantly, rule-based policy research should only be a guide and a component of the monetary policy tool box of central banks as opposed to strict requirement to follow a mechanical rule regardless of the economic realities.

2.6.1.4.3 Future Research

A typical Taylor rule involves a response of monetary policy rate (interest rate) to inflation and output gaps which has been captured by our model. Some augmentations have also been suggested in the literature including exchange rate for small open economies which we have done as well. The inflation dynamics of the two countries we studied also reveal important factors that drive inflation in these countries but which were not explicitly measured or included as regressors in our model. These factors are crude oil prices, food inflation and fiscal balance particularly the effect of debt burden. Future research should look at these variables in the policy rule construction.

2.6.2 The Case of Debt Constraint and Monetary Policy

Undertaking threshold analysis requires that we first test whether there is a threshold effect to start with. We therefore test a linear hypothesis against that of threshold. The results of the threshold test, following 5,000 bootstrap replications at a 15-percentage trimming, are presented in Table 2.10. The accompanying test of significance of the estimated threshold (on the basis of the bootstrap p-value) is also presented therein. With a large Lagrangian Multiplier test statistic, the null hypothesis of linearity is rejected.

Table 2.10: Test for Threshold

Moderated by	No. of Bootstrap replications	Trimming Percentage	LM-Test of no threshold	Bootstrap p-value
GH Debt to GDP	5,000	15	9.905	0.0282
SA Debt to GDP	5,000	15	10.792	0.0192

Note: The errors are corrected for heteroscedasticity. GH is Ghana and SA is South Africa.

The p-values of the bootstraps of 0.028 and 0.019 for Ghana and South Africa respectively indicate there is a threshold effect as we reject the null hypothesis of linearity. The accompanying threshold graphs and the confidence intervals of the normalized Likelihood Ratio (φ) are presented in Figures 2.7 and 2.8.

Figure 2.7: Confidence Interval – Ghana

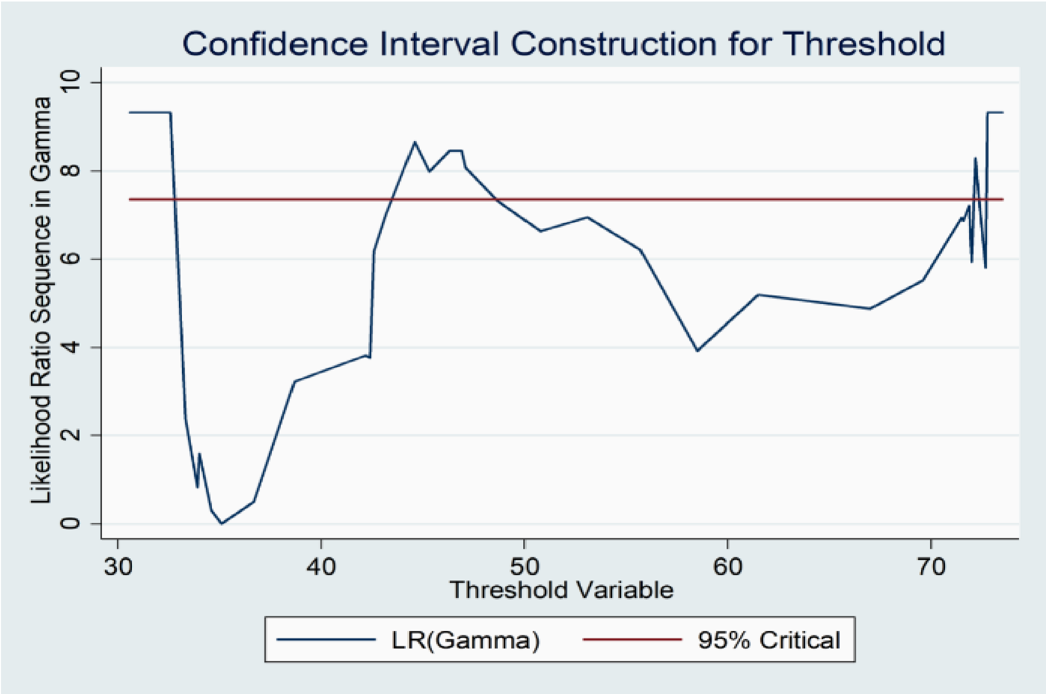
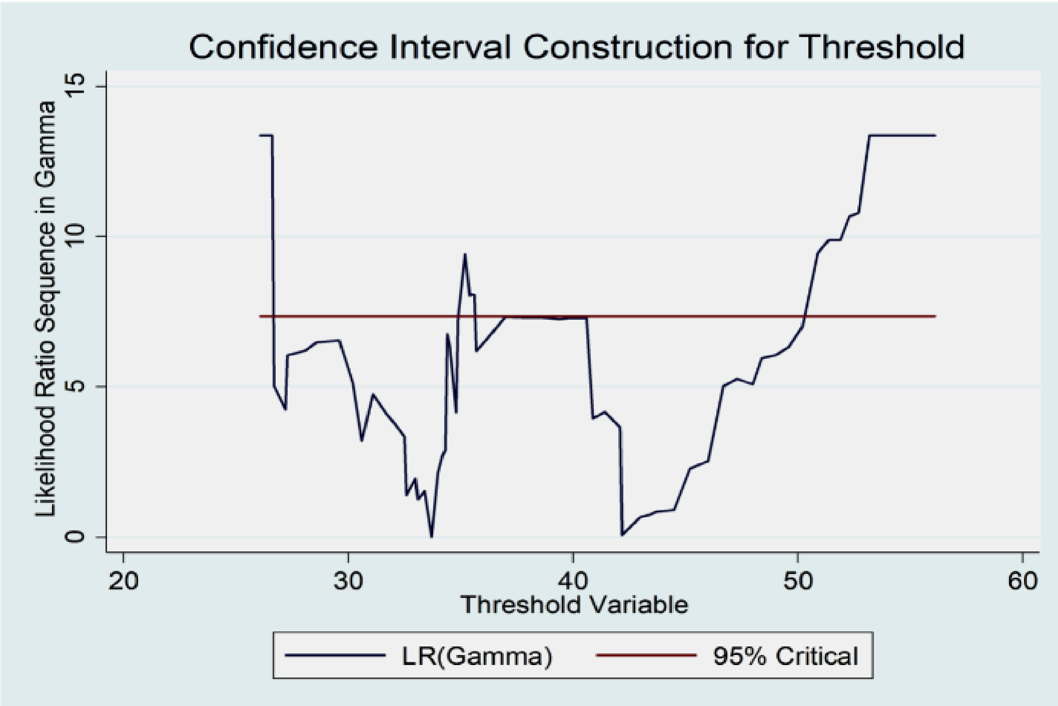


Figure 2.8: Confidence Interval – South Africa



We obtained a threshold debt to GDP ratio of 35.1% alongside a confidence interval of [33.3%, 72.7%] for Ghana and a debt to GDP ratio of 33.7% for South Africa with a confidence interval of [26.7%, 50.2%]. We find that for thirty-three (33) consecutive quarters (from Q3 of 2009 to Q4 of 2017), the debt levels have been above the estimated threshold of 35.1% for Ghana. For South Africa, we find that for 21 quarters, the observed debt to GDP ratio fell below the threshold while for as many as 51 quarters, the debt to GDP ratio was above the threshold of 33.7%. This presents a significant consequence to these central banks as high debt levels pose an upside risk to inflation. To ascertain the nature of policy responses to inflation and output gaps in the face of the rising debt, we now turn to Tables 2.11 and 2.12 for the empirical results. For each of these tables, the results from the linear estimation model is given in panel *A* while the threshold results is given in panel *B*.

2.6.2.1 The Linear Model

We find that while the Bank of Ghana is responsive to only inflation gap, the South African Reserve Bank is responsive only to the output gap. An increase in expected inflation by 1% in Ghana coincides with a 0.24% increase in the monetary policy rate. An increase (decrease) in output gap in South Africa elicits a 0.72% increase (decrease) in the policy rate. However, typical linear Taylor rules of this nature fail to capture debt concerns and the resulting constraint on interest rate setting behaviour of central banks. We therefore turn our attention to the results on the threshold estimate that incorporates debt 'constraint'.

Table 2.11: Results on the Linear and Threshold Models - Ghana

Panel A: The Linear Model			**Panel B: The Threshold Model**			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	0.177	(0.154)	0.639***	(0.227)	0.108	(0.175)
$y_{t+k} - y_t^*$	-0.156	(1.095)	0.772	(2.052)	-1.358	(1.084)
$\theta_{t+k} - \theta_t^t$	0.242***	(0.074)	0.044	(0.099)	0.412***	(0.093)
Diagnostics (Linear Model)						
Observations		42				
Sum of Squared Errors		41.4				
Residual Variance		1.06				
R Squared		0.12				
Heteroscedasticity Test (p-vale)		0.38				
Diagnostics (Threshold Model)						
Threshold estimate		35.1				
95% confidence interval		[33.3, 72.7]				
Observations				9		33
R Squared				0.02		0.21
Sum of Squared Errors				3.70		32.17
Residual Variance				0.62		1.07
Joint R Squared		0.24				
Heteroscedasticity Test (p-value)		0.38				

Note: *** represents 1% significance level. The standard errors in brackets are corrected for heteroscedasticity.

Table 2.12: Results on the Linear and Threshold Models – South Africa

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	-0.001	(0.001)	0.002**	(0.001)	-0.002**	(0.001)
$y_{t+k} - y_t^*$	0.717***	(0.168)	0.917***	(0.174)	0.849***	(0.278)
$\theta_{t+k} - \theta_t^t$	0.0003	(0.0003)	-0.001**	(0.0004)	0.001***	(0.0003)
Diagnostics (Linear Model)						
Observations	72					
Sum of Squared Errors	0.002					
Residual Variance	0.000					
R Squared	0.37					
Heteroscedasticity Test (p-vale)	0.71					
Diagnostics (Threshold Model)						
Threshold estimate	33.7					
95% confidence interval	[26.7, 50.2]					
Observations				21		51
R Squared				0.67		0.34
Sum of Squared Errors				0.0004		0.0014
Residual Variance				0.00002		0.00003
Joint R Squared	0.47					
Heteroscedasticity Test (p-value)	0.71					

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

2.6.2.2 The Threshold Model

The threshold model presents policy responses to inflation and output gaps below and above the estimated debt to GDP threshold. Below the estimated debt threshold is designated as low debt regime whereas the high debt regime is where debt levels exceed the estimated threshold. We begin the analysis with the low debt regime. For Ghana, we find that the Bank of Ghana is unresponsive to output and inflation gaps below the debt threshold. For the inflation gap in particular, this finding is worrying because the observed debt levels below the threshold coincide with the period between the start of the full-fledged inflation targeting in 2007 up to Q2 of 2009. Over this period, Ghana witnessed some of the worst inflationary episodes in its full-fledged inflation targeting history with inflation reaching 20.5% at the end of the first quarter of 2009. Indeed, in some cases, the observed inflation rates were more than twice the upper limit. A response of 0.044% which is statistically insignificant is therefore telling of the level of commitment to curbing inflation. Turning to South Africa, we find that the output gap is positive and statistically significant, implying that a fall (rise) in output gap informs a reduction (increase) in the policy rate by the SARB. Putting this finding into context, we observed that the low debt regime coincides with the period from the last quarter of 2004 to the first quarter of 2010, a period where real economic growth has not been spectacular in South Africa. For instance, while real growth was 4.5% in 2004, it only inched up to 5% in 2005. Growth then dropped to 3.7% in 2008 and the South African economy even contracted by 1.8% in 2009. Over this period, the quantum of policy easing on the aggregate was 6% as against an aggregate tightening of 5%, an indication that the SARB considered output growth as an added priority and thus took policy stance meant to prop up economic activities. Indeed, for 8 quarters out of the 21, policy remained unchanged although there were ample indications of inflationary momentum. Taking policy stance to boost economic activities might be noble but that obviously has ramifications for commitment to inflation targeting which is the primary objective. Indeed, over the sample period, there were ten (10) quarters out of the total twenty-one (21) where inflation was above the upper limit of 6% of the announced inflation target range. There were also four (4) quarters where inflation was between the midpoint target of 4.5% and the upper limit of 6%. Invariably therefore, there were only seven (7) quarters when inflation fell below the midpoint target. The nature of response of monetary policy under such circumstances where there were clear indications of inflation momentum is therefore telling. Unsurprisingly, we find that the policy response to inflation gap in the low debt regime is negative.

Rising debt levels pose an additional layer of risk to inflation and we now turn our attention to policy responses in the high debt regime. Mitra (2007) argues that a central bank's interest rate setting behaviour is constrained by debt when response of monetary policy to rising inflation reduces as debt exceeds a certain threshold. Dornbusch (1996) however reckons that a central bank may still take a tightening policy stance above a certain significant debt level but the extent of the tightening could be far lower than what is required.

To ascertain whether policy response to inflation reduces above the debt threshold (Mitra, 2007) or restrictive monetary policy stance is taken but less than required (Dornbusch, 1996), both of which are indications of debt constraint to monetary policy, we turn our attention to the results in the high debt regime. For Ghana, we observe that the Bank of Ghana is not responsive to output gap. For the inflation gap, we find that the Bank of Ghana responds positively to rising inflation expectations and with relative aggression compared to the response below the estimated debt threshold. Notably, we find that the response to 1% increase in inflation expectations is 0.412%. On the basis of the findings of Mitra (2007), such a response that is more than what was observed below the threshold would mean there is no debt constraint to interest rate setting. However, taking into account the magnitude of response in the context of the inflation developments during the period when the debt levels exceeded the estimated threshold leaves much to be desired. Over the 33 consecutive quarters that debt levels exceeded the threshold, inflation exceeded the publicly announced upper limit of 10% in as many as 22 quarters. For an inflation targeting central bank in particular, a response of 0.412% to an expected inflation increase of 1% (less than half of the expected inflation increase) is not only woefully disproportionate but also a clear indication of constraint and inflation accommodation, given that inflation exceeded the publicly announced upper limit in two-thirds of the quarters of the high debt regime. In line with the argument of Dornbusch (1996), importantly, a debt constraint is equally manifested in less than required policy tightening.

For South Africa, we find that SARB responds positively to output gap. We observe that given the growth challenges of South Africa over the period under consideration, the policy stance has been one of easing. The period of high debt regime coincides with the period prior to the last quarter of 2004 and after the first quarter of 2010, particularly the period after the first quarter of 2010. Over that period, real economic growth stagnated at 3% in the years 2000, 2001, 2002 and 2003. By 2013, real growth had waned to 1.9%, further down to 1.3% and 0.6% in 2015 and 2016 respectively. Although growth picked up to 1.3% in 2017, it was far lower than the average growth rate of 4.7% in emerging economies. Over that same period, the policy rate was eased by as much as 10.5% on the aggregate (at 11 different meetings) compared to an aggregate tightening of 6.25%. Meanwhile, this was a period when inflation exceeded the upper limit of 6% in as many as 22 quarters with some inflation observations being more than twice the upper limit, particularly in almost all the quarters of the year 2002. Additionally, for as many as 13 quarters, inflation was between the mid-point and the upper limit. Clearly, the focus was on stimulating economic growth at the cost of higher inflation. Meanwhile, this is an explicit or full-fledged inflation targeting central bank. This has dire consequences for the publicly announced inflation targets and erosion of public confidence in the commitment of the central bank to inflation. Looking at the inflation gap, we find that although the response is positive and statistically significant, the extent of response is worryingly small relative to the rise in expected inflation. Specifically, we find that a 1% increase in the expected inflation gap in the high debt regime elicits a policy response of approximately 0.001% which is less than a tenth (10^{th}) of the expected increase in inflation and therefore substantially disproportionate. So while debt levels are soaring far beyond the threshold, thereby precipitating inflationary momentum, policy restriction is far lower than the rising inflation, a phenomenon akin to the proposition of Dornbusch (1996). This is an indication of debt constraint on policy rate setting.

2.6.2.3 Robustness Checks

For the purposes of robustness checks, we include exchange rate in our model. We measure the exchange rate as the values of the domestic currencies of Ghana and South Africa against the United States dollar (USD) which is the dominantly traded foreign currency in these two countries. The findings, in Tables 2.13 and 2.14 for Ghana and South Africa respectively, indicate that our earlier results are robust. Indeed, the threshold estimates of debt for the two countries remain the same at 35.1% and 33.7% for Ghana and South Africa respectively. The Bank of Ghana is not responsive to output and inflation gaps in the low debt regime as found earlier. The response of the South African Reserve bank to inflation gap in the low debt regime remains negative and the response to the output gap is still positive and statistically significant. In the high debt regime, as previously found, the Bank of Ghana responds only to inflation gap. The response remains disproportionate to the expected increase in inflation. The case of South Africa in the high debt regime also mirrors the previous findings.

Table 2.13: Robustness results using exchange rate of the Ghana Cedi to the US dollar

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	0.050	(0.195)	0.407	(0.249)	0.049	(0.223)

$y_{t+k} - y_t^*$	0.240	(1.078)	0.604	(1.865)	-1.077	(1.065)
$\theta_{t+k} - \theta_t^t$	0.210***	(0.075)	-0.006	(0.090)	0.389***	(0.097)
$EXCH_{t+k}$	3.497	(3.166)	5.630	(5.701)	1.645	(3.450)
Diagnostics (Linear Model)						
Observations		42				
Sum of Squared Errors		40.06				
Residual Variance		1.05				
R Squared		0.15				
Heteroscedasticity Test (p-vale)		0.58				
Diagnostics (Threshold Model)						
Threshold estimate		35.1				
95% confidence interval		[33.9, 72.4]				
Observations				9		33
R Squared				0.15		0.22
Sum of Squared Errors				3.21		31.93
Residual Variance				0.64		1.10
Joint R Squared		0.26				
Heteroscedasticity Test (p-value)		0.58				

Note: *** represents 1% significance level. The standard errors in brackets are corrected for heteroscedasticity.

Table 2.14: Robustness results using exchange rate of the Rand to the US dollar

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	-0.001	(0.001)	0.001	(0.001)	-0.002**	(0.001)
$y_{t+k} - y_t^*$	0.724***	(0.174)	0.794***	(0.184)	0.836***	(0.275)
$\theta_{t+k} - \theta_t^t$	0.0003	(0.0003)	-0.0006	(0.0004)	0.001***	(0.0003)
$EXCH_{t+k}$	-0.002	(0.011)	0.016	(0.016)	-0.014	(0.011)
Diagnostics (Linear Model)						
Observations		72				
Sum of Squared Errors		0.002				
Residual Variance		0.000				
R Squared		0.37				
Heteroscedasticity Test (p-vale)		0.75				
Diagnostics (Threshold Model)						
Threshold estimate		33.7				
95% confidence interval		[27.2, 46.0]				
Observations				21		51
R Squared				0.69		0.37
Sum of Squared Errors				0.0004		0.001
Residual Variance				0.00002		0.00003
Joint R Squared		0.49				
Heteroscedasticity Test (p-value)		0.75				

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

Figure 2.9: Confidence Interval (The case of exchange rate of the cedi to dollar) – Ghana

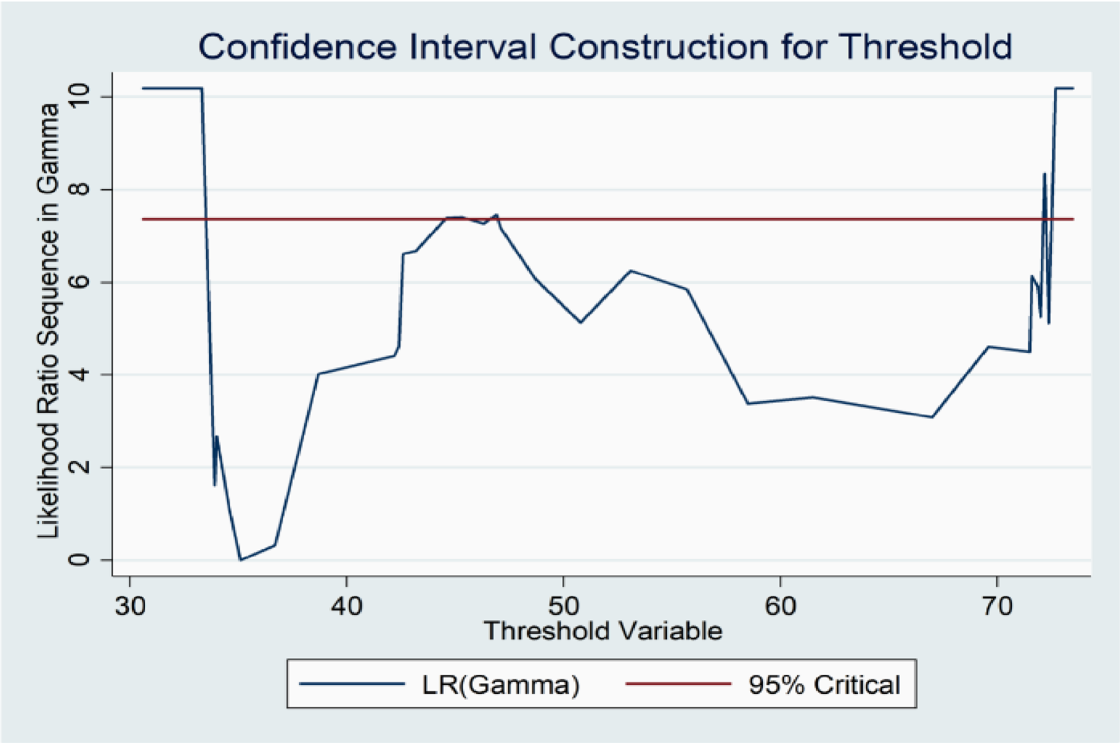
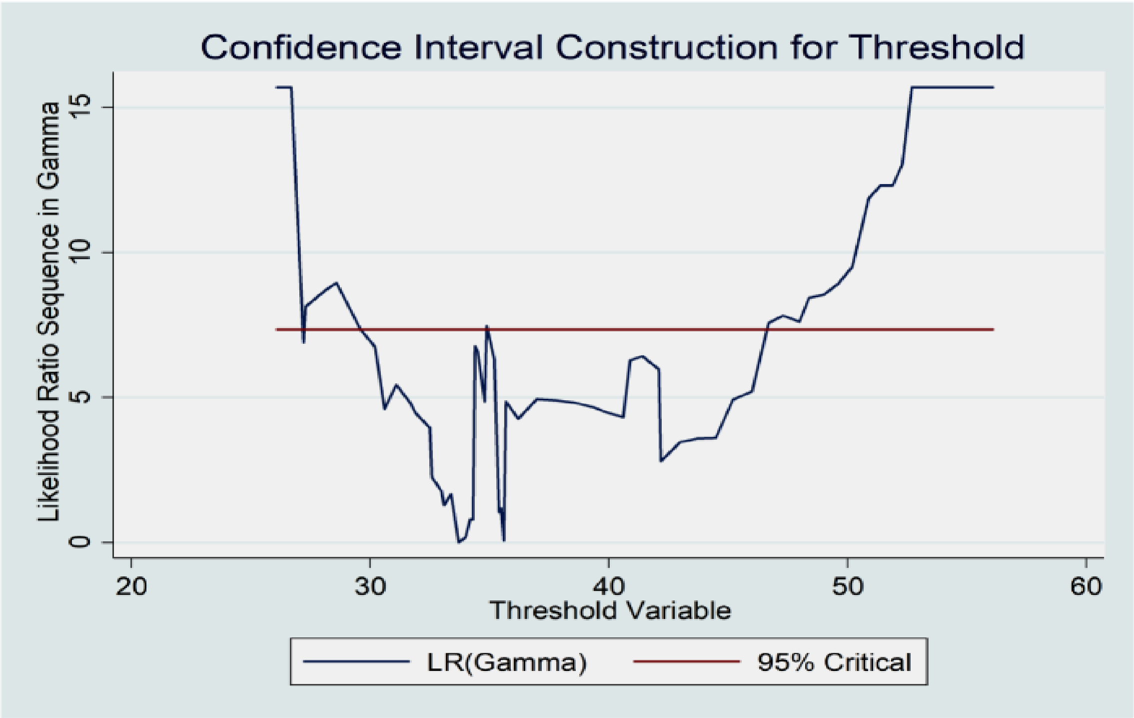


Figure 2.10: Confidence Interval (The case of exchange rate of the rand to dollar) – South Africa



Having measured the exchange rate as Cedi to the United States dollar for Ghana and the Rand to the United States dollar for South Africa, we reckon that such a measure may not comprehensively capture the values of these currencies as they also trade against other major international currencies. We therefore resorted to a broader measure of exchange rate to further assess the resilience of our findings. We use the real effective exchange rate (REER) of the Cedi against a weighted basket of currencies of major trading partners of Ghana and the Rand against a weighted basket of currencies of major trading partners of South Africa. For both countries, with results in Tables 2.15 and 2.16 for Ghana and South Africa respectively, we observe that the earlier findings remain robust.

Table 2.15: Robustness check using the real effective exchange rate - Ghana

Panel A: The Linear Model			**Panel B: The Threshold Model**			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	0.175	(0.157)	0.641***	(0.202)	0.122	(0.178)
$y_{t+k} - y_t^*$	-0.147	(1.142)	0.771	(2.056)	-1.484	(1.140)
$\theta_{t+k} - \theta_t^t$	0.240***	(0.075)	0.044	(0.101)	0.430***	(0.103)
$REER_{t+k}$	-0.002	(0.040)	0.001	(0.045)	0.018	(0.048)
Diagnostics (Linear Model)						
Observations		42				
Sum of Squared Errors		41.44				
Residual Variance		1.09				
R Squared		0.12				
Heteroscedasticity Test (p-vale)		0.53				
Diagnostics (Threshold Model)						
Threshold estimate		35.1				
95% confidence interval		[33.9, 72.4]				
Observations				9		33
R Squared				0.02		0.21
Sum of Squared Errors				3.70		32.01
Residual Variance				0.74		1.10
Joint R Squared		0.24				
Heteroscedasticity Test (p-value)		0.53				

Note: *** represents 1% significance level. The standard errors in brackets are corrected for heteroscedasticity.

Table 2.16: Robustness check using the real effective exchange rate – South Africa

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	**Global OLS**		**Regime 1: [$\delta \leq \varphi$]**		**Regime 2: [$\delta > \varphi$]**	
Intercept	-0.001	(0.001)	0.001	(0.001)	-0.002**	(0.001)
$y_{t+k} - y_t^*$	0.741***	(0.176)	0.829***	(0.181)	0.787***	(0.256)
$\theta_{t+k} - \theta_t^t$	0.0003	(0.0003)	-0.0006	(0.0004)	0.001***	(0.0003)
$REER_{t+k}$	0.0002	(0.0002)	-0.0002	(0.0002)	0.0004**	(0.0002)
Diagnostics (Linear Model)						
Observations		72				
Sum of Squared Errors		0.002				
Residual Variance		0.000				
R Squared		0.38				
Heteroscedasticity Test (p-vale)		0.65				
Diagnostics (Threshold Model)						
Threshold estimate		33.7				
95% confidence interval		[30.6, 44.5]				
Observations				21		51
R Squared				0.69		0.43
Sum of Squared Errors				0.0004		0.0012
Residual Variance				0.00002		0.00003
Joint R Squared		0.52				
Heteroscedasticity Test (p-value)		0.65				

Note: *** and ** represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

Figure 2.11: Confidence Interval (The case of real effective exchange rate) – Ghana

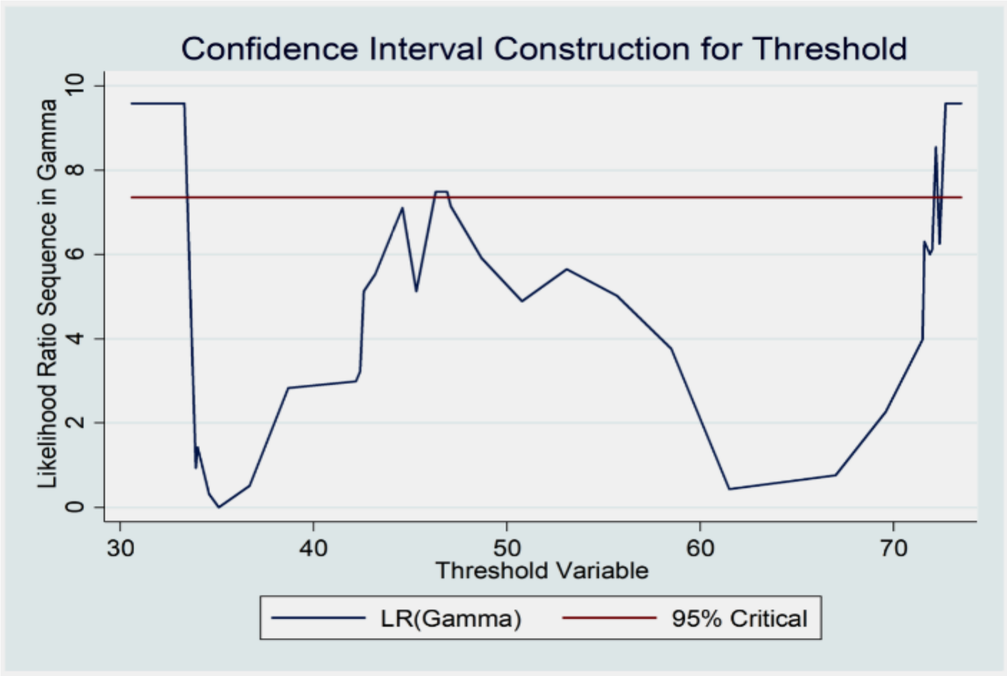
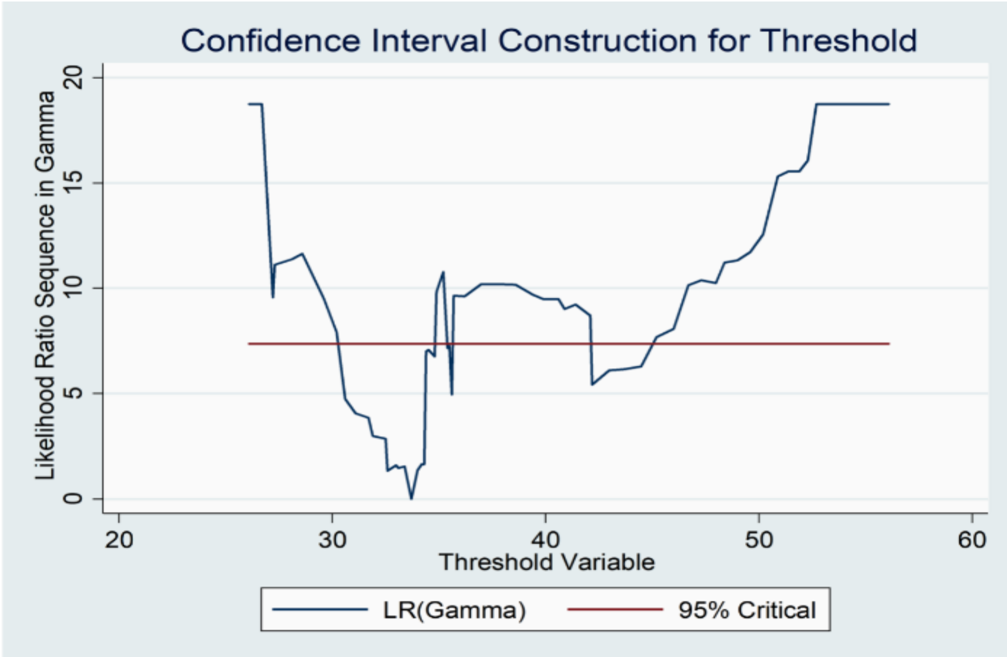


Figure 2.12: Confidence Intervals (The case of real effective exchange rate) – South Africa



2.6.2.4 Policy Discussions

Rising public debt levels undoubtedly pose a dilemma and concern to many central banks especially the inflation targeting central banks. Responding aggressively to rising inflation only increases the interest service burden of the government. The increase in interest burden then fuels widening fiscal deficit, the need for additional borrowing and inflation eventually. Meanwhile, accommodating inflation now in the name of lower government debt service burden could be more catastrophic, particularly for an inflation targeting central bank. An important point that complicates the dilemma of the monetary policy authorities is whether an accommodation of inflation now would not rather deteriorate the situation further as fiscal authorities may see the accommodation as extra fiscal space to spend more, especially when driven by political agendas and campaign promises. The choice of accommodating inflation now to reduce the debt service burden of the government is not a worthwhile pursuit especially for an inflation targeting central bank since it shakes the very core pillar of credibility required under a targeting framework.

In the case of Bank of Ghana in particular, the policy ramifications are numerous. First of all, the joint determination of the inflation target by the government and the Bank of Ghana is for a purpose. That purpose is to elicit fiscal and monetary discipline and concerted effort to achieving a target that has been publicly announced. It is therefore bizarre that the Bank of Ghana would accommodate fiscal indiscipline on the part of a party to the determination of the inflation target. A sterner monetary policy stance is appropriate to engender fiscal discipline through expenditure cuts especially when taxes are no longer responsive to the growing expenditure demands of the central government. Remarkably, inflation is an important political issue as well in Ghana and the sterner the monetary policy stance, the likelihood that the government would succumb to cleaning its fiscal mess as interest cost take significant bites. Such sterner monetary policy stance also sends an important message about the commitment of the Bank of Ghana to fighting inflation and helps in anchoring inflation expectations as an important dimension in inflation targeting framework.

The government of Ghana must understand that the fiscal profligacy does not only hurt the economy in terms fueling inflation above a target that they jointly set with the Bank of Ghana but it also has several other ramifications. Excessive spending would only constrain its own fiscal space further and deny the economy the needed boost in capital projects and infrastructural development. For how long would the economy continue in the vicious cycle of fiscal recklessness and IMF bailouts? Importantly, high inflation levels fueled by fiscal indiscipline have serious effect on the strength of the local currency. Unsurprisingly, Ghana has not only missed the publicly set inflation targets, but the cedi has suffered significant depreciation against the dollar over the period as well. While Ghanaians needed only *0.93* cedis to get *1* dollar in the second quarter of 2007 when full-fledged inflation targeting was unveiled, as much as *4.74* cedis was needed by the third quarter of 2018 to buy the same *1* dollar, representing a whopping 409.7% depreciation over the period. The question then is whether successive governments really meant to maximize the welfare of the very citizens they are leading. We recommend that while the Bank of Ghana takes a restrictive policy stance as appropriate, the government must ensure fiscal discipline on a sustainable basis. A number of African economies considering full-fledged inflation targeting can also take a cue from the experience of Ghana. Low debt levels and appropriate policy responses are critical to the success of inflation targeting.

To South Africa, the response of the SARB in the high debt regime when upside risk to inflation was glaring and the fact that inflation did rise far above the publicly announced target inflation range leaves much to be desired. As indicated earlier, this was a period when some inflation outcomes were more than twice the announced upper limit. Meanwhile, inflation targeting framework thrives when the public believes that the central bank is capable of achieving the announced inflation target on sustainable basis and although occasional inflation overshooting may occur, inflationary outcomes exceeding twice the upper limit is certainly detrimental to public confidence building. When such public confidence is lost, inflation targeting would come crashing. Fiscal authorities must show some responsibility and understand the effect of their fiscal decisions on inflation targets.

While it is the case that when economic growth of an economy is declining (such as the experience of South Africa) monetary policy could be accommodative to spur growth, the sacrificing of inflation which is the primary objective in an explicit or full-fledged inflation targeting framework in South Africa is worrying. Policy response should only be accommodative to the extent that inflation does not exceed the set target. Otherwise, the very purpose for such public announcements is defeated. Indeed, continued policy accommodation in the face of rising inflation above the publicly announced target in the name of propelling growth then leaves the public asking which the primary objective is. At that point confidence is derailed and anchoring inflation expectations in the future becomes even more difficult. The crusade for growth enhancement following the challenges should not be the burden of only the SARB. Indeed, the fiscal authorities should be seen taking a greater responsibility than the central bank to allow the latter focus squarely on inflation target.

2.7 Conclusion

Monetary policy characterization of the two full-fledged inflation targeting central banks in Ghana and South Africa as well as ascertaining whether their responses are constrained by high public debt has been the preoccupation of this chapter. In respect of the monetary policy characterization, we estimated both the linear and threshold models using the Sample Splitting and Threshold estimation technique developed by Hansen (2000). The null hypothesis of no threshold is rejected for both Ghana and South Africa. We find that a nonlinear Taylor rule best characterizes the monetary policy behaviour of the Bank of Ghana and the South African Reserve Bank. Specifically, we find that whiles the Bank of Ghana is not responsive to output gap across the threshold divide, the South African Reserve Bank responds to output gap above the threshold. In addition, whereas the South African Reserve Bank responds to inflation gap below and above the estimated threshold with relative aggression above the threshold, the Bank of Ghana responds to inflation gap only below the threshold. Notably, we find that the quantum of policy response to a rise in expected inflation by the two central banks clearly demonstrate accommodation of inflation which is surprising as these central banks are supposed to be targeting inflation. We find this to be counterintuitive and dangerous to public confidence building and credibility of these central banks. The results are robust to varied specifications. We observed that the inflation target for Ghana has largely been missed and it is suggestive of how unrealistic and unsupportive of the economic fundamentals it is. The credibility of the Bank of Ghana and its ability to then anchor inflation expectations is in clear jeopardy. The target which is jointly set by the government (Ministry of Finance) and the Bank of Ghana certainly needs a revision that takes the economic fundamentals into account. Much as single digit inflation is desirable, it must be reconciled with the economic blue prints of the country. Importantly, the rationale for the joint determination of the target in Ghana has been defeated. The joint determination was meant to get government committed to the inflation target but it is all too evident from the fiscal balances that the government has failed on its part and the significant financing levels of such fiscal mess by the Bank of Ghana is counterintuitive too and perhaps a reflection of the level of independence and strength of not only Bank of Ghana but institutions generally.

While literature acknowledges the dilemma and constraint posed to interest rate setting behaviour of central banks by high debt levels, there is remarkable paucity of empirical investigation into this phenomenon. The only study by Mitra (2007) concedes that the GMM estimation technique employed failed to importantly provide confidence intervals for the threshold estimate.

Meanwhile, for policy purposes, such estimations must be amenable to precision checks to engender soundness and credibility of policy. Our study fills this void as we modify the Taylor (1993) rule to take account of debt constraint on monetary policy and relying on the Hansen (2000) sample splitting and threshold estimation technique that delivers confidence intervals for the threshold estimate devoid of nuisance parameters that plague other threshold models. Our estimated threshold level of debt to GDP ratio for Ghana and South Africa are respectively 35.1% and 33.7%. For Ghana, we find that the Bank of Ghana is responsive only to inflation gap above the estimated debt threshold. While the response by Bank of Ghana to inflation gap above the debt threshold shows a relative aggression, the extent of response is woefully disproportional and an indication of debt constraint and inflation accommodation on the part of a central bank that is supposed to be targeting inflation.

For South Africa, we find that the policy response in the low debt regime to inflation gap is negative on the back of apparent policy easing at a time when inflation outcomes exceeded the upper limit of the publicly announced inflation target band in as many as 10 quarters. The policy response was much in favour of propelling economic growth as South Africa witnessed challenging growth pattern over the period. This is reflected in the positive and highly significant policy response to the output gap in the low debt regime. In the high debt regime, we find that the policy response to inflation gap is positive and significant but woefully disproportionate, given the fact that the period saw inflationary outcomes more than twice the upper limit, an indication of debt constraint on monetary policy. Notably, the accommodation of inflation was also on the back of deplorable growth performance as policymakers sought to provide impetus to growth. The response of policy to output gap was therefore significantly large relative to the response to inflation gap. Our findings are robust to different measurement of exchange rate for both countries.

We recommend that the Bank of Ghana takes restrictive policy stance as appropriate to subdue inflation that has largely exceeded the publicly announced target to elicit fiscal discipline on the part of the fiscal authorities as their fiscal space gets constrained further when interest service takes a significant bite. For South Africa, it is our recommendation that as an inflation targeting central bank, the SARB should put the achievement of inflation targets first. Although growth may be an added priority, it should not come at the cost of inflation that exceeds twice the upper limit publicly announced. Importantly, accommodating inflation in a high debt regime is inimical not only to the achievement of the targets set but derails public confidence and anchoring their inflation expectations would be difficult. Meanwhile, public confidence is a fundamental bedrock of the tenets of inflation targeting framework. The use of interpolation to obtain quarterly debt to GDP ratio is a limitation future research may overcome as high frequency data on debt become available. For Ghana in particular, we reckon that although 42 quarters is ample enough for an empirical exercise of the kind we conducted, future research may consider an expansive data as it becomes available and when the inflation targeting window grows further.

CHAPTER THREE

MONETARY POLICY TRANSMISSION IN SOUTH AFRICA AND GHANA

3.1 Introduction

The policy decisions of monetary authorities, either in response to deviations of macroeconomic fundamentals from their targets or systematic policy changes meant to achieve a macroeconomic outcome, may or may not generate the desired goals depending on the effectiveness of the channels of monetary policy transmission to the real economy. Imperatively therefore, policymakers require a succinct appreciation of the architecture and dynamics of the workings of these channels to be able to evaluate the timing and extent of impact of their decisions on the real economy (Cevik & Teksoz, 2012; and Boivin et al, 2010). Theoretically, the impulses of monetary policy are transmitted to the real economy through channels such as interest rate, credit, exchange rate and asset prices with an important role for components of aggregate demand to play in the transmission process (Boivin et al, 2010; and Mishkin, 1996). The monetary economics literature, unsurprisingly, is inundated with empirical research on the channels of monetary policy transmission (see for example, Anwar & Nguyen, 2018; Afrin, 2017; Chen et al, 2017; Mandler et al, 2016; Amar et al, 2015; Fernald et al, 2014; and Cevik & Teksoz, 2012), with inconclusive results (see Senbet, 2016; Cevik & Teksoz, 2012; and Sims, 1992). The results are sensitive to the countries being studied, the span of data and the model used for estimation.

We argue that the inconclusiveness in the literature can largely be attributed to fundamental flaws in the approaches to transmission channel exposition. Literature has tended to consider a direct effect of monetary policy impulses on the real economy using estimation techniques such as the vector error correction and the generalized method of moments in a single equation context (Tran, 2018; and Matousek & Solomon, 2018). Meanwhile, the theoretical prescriptions of the workings of the channels of monetary policy transmission are far from a direct monetary policy-real economy relationship. Theoretically the interest rate channel, for instance, works in a manner such that changes in monetary policy affects interest rates, then investment, then aggregate output or inflation. The same systematic transmission applies to the other channels (see Mishkin, 1996; and Boivin et al, 2010 for the theoretical prescriptions). Invariably, the effect of monetary policy on output or inflation is necessarily indirect through other intermediaries. To consider a direct relationship, as in the existing literature, is to obfuscate the underlying dynamics of the transmission mechanisms.

Furthermore, the very nature of the theoretical prescriptions of the transmission mechanism implies a significant role for the components of the aggregate demand in delivering the monetary policy impulses to the real sector of the economy. Investment, a component of aggregate demand, is key in the interest rate and credit channels, with import and exports also phenomenal in the exchange rate channel of monetary policy transmission. Surprisingly, empirical literature assume away such roles and stack a typical vector autoregressive (VAR) model or its variants with variables representing monetary policy, interest rate, output, inflation, exchange rate, asset prices and credit. They then report the impact of monetary policy on say interest rate (in pairs) and then the impact of interest rate on output or inflation as the interest rate channel (see for example, Anwar & Nguyen, 2018; Kim & Lim, 2018; Tran, 2018; Afrin, 2017; Chen et al, 2017; Zhang & Huang, 2017; Mandler et al, 2016; Senbet, 2016; Amar et al, 2015; Belke & Beckman, 2015; Fernald et al, 2014; Jain-Chandra & Unsal, 2014; Cevik & Teksoz, 2012; and Koivu, 2012 for different channels). Meanwhile, the theory is far from such over simplification.

Apart from ignoring the role of the aggregate demand components, contrary to the theoretical prescriptions, such an approach fails to establish whether the initial effect of monetary policy on interest rate (in the case of interest rate channel) is what is indirectly transmitted to output or inflation eventually from interest rate. The flagrant disregard for the role of the components of aggregate demand, the over simplification of the workings of the channels of monetary policy and the direct approach to the monetary policy-real sector relationship in the empirical literature is problematic for monetary policy coherence as monetary policymakers require an accurate and succinct understanding of the dynamics of these channels to be able to affect the real economy with the appropriate instruments and at the right time. Although few studies exist on the impact of monetary policy on some components of aggregate demand such as Owusu-Sekyere (2017), Koivu (2012), and Ncube & Ndou (2011) on consumption; Yang et al (2017) and Ndikumana (2016) on investment; Vithessonthi et al (2017) on corporate investment; Mukherjee & Bhattacharya (2011) on consumption and investment; Sariola (2009) on imports and exports and Aron et al (2014) on imports prices, but how such effects of monetary policy on these components eventually reflect in the ultimate variables of output and inflation remain unexplored.

In the light of these deficiencies in the literature, the current study makes significant contributions to the monetary policy transmission literature. We revisit the monetary policy transmission mechanism through the interest rate and bank lending channels by accounting for the role of investment (a component of aggregate demand) which is at the heart of the workings of these two transmission channels. Substantially, we consider a more systematic approach to unearthing the workings of these channels and in particular we trace the theoretical prescription of the indirect effect of monetary policy on inflation. Our focus on monetary policy effect on inflation is informed by the argument in the literature that price stability is gradually being accepted by economists as the desirable primary objective that central banks should pursue in the long term (Mishkin, 1996). Indeed, price stability is an important precursor for a sustained growth in output.

Inspired by the works of Nosier & El-Karamani (2018) as well as Tavares & Wacziarg (2001), both in the context of indirect effect of democracy on growth through numerous channels, we rely on the three stage least square technique (3SLS) in a system of equations that trace the indirect effect of monetary policy on inflation through different channels. By specifying a system of equations that are simultaneously estimated, our chosen approach enables us to determine how changes in monetary policy stance eventually impacts inflation through sub components of the respective channels. The technique is robust to endogeneity and delivers consistency and efficiency in our estimates. An important virtue of the 3SLS technique is the fact that it has the complement of comprehensive information which enhances its efficiency. The technique also takes into consideration the parameter restrictions in the distinct structural equations being considered (Zellner & Theil, 1962).

Our chosen estimation technique is also superior to the widely used VAR in the literature. The VAR is limited in terms of the number of variables it can accommodate and for that matter the degrees of freedom (Senbet, 2016). Bernanke et al (2004) also argue that one major issue with the VAR approach has been the disagreement on how the monetary policy shocks are identified because researchers adopt different techniques in policy shock identification in the same VAR and so different inferences or results are obtained in respect of the way economic variables respond to policy shocks. In addition, a typical VAR method captures monetary policy effects that are not anticipated as opposed to monetary policy changes that are systematic (Bernanke et al, 2004).

Given our focus on inflation, we consider inflation targeting countries and in particular the African context where there is considerable paucity of research on monetary policy transmission. Meanwhile, it is the largest continent in terms of countries and invariably the number of central banks. With South Africa and Ghana as the only two full-fledged inflation targeting countries in Africa, our study looks at monetary policy transmission channels in these two countries. The decision to focus on the interest rate and the bank lending channels is informed by the central role interest rate plays in the inflation targeting framework and the dominance of the banking sector in the African context in the absence of well-developed capital markets in Ghana in particular. In the inflation targeting framework, the interest rate is a key policy instrument used to convey monetary policy stance and the banking sector is an important conduit for transmitting monetary policy impulses.

We find that the interest rate and the lending channels are operative in Ghana and South Africa. For the interest rate channel, a percentage contraction in monetary policy reduces overall inflation by 0.002% and 0.001% in Ghana and South Africa respectively. For the lending channel, a percentage monetary policy restriction reduces overall inflation by 0.0012% and 0.01% in Ghana and South Africa respectively. We observed that whiles the lending channel is more effective relative to the interest rate channel in South Africa, the reverse is the case in Ghana. These results are robust to different samples and specifications. Sections 3.2 and 3.3 respectively deal with monetary policy frameworks and the banking sectors of Ghana and South Africa. Literature review is in section 3.4 and the methodology in section 3.5. Our results and analysis are in section 3.6, policy discussions in section 3.7 and the conclusion in section 3.8.

3.2 Monetary Policy Frameworks in South Africa and Ghana

Given the focus of our study on the effect of monetary policy on inflation and the fact that we consider inflation targeting countries, we provide the peculiarities of the inflation targeting frameworks in the two countries.

3.2.1 The South African Case

South Africa practices full-fledged inflation targeting, with price stability as the primary mandate of the South African Reserve Bank. The inflation targeting framework in South Africa was officially unveiled in February 2000, having been preceded by a public announcement in August 1999 of the desire to adopt the framework. The Reserve Bank uses repo rate as monetary policy instrument to achieve the announced inflation target range of 3% - 6%. The inflation measure is headline as opposed to core, given the dominance and volatility of food and oil in the country. Although the country's constitution and the Reserve Bank Act 1989 (Act number 90) guarantees operational independence to the Reserve Bank, the announced target inflation range is determined by the government. The determination of the instruments for the achievement of the set target range, however, is the sole prerogative of the Reserve Bank. Thus, the Reserve Bank enjoys instrument independence as opposed to goal independence.

Monetary policy decisions meant to achieve the announced inflation target are made by the Monetary Policy Committee (MPC) which comprises of only the staff of the Reserve Bank, with the governor as the chairperson of the committee. Monetary policy decisions are arrived at on the basis of consensus (Hammond, 2012) after considering major economic developments that pose upside and downside risk to inflation. Such a decision is then made public to help foster transparency and anchor inflation expectations. The MPC meets at least six times in a year. The schedules and dates for these meetings are published ahead of the year in question, although there is room for emergency meetings depending on the macroeconomic dynamics.

3.2.2 The Ghanaian Case

Ghana, like South Africa, also practices full-fledged inflation targeting and the Bank of Ghana's mandate is to deliver price stability. The medium target inflation (headline) in Ghana is currently 8% ± 2 jointly determined by the monetary and fiscal authorities. The central bank (Bank of Ghana) enjoys operational independence enshrined in the Bank of Ghana Act 612 (2002) and particularly instrument independence to guide inflation to the stipulated target. Monetary policy decisions are made by the Monetary Policy Committee which has seven members. Five out of the seven members are internal staff of the central bank with the governor as the chairperson of the committee. The remaining two members are external and appointed by the Finance Minister (Bank of Ghana, n.d.).

The Monetary Policy Committee sits every other month (thus every two months with dates published in advance) for the purposes of determining monetary policy rates meant to anchor expectations and rein in inflation. Each of these meetings takes place in two days with a climax of a press conference on the monetary policy decision on the third day. Every member of the committee has a single vote on the interest rate determination backed by justifications for the stance of the individual. The eventual decision on a particular policy rate or policy stance is reached through consensus. Whiles economic reports underpinning the policy decisions of each meeting are published, the minutes of the meetings are not. When the inflation target is missed, the Bank of Ghana is not under any legal obligation to explain the reasons for the failure to either the parliament of the country or the fiscal authorities. The parliament's finance committee can, however, summon the governor of the central bank to explain developments in the country (Bank of Ghana, n.d.).

3.3 The Banking Sectors of South Africa and Ghana

In inflation targeting framework, interest rate is an important policy instrument in the formulation of monetary policy decisions. That places the financial system, and the banking sector in particular, in an important position to serve as the conduit for the transmission of monetary policy impulses to the real economy. Indeed, the workings of the monetary policy channels place significant premium on the financial sector as important conduit. In this regard, we provide a brief on the banking sectors of the two countries under consideration.

3.3.1 South Africa's Banking Sector

South Africa's banking sector has nineteen (19) registered banks and fifteen (15) local branches of foreign banks, bringing the total to 34 as at the close of 2018. The banking sector is characterized by dominance of five banks, namely Standard Bank of South Africa Limited, Absa Bank Limited, FirstRand Bank Limited, Nedbank Limited and Investec Bank Limited. These five banks, as of March 2019, controlled 90.5% of the total assets of the sector which stood at ZAR 5.654 trillion. Local branches of foreign banks controlled 5.6% whiles the remaining banks mustered only 3.8% (SARB, 2019).

The year 2017 saw a major reconfiguration of the regulatory set up of South Africa's financial system. The desire to foster fair and safe financial system in the country saw the enactment of the Financial Sector Regulation Act 9 of 2017 on August 21 2017 on the back of collaborative efforts of the Financial Services Board, the National Treasury and the South African Reserve Bank. The Act brought with it three major modifications to the financial system regulation in the country. The first modification is the provision of an explicit mandate of the stability of the financial system to the Reserve Bank. The second modification is the creation of Prudential Authority, a body tasked with prudential regulation and domiciled within the Reserve Bank. The mandate of the Prudential Authority encompasses the regulation of banks, derivative and securities market infrastructures, cooperative financial institutions, insurance companies and financial conglomerates. The third modification is the creation of the Financial Sector Conduct Authority charged with the regulation of the market conduct of financial institutions. This authority, unlike the Prudential Authority, is domiciled outside the Reserve Bank. Significantly, the Act is designed to harness the financial sector's positive effect on the economy while reducing the fiscal and social impact of failures of banks and other institutions. The Act is also meant to engender transformation of the financial sector, boost financial inclusion, foster innovation, stimulate competition and enhance financial sector diversity (SARB, 2017).

3.3.2 Ghana's Banking Sector

The Ghanaian banking sector currently comprises of 23 banks. These banks have a total of 1,225 branches across the country. The banking sector in Ghana, until recently, was beset with severe systemic risk as many banks fell short of the capital adequacy requirements, erosion of capital by staggering loan delinquency, illiquidity and insolvency thereby threatening the stability of the banking system in the country. Substantial liquidity support by the Bank of Ghana (the regulator) failed to yield the desired results as the move tended to address the symptoms rather than the root cause of the capital debacle and apparent distress. In a more decisive approach, the regulator embarked on a massive clean-up and reformation of the banking sector in 2017. The first two casualties were Capital Bank and UT Bank which had their banking licenses withdrawn by the regulator in August 2017 on the grounds of insolvency with GCB Bank taking over the operations of the two defunct banks. The clean-up continued in 2018, with the regulator revoking the banking licenses of five banks. Three out of the five banks (The Royal Bank Limited, The Beige Bank Limited and uniBank Ghana Limited) had their licenses withdrawn on the grounds of insolvency whiles the remaining two banks (Construction Bank Limited and Sovereign Bank Limited) had their licenses withdrawn on the basis of irregularities in the process of acquiring the said withdrawn licenses. The operations of these five defunct banks were taken over by a new bank set up by the government of Ghana and named Consolidated Bank Ghana (Bank of Ghana, 2019a). The fall of these seven banks came at a cost of GHS 9.9 billion to the government of Ghana (Ministry of Finance, 2018).

The regulator also increased the minimum capital requirement from GHS 120 million to GHS 400 million on September 11, 2017 with existing banks obliged to meet the new requirement by the close of 2018 either by injecting fresh capital or undertaking income surplus capitalization or both. Apart from strengthening the apparent weak capital positions of many of the banks, the new requirement was also intended to engender consolidation in the sector to provide the impetus for growth of the economy of Ghana. At the close of 2018, only 23 banks out of the then 34 banks had met the new minimum capital requirements. Of these 23 banks that met the new requirement, 16 did so through the injection of new capital and income surplus capitalization. There were three mergers involving six banks. Thus, Energy Commercial Bank merged with First Atlantic Merchant Bank Limited to be able to meet the requirement, GHL Bank merged with First National Bank to meet the requirement and then Bank Sahel Sahara merged with Omni Bank but had to obtain additional capital injection from the Ghana Amalgamated Trust Limited, a company set up by a number of pension funds in Ghana as a special purpose entity. The remaining four slots out of the 23 were taken by indigenous banks that got fresh capital injection from the Ghana Amalgamated Trust Limited. The four banks are National Investment Bank, Universal Merchant Bank, Agricultural Development Bank and Prudential Bank (Bank of Ghana, 2019a).

Heritage Bank Ghana Limited and Premium Bank had their licenses withdrawn for varied reasons. While Premium Bank was insolvent with capital adequacy ratio in the negative (precisely negative 125.26%), Heritage Bank did not only fail to meet the minimum capital requirement but also procured their license by questionable capital sources. The Consolidated Bank Ghana took over the operations of these two banks in an arrangement that cost the state a whooping GHS 1.403 billion as the government had to issue a bond to Consolidated Bank Ghana to the tune of that amount. Bank of Baroda (Ghana) Limited which is fully owned by a parent bank in India (Bank of Baroda India) opted to divest their interest in Ghana and their operations was taken over by Stanbic Bank under an Assumption Agreement sanctioned by the regulator (Bank of Ghana, 2019a).

3.4 Literature Review

3.4.1 Channels of Monetary Policy Transmission: A Brief Introduction

Price stability is gradually being accepted by economists as the desirable primary objective that central banks should pursue in the long term (Mishkin, 1996). For the central banks to achieve such an objective, they would need to have a clear understanding and evaluation as to how and when their actions and decisions would eventually have an impact on the real economy. This requires therefore that the central banks understand the channels and mechanisms by which the real economy is impacted by monetary policy (Patrick & Akanbi, 2017; Cevik & Teksoz, 2012; Mukherjee & Bhattacharya, 2011; Mishkin, 1996). Boivin et al (2010) argue that one of the reasons why it is imperative for the monetary authorities to have an idea of how and when their decisions affect the real economy or policy target is to enable them make decisions as to how policy instruments are set. The authors contend that having such a clear idea requires that the monetary policy makers understand how and the mechanics through which real economic activities and price levels are impacted by monetary policy. This makes studies on the effectiveness of monetary policy transmission channels an important area of research. An empirical investigation of the efficiency of the transmission channels of monetary policy is important to gauge reasonably accurate decision-making by central banks (Cevik & Teksoz, 2012).

3.4.2 Channels of Monetary Policy Transmission: Theoretical Literature

The mechanism of monetary policy transmission is understood to be the procedure by which decisions and actions of monetary policy authorities are reflected into price levels and income (Taylor, 1995). The earlier assertion about what constitutes monetary policy transmission mechanism is that it is the process or procedure by which monetary instruments affect asset prices and output through an asset market equilibrium with eventual impact on the target investment and consumption (Purvis, 1992). A key characteristic of the channels and mechanisms of monetary transmission is the fact that spending decisions and prices of assets are affected by real interest rates as opposed to nominal interest rates. Similarly, spending decisions and asset prices are influenced not just by recent values but also the anticipated trajectory of interest rates (Boivin et al, 2010). The authors argue that since spending decisions and asset prices are affected by both real interest rate and the anticipated trajectory of interest rates, then expectations play an important role in the transmission of monetary impulses into the economy. Mishkin (1996) groups the transmission mechanisms into the interest rate channel, the credit channel and the asset price channels, with exchange rate channel placed under the asset price channels. The theoretical framework for the various channels of monetary policy as illustrated below is largely based on the works of Mishkin (1996) and Boivin et al (2010).

The expectations channel of monetary policy is essentially an integral part of all the other channels since modern analysis of monetary policy tend to be forward-looking. The expectations channel works efficiently in the developed markets and economies. When the market participants expect changes in interest rate in the future, this expectation quickly feeds into the medium to long-term rates of interest (Davoodi et al, 2013).

3.4.2.1 The interest rate channel (The Money View)

The fundamental Keynesian ISLM model for the interest rate channel for the mechanism of monetary policy transmission can be illustrated as follows:

$M\uparrow \rightarrow i_r\downarrow \rightarrow I\uparrow \rightarrow Y\uparrow$

such that M↑ represents monetary policy expansion which causes real interest rates to fall (thus $i_r\downarrow$), thereby making cost of capital cheaper and which in turn spurs on investments (thus I↑) with its positive impact on aggregate demand and eventual increase in economic output (thus Y↑).

This channel, as was envisaged by Keynes, was supposed to operate through investment spending decisions by firms but subsequent research has uncovered that expenditure on consumer durables and housing are equally investment spending decisions. Mishkin (1996) therefore argues that the interest rate channel is applicable to household or consumer spending decisions and as such the expenditure on housing as well as consumer durables is represented by ‘I’ in the scheme above. In the interest rate channel, a change in monetary policy has an effect on both the short term and the long-term real interest rates which is important in affecting spending decisions rather than nominal interest rates. The idea is that as the average of short-term interest rates gives the long-term interest rates, when monetary policy lowers short term interest rates, future long-term real interest rates would be lower. When the long term real interest rates decrease in such a manner, it promotes higher investments in fixed assets and inventory by firms as well as increased spending on consumer durables and residential housing by consumers which eventually increases aggregate demand and national output.

Mishkin (1996) argues that because it is real interest rate and not nominal that has an effect on decision to spend, it provides an avenue for monetary policy to impact the economy even when nominal interest rates are zero during periods of very low inflation or deflation. So even if nominal interest rates are fixed at zero, an increase in money supply leads to an increase in expected price levels and inflation which then decreases real interest rates and promotes higher investment spending in the economy which works through the scheme above. The author thus presents the scheme of the interest rate channel when even nominal interest rates are fixed at zero as:

$M\uparrow \rightarrow P^e\uparrow \rightarrow \pi^e\uparrow \rightarrow i_r\downarrow \rightarrow I\uparrow \rightarrow Y\uparrow$

where $P^e\uparrow$ is the rise in expected price levels and $\pi^e\uparrow$ is the increase in inflation. So even if the central bank drives nominal interest rates to zero, monetary policy can still impact the economy through the interest rate channel.

Researchers such as Bernanke & Gertler (1995) have a different view of the interest rate channel in terms of its effectiveness for monetary policy transmission and they believe there should be alternative channels that may provide the needed effectiveness for monetary policy transmission.

3.4.2.2 The Credit Channel (The Credit View)

The discontentment about the effectiveness of the interest rate channel gave birth to a proposition of a new model for transmission of monetary policy which hinges on information asymmetry. Bernanke & Blinder (1988) argue that banks and other institutions that grant credit are capable of mobilizing information on borrowers and observing borrowers' performance in a manner that cannot be done in the bond market or auction markets that are anonymous. As these banks and credit-advancing institutions are able to provide financing for ventures that the bond market cannot finance, bank loans and credit provided by other institutions play a unique and special role. In this regard, aggregate demand and aggregate supply would be affected when financial intermediation is lowered either by price or by rationing. Such a relationship between credit and output implies that the rather fixated focus on money view is not only too simplistic but also inapt. To lay a foundation for their proposition of the credit view of monetary policy transmission, Bernanke & Blinder (1988) laid out a macro model that gives a framework for determining how the economy is affected by various shocks. Their model is based on the idea that due to reasons such as problem of information, prohibitive transaction costs of raising bonds and liquidity differences, bank loans and bonds are imperfect substitutes. They therefore developed their model by incorporating three assets which are bonds, money and loans. For loans and bonds, Bernanke & Blinder (1988) assumed that the choice between these two assets by lenders and borrowers depends on the rate of interest on these two credit instruments.

The authors denote interest on loans by ρ, then i denotes rate of interest on bonds and y denotes gross national product which the authors used to capture transactions demand for credit resulting from considerations of liquidity or working capital purposes. So loan demand represented by L^d is given by:

$L^d = L(\rho, i, y)$

where interest on bonds (i) as well as y are expected to have a positive relationship with loan demand while interest on loans (ρ) is expected to have a negative relationship with loan demand.

Gertler & Gilchrist (1993) posit that the effect of monetary policy changes on short term interest rates tend to wither away as close substitutes for money emerge. The availability of such close substitutes for money namely mutual funds of the money market and their movement in opposite direction tend to bring demand for money and supply of money back into equilibrium, and this affects the needed interest rate response. The authors argue therefore that the long held money view tend to depend on the notion that close substitutes for money have not emerged and tends to lay emphasis on the liability side of the balance sheet of banks. The credit view focuses on the asset side of the balance sheet of banks.

The concept of the credit view is that a greater percentage of firms and individuals do not have access to any source of finance except through bank credit. As a result of friction of information, such firms and individuals find it extremely expensive to raise finance through issuance of stocks or other securities in the capital markets and thus depend heavily on bank loans (Gertler & Gilchrist, 1993). This implies that any shock to bank lending affects investment spending of these firms directly. Since banks are required to maintain a certain portion of deposits received as reserve requirement, central banks then have the leverage to directly influence the quantity of money that banks can have. A contractionary monetary policy can thus lead to a reduction in bank lending and investment spending of firms that heavily depend on bank loans due to the absence of close substitutes to bank loans for these firms (Gertler & Gilchrist, 1993). The credit channel is made up of sub channels as follows:

3.4.2.2.1 Bank lending sub channel

This channel is based on the idea that banks are better placed to surmount the problem of information asymmetry inherent in the financial markets. This therefore gives banks a critical role to play in the credit channel. The bank lending channel operates on condition that bank deposits cannot be perfectly substituted for other avenues of raising funds. In this regard, when a central bank embarks on an expansionary monetary policy, loanable funds increases or bank loan increases since bank deposits and reserves become more available. As the amount of bank loans increase, and since firms and consumers depend on bank loans, consumer and firm investment spending increases.

Schematically, $M\uparrow \rightarrow$ bank deposits$\uparrow \rightarrow$ bank loans$\uparrow \rightarrow I\uparrow \rightarrow Y\uparrow$.

The key feature of the bank lending channel is that changes in monetary policy would significantly impact businesses that depend more on bank loans as compared to businesses that can raise finance from the capital markets and can therefore protect their portfolio when monetary policy changes. Similarly, the loan portfolio of banks that are unable to raise funds for lending apart from deposits would be significantly impacted as compared to banks that are able to raise funds from other sources.

3.4.2.2.2 The balance sheet sub channel

This channel is also based on the idea of information asymmetry in the financial markets. With a fall in firms' net worth, moral hazard and adverse selection issues become more pronounced in a bid to make loans to these companies. A decline in the net worth implies that the value of collateral for securing loans also falls, thereby magnifying the impact of losses when there is adverse selection. This phenomenon discourages the banks from lending and thus decreases funds for investment purposes by firms and consumers. According to Mishkin (1996), the fall in net worth of firms magnifies the problem of moral hazards as business owners see their equity stake deteriorate which incentivizes them to take more risks. This discourages banks from making more loans for the fear of losing their funds and this affects spending on investments. Alternatively, when central bank expands monetary policy, it improves net worth of firms through an appreciation of share prices. This improves investment since the improvement in net worth reduces the problems of moral hazard and adverse selection and therefore increases bank lending. The increase in bank lending as a result of improvement in net worth increases investments and national output eventually.

Thus $M\uparrow \rightarrow Pe\uparrow \rightarrow$ adverse selection$\downarrow$ and moral hazard $\downarrow$ $\rightarrow$ bank lending $\uparrow$ $\rightarrow$ $I\uparrow \rightarrow Y\uparrow$.

The other way an expansionary monetary policy works through the balance sheet channel is that it decreases interest rates which in turn decreases interest burden of firms and improves their cash flow. This helps to lower the problems of moral hazard and adverse selection and thus improve bank lending, investment and national output.

Thus $M\uparrow \rightarrow i\downarrow$ cash flow $\uparrow$ $\rightarrow$ adverse selection $\downarrow$ and moral hazard $\downarrow$ $\rightarrow$ lending $\uparrow$ $\rightarrow I\uparrow \rightarrow Y\uparrow$.

The striking difference between the mechanism of this channel and the interest rate channel is that while monetary policy expansion impacts real interest rate in the latter, monetary policy expansion in the former affects nominal interest rates. Another mechanism that is based on the moral hazard and adverse selection notion is the rationing of credit. Rationing of credit is said to take place when borrowers are refused loans even though they are desirous of making higher interest rate payments. The rationale is that businesses and consumers who have such desires to make higher interest rate payments tend to make investments in high risk assets or ventures. When interest rates are high, the problem of adverse selection increases but falls when interest rates are low since risk-averse businesses are more likely to borrow when interest rates are low. With lower interest rates occasioned by an expansionary monetary policy, banks are rather motivated to lend since adverse selection problem is reduced. This increases investments and output eventually.

The balance sheet channel is also said to work through the way general price level is impacted by monetary policy changes. When businesses borrow, their indebtedness or obligations tend to be nominally fixed due to their contractual nature. As a result, when there is an expansionary monetary policy which fuels unexpected high levels of general prices, such indebtedness of the firms tend to fall in real terms without decreasing the value of the assets of these firms in real terms. As the value of the liabilities decrease with no impact on the value of assets, the net worth improves which reduces adverse selection and the problem of moral hazards. This encourages bank lending, investment spending and output eventually.

Thus $M\uparrow \rightarrow$ unanticipated $P\uparrow \rightarrow$ adverse selection$\downarrow$ and moral hazard $\downarrow \rightarrow$ bank lending $\uparrow \rightarrow I\uparrow \rightarrow Y\uparrow$.

Mishkin (1996) puts forward an argument that it is not only the balance sheets of firms that are affected when monetary policy changes. Indeed, spending on housing and consumer durables are also affected. When bank lending falls as a result of a contractionary monetary policy, consumers' spending on durables and housing will witness a decline, particularly for those consumers who do not have any other source of funding except bank loans. Consumers have a balance sheet and hold financial assets in much the same way they hold debt. The willingness of consumers to spend high on durables and housing tend to be stronger when they hold more financial assets than debt because their assessment of financial distress probability is minimal under such circumstances. So an increase in equity prices resulting from monetary policy change tend to increase the value of the financial assets of these consumers leading to an increased spending on housing and consumer durables and then output eventually. Thus M↑→ Pe↑ → financial assets ↑ → likelihood of financial distress↓ → consumer durables and housing expenditure↑→Y↑.

Some authors such as Romer & Romer (1990) posit that a number of banks are able to make loans from other financing sources apart from deposits and so there is a minimal effect of monetary policy on bank lending. That is, banks are able to raise other liabilities such as certificate of deposits and therefore can shield their loan portfolios or lending capabilities from a contractionary monetary policy. Gertler & Gilchrist (1993) argue that much as banks are capable of raising such liabilities like certificate of deposits, there is an issue with how much of such certificate of deposits the bank can actually issue or raise to offset the shrinking deposits occasioned by monetary policy contraction. They note however that banks usually hold a lot of liquid assets such as government securities and can actually sell them off to support their lending and avert the impact of such contraction of monetary policy stance. It is only when the banks exhaust such liquid assets that bank lending can be constrained by reduction in money supply.

In reviewing both the money and credit views, Hubbard (1995) posits that much as the money view has gained acceptability in the literature, it tends to rely on a number of assumptions. The first is that supply of money which has no perfect substitutes should be under the control of the central bank. The second is that both nominal and real short-term interest rates are capable of being impacted or influenced by the actions of the central bank. In that case there is no instantaneous price adjustments. The third assumption is that variations in the short-term real interest rates resulting from policy changes impacts long term rate of interest which then affects investment spending decisions of both businesses and households. The fourth assumption is that changes in spending that is interest-sensitive occasioned by monetary policy changes tend to move in tandem with observed changes in national output. Hubbard (1995) argues that the observed cyclical fluctuations in aggregate demand and especially fixed and inventory investments by firms is rather too significant to be attributed to changes in monetary policy which have not had large impacts on short term real rate of interest. Kashyap et al (1996) argue that if monetary policy transmission works through only the traditional interest rate or money view and that any decline in bank loans is as a result of falling demand for loan resulting from a decline in output, then a contractionary monetary policy should cause not only demand for bank loans to fall but also there should be a decline in demand or issuance of other debt instruments such as commercial papers and bonds.

3.4.2.3 Other Asset Price Channels

The ISLM model presented in the interest rate channel was rejected by the monetarists on the grounds that it is too fixated on interest rate which is just one asset price instead of a number of asset prices (Mishkin, 1996). The monetarists predict real wealth and other asset prices as capable of transmitting effects of monetary policy changes into the real economy. These other assets whose prices can help transmit monetary policy impulses are bonds, equities and foreign exchange (Mishkin, 1996).

3.4.2.4 The Exchange Rate Channel

This channel gained prominence as economies are becoming more integrated with each other and as countries adopt flexible exchange rate regimes. The exchange rate channel involves net exports and the role of interest rates (Mishkin, 1996). In the workings of this channel, when real interest rates in the domestic country decreases, deposits and other investments denominated in the domestic currency become less attractive compared to investments and deposits denominated in foreign currencies in relative terms. This, in turn, causes the domestic currency to depreciate relative to other currencies. The exports of the domestic country become cheaper in the international market which leads to more export revenue, high net exports and then output eventually. Thus $M\uparrow \rightarrow i\downarrow \rightarrow E\downarrow \rightarrow NX\uparrow \rightarrow Y\uparrow$ where $E\downarrow$ is domestic currency depreciation and $NX\uparrow$ is increased in net exports.

3.4.2.5 Equity Price Channels

Two channels emerge in monetary transmission mechanism with equity prices. These are the Tobin's Q investment theory and the effect of wealth on consumption.

3.4.2.5.1 The Tobin's Q Theory

In this theory, Q is defined by Tobin as the firm's market value divided by the cost of replacing capital. When Q is high, then it implies that the firm's market price is higher compared to the cost of replacing capital and that means equipment capital as well as new plant are cheaper compared to the firm's market value. This also means that the firm can issue shares for a higher price as compared to the cost of buying new equipment and plant. So, by issuing a small quantity of shares, firms can actually buy more plant and equipment which then increases investment spending on plant and equipment. Conversely, with lower Q, businesses will not invest in new plant and equipment as the cost of capital is far more than the firm's value. It will then serve firms better to cheaply acquire another firm and obtain its capital and drives down investment in the country. There is therefore a link between investment spending and Tobin's Q. The monetarists argue that when there is an expansionary monetary policy, excess liquidity in the hands of the public pushes them to acquire equities in the stock market (Mishkin, 1996). The keynessians' view is that declining interest rates occasioned by an expansionary monetary policy make equities more attractive compared to bonds. Essentially therefore, both views converge on the point that equity prices appreciate with an expansionary monetary policy. Putting the two stands together, a higher price of share or equity improves the Tobin's Q and thus the market value of the firm. The higher Q translates into increased investment spending and national output eventually.

Thus $M\uparrow \rightarrow Pe\uparrow \rightarrow Q\uparrow \rightarrow I\uparrow \rightarrow Y\uparrow$.

According to Mishkin (1996), another way or channel for transmission of monetary policy through prices of equity is how consumption is affected by wealth. A greater portion of the wealth of individuals tend to be equities. As a result, an increase in the prices of equities leads to an increase in the wealth of consumers through the appreciation of their financial assets (equities) and this increases their consumption.

Thus $M\uparrow \rightarrow Pe\uparrow \rightarrow \text{wealth}\uparrow \rightarrow \text{consumption}\uparrow \rightarrow Y\uparrow$.

3.4.2.5.2 Housing and land price channels

A number of individuals also keep their assets in the form of houses or land. Mishkin (1996) argues that using the Tobin's Q framework to define equity more generally, then houses and lands can be viewed as equity. So, when prices of houses increase, the cost of building them become lesser than their market value and thus a higher Q. This leads to increased building of houses. As houses and lands are also major aspects of individuals' wealth, increase in the prices of houses and land increases the individuals' wealth and their consumption. Therefore, when monetary policy increases the prices of lands and houses through this mechanism, consumption increases and aggregate demand also increases (Mishkin, 1996).

3.4.3 Channels of Monetary Policy: Empirical Evidence

The effectiveness or workings of the various channels of monetary policy would differ from country to country as a result of differences in the developmental stage of their respective capital markets, financial intermediation, the extent of independence of their central banks and the varying economic conditions in these countries (Cevik & Teksoz, 2012). While some channels are effective in some countries, same channels are not effective in other countries. The literature is diverse with some authors studying single channels while others study a number of channels at the same time. We therefore categorize these studies as follows: studies on single channel and studies on multiple channels at a time. These two categorizations look at studies on developed and emerging economies. We then pay a particular attention to studies on African countries.

3.4.3.1 Studies on multiple channels at a time

Oros & Romocea-Turcu (2009) studied the transmission of monetary policy in Slovenia, Romania, Czech Republic, Slovakia, Poland and Hungary using structural vector autoregressive model. Specifically, the authors explored three channels namely credit, exchange rate and interest rate channels. They found the credit channel to be weak in all the countries. There was significant difference in respect of the interest rate channel. The interest rate channel tended to be very strong in Slovenia, Czech Republic and Slovakia but less strong in Romania. For Poland and Hungary, the authors found the existence of the effect of price puzzle. There was also a significant role for exchange rate in Poland and Hungary relative to the other countries.

Cevik & Teksoz (2012) studied countries within the Gulf Cooperation Council using structural vector autoregressive model with quarterly data spanning 1990 and 2010. The authors found that both the bank lending and interest rate channels are effective for these countries especially in impacting consumer prices and output that is not related to hydrocarbons. They however did not find the exchange rate channel to work in these countries, a finding they attributed to the regimes of pegged exchange rates in these countries.

Duran et al (2012) found that when monetary policy rate rises, stock prices in Turkey tend to decline, especially the share prices of firms in the financial sector. The authors also found that the effect of monetary policy changes on exchange rate in Turkey is minimal. Meanwhile, Turhan & Gumus (2014) also studied the channels of monetary policy transmission in Turkey with monthly data from January 2004 to November 2013 and adopted the vector autoregressive model for estimation. They found that the exchange rate, credit and interest rate channels are operative in Turkey.

Using a factor-augmented vector autoregressive model with monthly data from January 2000 to September 2013, Fernald et al (2014) found that the contractionary monetary policy in the form of an increase in the reserve requirement tend to lower both inflation and economic activity in China. The authors also found the interest rate channel to be effective as changes in interest rates induced by the central bank affected both inflation and economic activity. The authors did not find the credit channel to be effective.

Amar et al (2015) studied the effectiveness of the channels of monetary policy in Saudi Arabia with quarterly data from the fourth quarter of 1990 to the third quarter of 2013 and using the structural autoregressive model, the authors found that while credit channel (specifically the bank lending channel) was weak in terms of its influence on consumer prices, it was quite effective in terms of its influence on non-oil private output.

Studying major countries in the Eurozone such as Italy, Germany, Spain and France using the Bayesian vector autoregressive model, Mandler et al (2016) found that the negative effect on Spain's real output is less compared to Germany, France and Italy when there is monetary policy tightening. They also found that the fall in price level in Germany when there is tightening of monetary policy is lower compared to the other three countries.

Mishra et al (2016) studied the transmission mechanism of monetary policy in India using a structural vector autoregressive model and monthly data covering the period April 2001 and December 2014 but did not find monetary policy to have an effect on both the rate of inflation and aggregate demand.

Afrin (2017) studied the bank lending and exchange rate channels in Bangladesh using the structural vector autoregressive approach. The results indicate that while the exchange rate channel was less effective, the bank lending channel plays a dominant role in the transmission of monetary policy in Bangladesh.

Using Qual vector autoregressive model and annual data to study the transmission of monetary policy, Chen et al (2017) found that a tightening of monetary policy leads to a decline in economic growth, inflation and consumption growth in China for a long period. According to the authors, the reverse is found when monetary policy is expansionary. The authors did not find bank loans to respond to shocks from monetary policy. While they found stock prices to increase in both monetary policy expansion and contraction, housing prices tend to increase during contractionary shock of monetary policy.

Anwar & Nguyen (2018) studied how money supply, output, exchange rates and interest rates are affected by monetary policy shocks in Vietnam by controlling for both foreign and domestic shocks. Their data was in quarterly frequency spanning the first quarter of 1995 and the last quarter of 2010 and they employed the structural vector autoregressive model. The authors explored exchange rate, credit and money view of monetary policy transmission. Their results indicate that an increase in money supply or an expansionary monetary policy (increase in M2) affect output positively. They also show that price levels in Vietnam increase considerably in response to monetary policy shocks (M2) although this is preceded by an initial decline in the price levels. Their results also show that when interest rate is used as monetary policy variable, price levels tend to fall when interest rate increases but output only responds between the second and fourth quarters. Exploring the exchange rate channel, the authors found that the depreciation of the domestic currency of Vietnam causes a fall in price level while output increases in response to currency depreciation in the short term.

3.4.3.2 Studies on single channel

3.4.3.2.1 Interest rate channel

Erdogan & Yildirim (2010) studied the existence of interest rate channel in Turkey. The authors used monthly data from January 1995 to September 2008 but divided the data into two sub periods. Adopting the vector autoregressive model, the authors found the interest rate channel to exist in Turkey only in the latter sub period.

Jain-Chandra & Unsal (2014) found that international factors such as the US long term interest rate play an important role in influencing the long-term interest rate in selected countries in Asia. They also found interest rate channel to be effective although it works through short term interest rate as opposed to long term rates. The authors further found that the mechanism of monetary transmission remain strong even though flows of international capital weakens long term interest rates.

Zhang & Huang (2017) found that fluctuations in yields on bonds is greatly influenced by monetary policy changes. They also found that there is a minimal effect of bond market on the economy. They further established that while bond yields in the short term provides a stronger transmission channel to inflation as well as components of output such as investment and consumption, bond yields in the long term do not affect the economy.

Tran (2018) studied the effectiveness of monetary policy transmission in Vietnam using monthly data covering the period December 2001 to December 2015 and employing vector error correction model. The author found that inflation increased in the long term when there was monetary policy tightening through the interest rate channel. The author also established that inflation was largely fueled by growth of credit.

3.4.3.2.2 Credit channel

The critical effect of credit on real or economic activities of economies was significantly underscored by the financial crisis that the world witnessed between 2007 and 2010 (Afrin, 2017). Using the FAVAR model with data spanning 1970 to 2014, Senbet (2016) finds the credit channel to work effectively in the United States.

The credit view of monetary policy transmission, following the work of Bernanke & Gertler (1995), is said to contain two sub channels namely the channel operating through the balance sheet of firms and the bank lending channel. The balance sheet channel is where changes in monetary policy is said to affect directly and indirectly the strength of the balance sheet of firms as well as the ability of these firms to access funds from external sources (Ippolito et al, 2018). The work of Gertler & Gilchrist (1994) showed that investment in inventory, short term debt and sales of smaller firms are affected significantly by variations in monetary policy as compared to larger firms. Subsequent studies by Ciccarelli et al (2015) and Ashcraft & Campello (2007) sought for the likelihood that a reduction in the supply of loans could have influenced such a result. They found a robust channel working through the balance sheet of firms (Ippolito et al, 2018).

Ippolito et al (2018) argue that previous studies on balance sheet channel fail to account or specify the exact mechanism of how the channel of firm balance sheet works. They therefore make a contribution to the literature by quantitatively showing that monetary policy significantly affects the debt service burden of firms when such firms take bank loans without hedging the interest rate risk. Ippolito et al (2018) studied how monetary policy affects floating interest rates on bank loans secured by firms. They found that financially constrained firms tend to have their liquidity and balance sheet strength affected by changes in monetary policy especially when such floating interest rates are not hedged. That is, an increase in monetary policy rate feeds into the floating interest rates on existing bank debt secured by firms which then affects their interest cost or debt service burden, their internal funds and ability to finance new projects that are profitable.

3.4.3.2.3 The risk-taking channel

Previous studies on the credit channel of monetary policy transmission had focused on two sub channels, namely the bank lending channel and the balance sheet channel. Following the work of Borio & Zhu (2008), a new strand of literature began to focus on the risk-taking channel of monetary policy transmission (Andries et al, 2015). According to Borio & Zhu (2008), banks' risk perception and portfolio risk position is impacted by changes in monetary policy. In addition, the authors argue that changes in monetary policy impacts asset prices, valuation of assets and cash flow of firms. Moreover, issues of transparency surrounding the policy decisions of central banks can also affect bank risk-taking behavior (Andries et al, 2015). Rajan (2005) also argues that lower interest rates translate into lower yields on assets that are risk-free and this incentivizes banks to opt to invest in high yielding assets (risky assets), a phenomenon the author describes as 'search for yield' (Andries et al, 2015).

The work of Maddaloni & Peydro (2011) indicated that securitization tend to magnify the effect on the lowering of lending standards by lower rates of interest. With low interest rates, the liquidity and credit risk of banks rises and this can feed into crisis. The resultant crisis prompts the monetary authorities to lower interest rates further to shore up the economy and this can potentially fuel another crisis due to the risk-taking behavior of banks (Andries et al, 2015).

Dell' Ariccia et al (2013) argue that the concept of the risk-taking channel of monetary policy is to the effect that monetary policy, through interest rate, affects not only the quantity of loans or credit that the banks give but also the quality of these loans. Dell' Ariccia et al (2013) studied the risk-taking of monetary policy transmission in the United States using data between 1997 and 2011 and find that the risk-taking channel exists for the United States.

Taking into account the influence of the recent economic crisis, Andries et al (2015) studied the risk-taking channel of monetary policy in the Eurozone using GMM. The authors found that the risk-taking channel of banks is negatively related to interest rates, indicating that a reduction in interest rate fuels higher risk taking by banks. This negative relation was magnified during the crisis period.

Paligorova & Santos (2017) studied the risk-taking channel of monetary policy transmission in the United States by focusing on pricing of corporate loans by banks. They found that when monetary policy is expansionary, the spread on loans to firms that are risky tend to fall as compared to when monetary policy is contractionary. They added that banks with high appetite for risk tend to fuel this phenomenon.

Using the VAR approach to study the impact of monetary policy on risk-taking behavior of banks, Neuenkirch & Nockel (2018) found for the euro area that an expansion in monetary policy causes banks in the euro area to lower lending standards and engage in aggressive lending. Other studies on the euro area that have documented similar results are Jimenez et al (2014), Altunbas et al (2014) and Maddaloni & Peydro (2011) as indicated in Neuenkirch & Nockel (2018). For the United States, the studies with similar results as Neuenkirch & Nockel (2018) are Delis & Kouretas (2011), Angeloni & Faia (2013) and then Abbate & Thaler (2015).

3.4.3.2.4 Exchange rate channel

Monetary policy impact on exchange rate remains inconclusive in the literature with existing studies finding that there is enormous delay in the full response of exchange rate to changes in monetary policy and substantial departure from the uncovered interest rate parity condition when monetary policy changes (Kim & Lim, 2018).

In a study of the impact of monetary policy on exchange rate in the United States for instance, Eichenbaum & Evans (1995) found that the delay in the response of exchange rate to changes in monetary policy could last for between two and four years. The authors also found large deviations from the condition of the uncovered interest parity. Recent studies such as Heinlein & Krolzig (2012), Bouakez & Normandin (2010) and Scholl & Uhlig (2008) made similar findings for the United States. Contrary to existing theory, Grilli & Roubini (1995) found monetary policy tightening to rather depreciate the exchange rate instead of appreciating it, a condition known in the literature as exchange rate puzzle.

The openness of an economy is essential in studying monetary policy transmission especially when the economy operates a floating exchange rate regime. Such considerations of openness is much more critical for inflation targeting countries in the conduct of monetary policy as most of the economies where inflation targeting is practiced are open. In an open economy, the exchange rate channel tend to significantly complement the interest rate channel (Smets & Wouters, 1999). Smets & Wouters (1999) argue that exchange rate plays an important role in the transmission of monetary policy in an economy and the size and timing of its effect on inflation and output may differ which can affect policy optimality. Many of the existing literature on monetary policy transmission tend to overlook aspects of open economy in such transmission mechanisms (Smets & Wouters, 1999).

Smets & Wouters (1999) studied the exchange rate channel of monetary policy transmission in Germany using the VAR approach. They found that monetary policy effect on exchange rate hastens the impact on inflation while different GDP components respond differently.

Tahir (2012) argues that the value of a country's currency, following increases in integration of financial markets globally, tend to respond more to differentials in interest rates. As a result, it helps to enhance the channel of exchange rate for monetary policy transmission. According to Boivin et al (2010), the exchange rate channel's effectiveness is influenced by the sensitivity of exchange rate to movements in interest rates as well as the degree of openness of the country. Economies that are small and open tend to have an effective transmission of monetary policy through the exchange rate channel. The strength of the exchange rate channel is also influenced by the ratio of net exports to gross domestic product (Tahir, 2012).

Using the event study approach, Kohlscheen (2014) studied the impact of monetary policy on exchange rate in Chile, Mexico and Brazil and found a result that is not supportive of the well-known view that an increase in interest rate leads to an appreciation of exchange rate. Using monthly data from January of 2007 to December of 2014 and employing an unrestricted vector autoregressive model for estimation, Bungin et al (2015) found exchange rate to exert significant effect on inflation in Serbia. The authors also found interest rate channel to work in Serbia.

Kim & Lim (2018) studied the response of exchange to changes in monetary policy in four open economies, namely Sweden, Canada, Australia and the United Kingdom using vector autoregressive model. They found that exchange rates in these countries appreciate when there is monetary policy tightening with minimal delays and less departure from the uncovered interest rate parity condition.

3.4.3.2.5 Asset price channels

Koivu (2012) studied the impact of policy changes on asset prices in China (wealth effect channel). The author estimated how housing prices and stock prices respond to monetary policy changes. The author then explored how such impact of monetary policy on asset prices can affect consumption in China. Using structural VAR approach, the author finds that an expansionary monetary policy causes asset prices (stock and houses) to rise in China. When this happens, consumption also responds positively. However, the positive response of consumption to increase in housing prices is stronger than its response to increases in stock prices.

Tahir (2012) argues that in addition to the extent of development of the country's capital markets, household engagement in capital market influence the strength of the asset price channel. Tahir (2012) found the asset price channel (using share prices) and the exchange rate channel to be effective in Korea, Chile and Brazil (inflation targeting countries). The author used monthly data and employed the structural vector autoregressive approach. Using the VAR approach, Gali & Gambetti (2013) found that stock prices increase in reaction to monetary policy tightening.

Belke & Beckmann (2015) reckon that stock market failure is a prominent characteristic of financial and economic crisis. The flow of capital in the short term helps to enhance the prices of stocks in the emerging markets in much the same way such capital inflows can dampen stock prices significantly when they are later reversed (Belke & Beckmann, 2015). Using cointegrated VAR approach, Belke & Beckmann (2015) studied emerging and developed economies. They found that monetary policy represented by capital flows and aggregates of money tend to affect stock prices in emerging countries while monetary policy represented by interest rates tend to affect stock prices only in few countries out of the eight countries they studied.

Whether in the context of a single channel or multiple channel study, an overwhelming commonality in these studies is the exclusion of the components of aggregate demand (consumption, investment, import and export) in the transmission mechanism, an approach that is far from the theoretical prescriptions. These studies have also relied substantially on the VAR technique which fails to capture the indirect effect of monetary policy on price and output. In addition, the VAR technique fails to capture systematic policymaking as it focuses on only surprises. Meanwhile, monetary policy decisions are not always made out of surprises. The decisions are most often planned and systematically meant to achieve an economic outcome. Indeed, for inflation targeting central banks in particular, monetary policy decisions are systematic and meant to anchor inflation expectations as opposed to surprises.

3.4.3.2.6 The case of Africa/Developing Countries

Mishra & Montiel (2013) argue that while the literature on the advanced economies have largely confirmed the effects of monetary policy on inflation and output, the nature of the financial structure in low income economies makes it difficult to conclude wholesale the effectiveness of transmission of monetary policy impulses for these countries. Indeed, these low-income economies tend to have weak fixed income, real estate and equity markets thereby making the banking sector the major avenue for financial intermediation. Further, although the banking sector is the major financial intermediation avenue, it is small compared to the size of these countries' economies. Moreover, these countries, according to the authors, do not have a strong link with global financial markets and have heavy interference in the market for exchange rates by their central banks. These factors led the authors to conclude that there would be substantial difference between the advanced economies and the low-income economies in terms of the effectiveness of the transmission of monetary policy shocks.

The banking sector dominance in the financial systems of low income countries may lead to an inference that the bank lending channel could be the main channel for transmission of monetary policy for the low income countries but the small size of the banking system compared to the size of the economies, coupled with high lending cost and lack of competition could potentially impair the effectiveness of the bank lending channel for these economies (Mishra & Montiel, 2013). The authors assert that an empirical assessment of the effectiveness of monetary policy transmission for low income economies is a valuable research consideration. See also Cevik & Teksoz (2012) for similar arguments.

While some results support the ineffectiveness of some of these variables in Africa, others contradict the above assertion. For Kenya, Tanzania and Uganda, Buigut (2009) established that the interest rate channel does not work. A later study by Mugume (2011) also established that in addition to the interest rate channel, the credit and exchange rate channels are not working in

Uganda. Montiel (2013) studied transmission of monetary policy in Uganda using the vector autoregressive model and monthly data starting from December 2001 and ending at June 2011. The author found that monetary policy does not impact aggregate demand. Patrick & Akanbi (2017) studied four channels of monetary policy transmission in Zambia, namely the exchange rate, asset price, credit and the interest rate channels. Using monthly data covering the period January 1993 to June 2015 and employing the vector autoregressive model, the authors found the asset channel to be unimportant while the interest rate channel is weak. They however found credit and exchange rate channels to be very effective in transmitting monetary policy impulses in Zambia.

Nunkoo-Gonpot et al (2011) studied the exchange rate and the interest rate channels of monetary policy transmission in Mauritius using quarterly data between 1985 and 2006 and employed the vector autoregressive model. Their results show that both the exchange rate and the interest rate channels work effectively in Mauritius although the interest rate channel is stronger in terms of its impact on output.

Morales & Raei (2013) studied the effectiveness of both exchange rate and interest rate channels in the East African Community using the structural autoregressive model and found the interest rate channel to have strengthened over time in all the countries under study. Morales & Raei (2013) argue that because of the dominance of agricultural products and commodities in the exports of countries in East Africa, their exports are usually not responsive to variations in exchange rates. Moreover, the ratio of their exports to the domestic GDP tend to be small. The authors however argue that an alternative model for the exchange rate channel can be very important for low income countries. In that model, exchange rate influences expectation of inflation and price level in general. Indeed, this particular model can be much relevant than the interest rate channel in economies where financial intermediation is rather weak (Morales & Raei, 2013).

Kelikume (2014) studied the interest rate channel in Nigeria using quarterly data from the first quarter of 1996 to the third quarter of 2013 and adopted cointegration and error correction model for estimation. The author found interest rate channel to be effective in impacting output.

Suhaibu et al (2017) studied the impact of monetary policy on the performance of stock markets in a number of African countries. The authors found stock markets in these countries to be positively affected by changes in monetary policy through the interest rates of the various countries. The authors also found that a negative shock from the stock market leads to a positive response of inflation while both supply of money and real rate of interest fall in reaction to positive and negative shocks from stock market respectively. In terms of the strength of the monetary policy instruments adopted in the study, the authors found real rate of interest to be superior to supply of money in terms of the influence they exert on inflation and stock markets.

Matousek & Solomon (2018) studied the bank lending channel in Nigeria from 2002 to 2008 using the Generalized Method of Moments approach. They found that the bank lending channel is effective in Nigeria and also the fact that the channel has become stronger following the banking sector restructuring conducted by the central bank.

3.4.3.2.7 Turning to Ghana and South Africa

i. Ghana

With a structural vector error correction model, Abradu-Otoo et al (2003) found that the policy instruments of Bank of Ghana have effect on both output and inflation over the long term. In particular, the authors found exchange rate channel to be the dominant transmission channel of policy to the real sector.

Frimpong & Adam (2010) studied how consumer prices in Ghana are affected by changes in exchange rate. The authors used monthly data from January 1990 to February 2009. With VAR approach, the authors found that the pass through of exchange rate to inflation in Ghana is not complete. In the short term, the pass through is significant although it is low.

Studying pass through of interest rate in Ghana, Kovanen (2011) used data from 2005 to 2010 and employed the VAR approach. The author found Treasury bill rate and interbank rate to strongly respond to policy rate in the short term. The author also found that although the interbank rates respond to changes in the Treasury bill rate in the long term, the response is delayed.

Akosah (2015) studied both the channels of transmission of monetary policy in Ghana and how policy rate affects money market rates using monthly data from 2002 to 2014. The author finds that although the impact is not complete, the policy signals money market interest rates effectively in both the long and short terms. The author also identifies a hierarchy of rates that enhance the role that Treasury bill rate plays in the channel of interest rate in Ghana. Moreover, the author finds that monetary policy reacts to inflation and output pressures positively. While in the medium to long term the interest rate channel is effective in impacting inflation in Ghana, it is the exchange rate channel that is stronger in the short term. Further, the author finds that shocks from asset prices and credit drive output in Ghana.

Sakyi et al (2017) explored how other interest rates in Ghana respond to changes in the policy rate (pass through) after the implementation of the inflation targeting. Using the fully modified OLS and the dynamic OLS techniques for estimation and monthly data from January 2002 to March 2016, the authors found that in the long run, while the pass through from policy rate to deposit and lending rates of banks is incomplete, there is over pass through to the rate on 91 day Treasury bill. Further, the authors found that the transmission to other interest rates from the policy rate is slow in the short run.

Kyereboah-Coleman (2012) explored the impact of inflation targeting framework on inflation in Ghana using monthly data between 1980 and 2009. The author found that the implementation of IT framework in Ghana did not just reduce inflation substantially in Ghana but it also helped to curb persistence in inflation.

ii. South Africa

Adopting the OLS technique with data spanning between 1960 and 1997, Khabo & Harmse (2005) explored monetary policy effects on South Africa's economic growth. The authors found that GDP was adversely affected by policy tightening (Kabundi & Ngwenya, 2011). Using the FAVAR model, Kabundi & Ngwenya (2011) found that inflation in South Africa is stabilized by monetary policy.

Gupta et al (2010) adopted the FAVAR approach study the effect of monetary policy on house prices with disaggregated data. The authors found monetary policy shock to negatively impact house price inflation in South Africa (Ncube & Ndou, 2011). Ncube & Ndou (2011) posit that when consumption is affected by changes in housing wealth, and prices of houses are themselves influenced by changes in interest rate, then monetary policy changes affect consumption through housing effect. The authors found that changes in credit as well as changes in housing wealth tend to affect consumption in South Africa. In particular, the authors found that contractionary monetary policy leads to a decrease in consumption. The authors used SVAR and Absa house prices quarterly data from 1975 to 2009.

De Waal & Van Eyden (2012) used a vector error correction model which includes foreign variables that are weakly exogenous to study the transmission of monetary policy in South Africa. The authors found that the effect of changes in monetary policy on inflation takes as long as eight quarters or two years.

Mishi & Tsegaye (2012) studied bank lending channel in South Africa. The authors found that the bank lending channel is operative in South Africa. Having considered bank-specific factors, the authors argue that the size of the banks play a key role in the transmission mechanism. Guamata et al (2013) studied various channels of monetary policy transmission using quarterly data from the first quarter of 1990 to the second quarter of 2012 in South Africa using Bayesian VAR. The authors found that while all the channels, namely the interest rate, credit, asset prices, expectations and exchange rate channels were effective, their level of effectiveness differed. The interest rate channel emerged the strongest for South Africa with the asset channel being the weakest.

The user cost of capital rises when interest rate increases, leading to a decline in real estate activities and the prices of houses consequently (Simo-Kengne et al, 2013; and Demary, 2010). Simo-Kengne et al (2013) studied the effect of monetary policy changes on prices of houses in South Africa. The authors considered a possible nonlinearity in the effect of monetary policy on prices of houses. With monthly data covering the period between February 1966 and December 2011 and adopting a markov-switching VAR, the authors found that monetary policy changes affect prices of houses in South Africa. That is, a contraction of monetary policy leads to a significant decline in prices of houses. While the effect is bigger during a bear period, the bull period is characterized by a lower effect. The authors also found that the reaction of monetary policy to changes in prices of houses is larger during bull period.

Matemilola et al (2015) studied the effect of monetary policy changes on lending rates of banks in South Africa. The authors found that the interest rate at which banks lend adjust when there is a decline in policy rate (money market rate). The authors conclude that commercial banks in South Africa tend to reduce their lending rate but seldom adjust it upwards which the authors attribute to the hypothesis of customer reaction.

Using structural vector error correction model to study the effectiveness of monetary policy under inflation targeting regime, Bonga-Bonga (2017) finds that tightening of monetary policy in an effort to dampen inflationary pressures in South Africa has been ineffective. Such tightening of monetary policy rather decreases the level of output in the economy. The author concludes that the SARB should consider targeting both output and inflation.

3.4.4 Monetary Policy Transmission and the Components of Aggregate Demand

While several studies have been conducted on the impact of monetary policy on aggregate demand and inflation, studies on the response of components of aggregate demand to changes in monetary policy remain scarce. As argued by Owusu-Sekyere (2017), the few studies on monetary policy transmission in Sub-Sahara Africa have largely looked at how the changes in policy affect macroeconomic variables such as output, inflation, exchange rates and interest rates. Very limited attention has been paid to how various components of the aggregate demand respond to policy changes.

A similar argument was made by Mukherjee & Bhattacharya (2011) who asserted that existing studies tend to look at effect of policy on overall output using GDP at the neglect of the components of aggregate demand such as investment and consumption which are sensitive to interest rates. Taking interest rate channel for example, the authors posit that the interest rate channel of monetary policy works in stages. Policy rate changes are expected to influence changes in retail rate of interest which include lending rates and rates on deposits. The resultant changes in retail interest rates affect investment, consumption and aggregate demand eventually. When aggregate demand changes, it affects economic activities in the country and that has an impact on inflation.

Using quarterly data from 1997 to 2007 and employing the VAR approach, Sariola (2009) found that the negative effect of monetary policy contraction on exports is not immediate in Finland and that the negative effect only manifests beyond one and half years and becomes persistent thereafter although the said negative impact is not statistically significant. On the other hand, the negative impact of monetary policy changes on imports manifest within a year. The author also found that the export volumes of Finland is negatively impacted by appreciation of the Euro against the US dollar and the impact is immediate. In addition, there is an immediate adverse effect on volumes of imports following the appreciation of the Euro but it dissipates with time.

Mukherjee & Bhattacharya (2011) studied how consumption and investment respond to interest rate changes for MENA countries. They controlled for the level of financial market development in each country to see if that affect the response of investment and consumption to interest rate changes. The authors included other emerging market economies who practice IT in their study for the purposes of comparison. The authors found that the real interest rate for lending (lending rate) significantly impacted private investment in countries within the MENA and other emerging economies. The authors also found that while real interest rate on deposits had a significant effect on consumption in the emerging economies practicing IT, same cannot be said of countries in MENA. Furthermore, the authors found that the IT implementation by the emerging economies in their study had very little effect on the operation of the transmission through interest rate channel.

The authors also found heterogeneity in the response of private investment and consumption to interest rate in different countries due to the differences in the level of financial sector development in these countries. In particular, the authors found that while the wealth effect associated with changes in interest rates (deposit rate) significantly overshadows the substitution effect associated with deposit rate changes with development of the financial sector in the emerging economies practicing IT, the reverse prevails in the MENA countries. In addition, the authors found that while financial sector development impacted significantly on private investment directly and indirectly in the MENA countries, it had no significant impact on private investment in the emerging IT economies whether directly or indirectly. Finally, the authors found that while capital account liberalization positively impact private investment but impact negatively on private consumption in the emerging economies, the reverse prevails in the MENA countries where such capital liberalization rather impact negatively on private investment but positively on private consumption.

As small open economies allow their exchange rates to float freely, coupled with removal of capital controls, and with increasing linkages of global financial markets, such countries have to contend with contagion effects, speculative attacks, reversibility of flows of capital, greater possibility of imported inflation and volatility of exchange rates (Aron et al, 2014). Aron et al (2014) used monthly data on prices from 1980 to 2009 to study the pass through of exchange rates to import prices in South Africa. The authors found that there is incomplete pass through, on the average, in the short and long term. Specifically, the authors found that in the short term, the pass through is around 50% in a year and around 30% within six months. They also found that volatility in exchange rate in recent times has fueled the decline in the pass through. Finally, they found asymmetry in the pass through as marginal appreciations tend to elicit bigger pass through. The authors conclude that following the implementation of inflation targeting, the pass through is slow.

Osei-Fosu et al (2014) studied the impact of deposit interest rate on consumption in Ghana by using annual data between 1970 and 2009. With ARDL approach, they found that in both the short term and long term, consumption is inversely related to deposit interest rate. The negative relationship is however significant only in the short term but not in the long term.

Using the ARDL framework and annual data from 1975 to 2011, Hailu & Debele (2015) studied the impact of monetary policy changes on private investment in Ethiopia. The authors found that in the short term while money supply, public investment and output affect private investment positively, real exchange rate tend to negatively impact private investment. The authors did not find real rate of interest to be significant in impacting private investment in the short term and has a negative sign. Same results were found for the long term except that real interest rate is positive but still insignificant.

Many African countries have over the years tilted towards the control of inflation as the primary objective of their central banks. As a result, policy stance have tended to be one contractionary which Ndikumana (2016) argues has negative impact on investments and growth since many firms tend to rely on credit, particularly from the banks. The author posits that because of the reliance of firms on bank lending in Africa, monetary policy contraction affects investments of these firms through cost of capital and the quantum of loans the banks are willing to supply. Ndikumana (2016) studied a number of African countries using annual data from 1980 to 2012 and the system GMM and fixed effect model for estimation and finds that a monetary policy contraction negatively affects investments in the domestic economy through the bank lending channel as well as the cost of capital.

Kabundi & Mbelu (2016) studied the pass through of exchange rate in South Africa with data spanning the period 1994 – 2014. The authors focused on a two-stage framework by looking at how variations in exchange rate first affect prices of imports and how the resultant effect on import prices affect general consumer prices or inflation in South Africa. Using the rolling window technique for estimation, the authors find that while the pass through is complete in the first stage, the pass through in the second stage is not complete. In other words, while exchange rate changes are reflected in the prices of imports, importers do not transfer the entire cost to the final consumers. The authors found further that following the global economic crisis, the pass through at the first stage has declined marginally. The first stage pass through also exhibits asymmetry as the pass-through increases when the economy is experiencing boom while it declines with downturn in the economy. The authors also found the second stage pass through to have declined considerably following the implementation of inflation targeting framework in South Africa.

Owusu-Sekyere (2017) explored the effect of monetary policy changes on consumption of households in South Africa. The author used quarterly data from 1994 to 2012 using both time-varying VAR and VAR with constant parameter. The author found that tightening of monetary policy lead to a reduction in consumption by households as well as household credit in South

Africa, particularly after the transition period and the inflation targeting. The author also found that following an expansion in monetary policy in the wake of the financial crisis, consumption by households increased.

Yang et al (2017) studied the effect of monetary policy on investment of companies in China by capturing the role of financial sector development, ownership structure of these firms, and whether cash holding by the firms can mitigate the availability of funds from contractionary policy. They used data from 2003 to 2013. For estimation, they employed various techniques such as pooled OLS, fixed effect, random effect and system GMM. The authors found that when monetary policy is contracted in China, investment by companies reduces but the extent of reduction or its effectiveness in reducing investment is mitigated by holdings of cash by the companies. The authors also found that with contractionary monetary policy, privately owned firms which are constrained financially resort to cash holdings or external funding from a financial market that is highly developed to keep their investments afloat.

In the corporate finance literature, the argument is that shocks in supply of credit from the financial markets tend to have a heavy toll on companies that do not have internal financing buffers but heavily rely on external financing sources (Yang et al, 2017). Internal cash holding has also been argued to play a hedging role that support investments of companies (Duchin et al, 2010; and Yang et al, 2017). The unfavourable effects of volatility in cash flow lead many companies to hold more cash as a precautionary measure (Opler et al, 1999) as well as to protect their portfolio of investments from any future underinvestment (Yang et al, 2017).

With contractionary monetary policy, interest rate increases and that means companies with interest-bearing debt will now pay out more interest than before with its negative effect on their profitability since cash is reduced and the value of the firm drops. As a result, the risk premium associated with external finance rises leading to a fall in investments by companies and the resulting decline in loan demand by these companies. However, companies that have higher levels of holdings of cash provide not just a shield to their investment portfolio (enable them to still invest) but it also shores up their collateral value which helps reduce cost of securing external finance (Bernanke & Gertler, 1989; and Yang et al, 2017).

Vithessonthi et al (2017) argue that there is paucity of research on the effect of monetary policy changes on the behaviour of banks that eventually affect investments of companies. The authors assert that the paucity of research on this dimension is even more acute in inflation targeting countries, especially the developing countries practicing IT. As a result, the authors studied Thailand, Switzerland and Germany with the focus of finding how monetary policy affect corporate investment using firm level data from 1990 to 2013. The authors employed panel quintile regression and panel OLS regression. They found that there is a positive relationship between a change in monetary policy rate and lending rate in Thailand and Germany in the short term. Further, they found that bank loans are negatively impacted by lending rates. In addition, an increase in lending rate shrinks corporate investment while there is also a positive relationship between corporate investment and loan supply. After controlling for financial constraints on firms, the authors found that there is a negative effect of bank lending rate on investments by firms that are not constrained financially, while the effect of bank lending rate on investment is significant for firms that are constrained financially. In addition, whether the firm is constrained financially or not, bank loan supply has a positive relationship with corporate investment. Finally, while the authors found that the positive impact of loan supply on investment is significant for firms that are performing well (measured by ROA and sales growth), it is insignificant for firms that are performing poorly.

Brima & Brima (2017) studied monetary policy impact on private investment in Sierra Leone. Using data from 1980 to 2014 and employing OLS technique, the authors found that while gross domestic savings and money supply positively and significantly impact private investment, gross domestic debt, inflation and treasury bill rate negatively impact private investments in Sierra Leone.

These studies, although an important step in the consideration of the components of aggregate demand in the transmission mechanism, fall short of the eventual impact of the monetary policy impulses on output or inflation, a step this study takes.

3.5 Methodology

3.5.1 Data and Data Sources

We use quarterly data from 2000 to 2018 for South Africa and from 2007 to 2018 for Ghana, with the starting years of the data informed by the year of launch of the inflation targeting framework in the respective countries. For South Africa, we obtain data on repo rate (monetary policy variable), interbank rate, gross fixed capital formation, private sector credit, deposit, inflation and monetary aggregates (M2) from the South African Reserve Bank. M2 was originally in monthly series but converted to quarterly series using simple averages. Lending rate and deposit rate were obtained from the IMF's International Financial Statistics. Data on the exchange rate of the Rand to the Dollar was obtained from Datastream. GDP growth was obtained from World Bank's World Development Indicators (WDI) which was originally in annual frequency but converted to quarterly frequency using interpolation. The interpolation technique, for every annual observation, delivers a local quadratic polynomial estimation. The resulting polynomials are then used to provide quarterly series that match the observed annual observations. The quadratic polynomial is formed by this interpolation technique by utilizing adjacent points in sets of three that are taken from the annual series to estimate the quadratic with the result that the sum or the average of the obtained quarterly observations are in synchrony with the annual series that were originally observed in the economy (IHS Global, 2017). For Ghana, data on monetary policy rate, lending rate, exchange rate of the Cedi to the Dollar, private sector credit, inflation, monetary aggregates (M2) and deposit rate were obtained from the Bank of Ghana time series database. Data on GDP growth and gross fixed capital formation were obtained from the World Bank's World Development Indicators (WDI) and the Ghana Statistical Service in annual series. They were then converted to quarterly series using interpolation as explained earlier. Gross fixed capital formation was in nominal values but deflated with GDP deflator obtained from WDI.

3.5.2 Description of Variables

Investment (GFCF): measured as natural log of real gross fixed capital formation.

Monetary Policy (MPR): measured as repo rate in the case of South Africa and monetary policy rate in the case of Ghana.

Exchange rate (EXCH): measured as real exchange rate of the local currencies (Rand in South Africa and Cedi in Ghana) to the United States dollar.

Bank loans (PSC): measured as the natural log of the total banking sector credit to the private sector.

Lending rate (LNDR): measured in percentage. It represents the weighted average of the interest rates charged by banks for lending purposes.

Inflation (INF): measured as quarterly inflation rate.

Deposit rate (DPSR): measured in percentage. It represents interest paid on deposits by banks. For Ghana in particular, it is the savings deposit rate paid by banks.

GDP growth (GDPG): measured in percentage. It represents growth in output.

Money supply (M2): measured as natural log of broad money (M2).

3.5.3 Summary Statistics and Stationarity Test

Table 3.1: Descriptive Statistics

S. Africa	**INF**	**GFCF**	**LNDR**	**EXCH**	**PSC**	**MPR**	**GDPG**
Mean	6.146053	26.89649	11.45285	9.230263	28.11710	7.990132	2.771129
Median	5.800000	27.01596	10.50000	8.050000	28.31854	7.000000	2.830961
Maximum	16.30000	27.19182	17.00000	15.42000	28.91791	13.50000	5.752676
Minimum	0.400000	26.32949	8.500000	5.730000	27.01055	5.000000	-1.83840
Std. Dev.	2.959119	0.288327	2.420489	2.695055	0.600167	2.515101	1.846231
Skewness	1.039017	-0.81632	0.707084	0.795106	-0.45830	0.738881	-0.33650
Kurtosis	4.412504	2.101800	2.291021	2.360356	1.831311	2.257739	2.778584
Observations	76	76	76	76	76	76	76
Ghana							
Mean	0.132906	23.74161	27.96500	2.498531	23.18578	17.69375	6.651969
Median	0.124750	23.72835	27.50500	1.891400	23.19351	17.00000	6.629876
Maximum	0.207400	24.36348	32.75000	4.820000	24.35009	26.00000	14.47487
Minimum	0.084000	23.09351	24.17000	0.926000	21.53522	12.50000	2.050250
Std. Dev.	0.037986	0.486788	2.558077	1.331500	0.838023	4.169770	3.360306
Skewness	0.335711	0.032301	0.355433	0.433123	-0.21569	0.692142	0.573019
Kurtosis	1.725973	1.311763	2.243659	1.558178	1.777094	2.452268	2.764040
Observations	48	48	48	48	48	48	48

Notes: MPR is monetary policy rate, INF is inflation rate, GFCF is gross fixed capital formation, LNDR is lending rate, EXCH is exchange rate, PSC is private sector credit and GDPG is gross domestic product growth.

Table 3.2: Stationarity Test

		ADF Test		PP Test	
		Level	First Diff.	Level	First Diff.
Ghana	INF	-1.9766	-4.3184***	-1.8943	-4.4046***
	MPR	-3.3735*	-3.8082**	-1.5491	-3.9334**
	GDPG	-2.8308	-3.6347**	-2.1712	-3.7993**
	DPSR	-1.7372	-5.6835***	-1.8820	-5.6750***
	LNDR	-1.8800	-6.0396***	-2.1980	-6.0632***
	GFCF	-0.6439	-2.4966	-0.4791	-2.4870
	PSC	-1.6170	-7.075***	-1.7596	-7.0222***
	EXCH	-1.8336	-6.0489***	-1.8868	-6.0489***
South Africa	INF	-4.8511***		-4.8052***	
	MPR	-3.2514*	-4.5111***	-2.2631	-4.0538**
	GDPG	-3.0178	-2.8399	-2.7078	-4.8585***
	DPSR	-2.7075	-5.1677***	-2.2942	-5.1677***
	LNDR	-3.5149**	-4.9502***	-2.3011	-4.0361**
	GFCF	-0.6186	-5.8342***	-0.4841	-5.7810***
	PSC	-0.7752	-5.2939***	-0.5723	-5.2962***
	EXCH	-1.5969	-7.3990***	-1.8031	-7.3500***

Note: ***, ** and * indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root.

3.5.4 Estimation Technique

As existing studies have largely failed to capture the apparent indirect effect of monetary policy on inflation inherent in the theoretical stipulations of the channels of transmission of monetary policy impulses, we rely on the three-stage least square technique to capture the indirect relationship.

3.5.4.1 The Three-Stage Least Square (3SLS)

Following the works of Nosier & El-Karamani (2018) and Zellner & Theil (1962), we provide a brief description of our estimation technique. The ordinarily least square technique (OLS) fundamentally assumes that the variables on the right-hand side of the model (regressors) are necessarily exogenous, implying absence of correlation with the errors. A violation of this assumption then renders estimates from the OLS inconsistent and biased. A way to deal with such a weakness is to employ the two-stage least square approach in a simultaneous equation set-up which delivers consistent estimates even in the presence of endogeneity of the regressors. However, that is only to the extent that the errors in the specified simultaneous equations are not themselves correlated. Where the errors are correlated, then the two-stage least square technique lacks efficiency although the estimates can still be consistent. In the presence of such correlations between the errors, an estimation technique that ameliorates the weakness is the seemingly unrelated regression as it accounts for these correlations and still deliver efficient estimates. But that is also to the extent that the right-hand side variables are not endogenous. Where there are endogenous right-hand side variables, then the seemingly unrelated regression must necessarily be complemented with method of instrumental variables under the two-stage least square. Such complementation then yields an estimation technique known as the three-stage least square approach which we use for our study.

The three-stage least square technique delivers estimates that are superior to the two-stage least square because even though they both maintain consistency, the former churns out estimates that are efficient asymptotically as it utilizes information inherent in the correlations among the errors within the structural equations specified (Nosier & El-Karamani, 2018). There are three steps in the three-stage least square set up. The first step involves the estimation of the coefficients of the reduced form specifications. The second step entails the application of the two-stage least square to the respective structural equations for the estimation of the structural coefficients. The last step involves the use of generalized least square technique to estimate the entire system's structural coefficients with the aid of the covariance matrix of the structural equations' errors obtained from the residuals in the two-stage least square (Nosier & El-Karamani, 2018). The generalized least square technique, unlike the OLS, relaxes the homoscedasticity assumption. A virtue of the three-stage least square technique is the fact that it has the complement of complete information which enhances its efficiency and it takes into consideration the parameter restrictions in the distinct structural equations being considered (Zellner & Theil, 1962).

3.5.4.2 Model Specification and Estimation

As indicated earlier, we consider the interest rate and bank lending channels of monetary policy transmission. We therefore specify simultaneous equations for each of these channels based on the theoretical stipulations.

3.5.4.2.1 The Interest Rate Channel

$$INF_t = \alpha_0 + \alpha_1 GFCF_t + \alpha_2 LNDR_t + \alpha_3 EXCH_t + \varepsilon_t \quad (1)$$

$$GFCF_t = \beta_0 + \beta_1 LNDR_t + \beta_2 PSC_t + \beta_3 INF_t + \varepsilon_t \quad (2)$$

$$LNDR_t = \gamma_0 + \gamma_1 MPR_{t-k} + \gamma_2 GDPG_t + \gamma_3 EXCH_t + \gamma_4 DPSR_t + \varepsilon_t \quad (3)$$

Where INF_t in equations (1) and (2) is inflation rate at time *t*, $GFCF_t$ in equations (1) and (2) represents investment (gross fixed capital formation) at time *t*, $LNDR_t$ in equations (1), (2) and (3) represents the lending rate, $EXCH_t$ in equations (1) and (3) is the exchange rate of the domestic currencies (Rand and Cedi) to the United States dollar at time *t*, PSC_t in equation (2) represents private sector credit at time *t*, $GDPG_t$ in equation (3) represents growth of gross domestic product at time *t*, $DPSR_t$ represents deposit rate at time *t*, ε_t is the standard error and MPR_{t-k} in equation (3) is a four-period lag of monetary policy in the case of Ghana but two-period lag of monetary policy in the case of South Africa. The lag in monetary policy is informed by the fact that monetary policy is expected to impact the real economy with a lag. The choice of four lags in the case of Ghana and two lags in the case of South Africa are informed by a number of lag selection criteria. For each of these countries, we estimate a VAR and specify a maximum lag. For Ghana, all the lag selection criteria (in Table 3.3) indicate four (4) as the optimal lag for monetary policy. For South Africa, all the lag selection criteria (in Table 3.4) indicate two (2) as the optimal lag for monetary policy.

Table 3.3: Lag selection criteria – Ghana

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-113.6004	NA	18.03212	5.730021	5.772243	5.745287
1	-60.05107	101.7438	1.303118	3.102554	3.186998	3.133086
2	-53.39672	12.31056	0.982398	2.819836	2.946502	2.865634
3	-52.39057	1.811070	0.982477	2.819528	2.988416	2.880593
4	-49.60276	4.878655*	0.899043*	2.730138*	2.941248*	2.806469*
5	-49.56086	0.071233	0.944072	2.778043	3.031375	2.869640
6	-49.53113	0.049061	0.992349	2.826556	3.122110	2.933419
7	-48.21995	2.097889	0.978813	2.810997	3.148773	2.933126
8	-48.08231	0.213346	1.024363	2.854115	3.234113	2.991510

The * represents the lag order chosen by the criterion. HQ: Hannan-Quinn information criterion; SC: Schwarz information criterion; AIC: Akaike information criterion; FPE: Final prediction error; LR: sequential modified LR test statistic (each test at 5% level).

Table 3.4: Lag selection criteria – South Africa

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-154.7036	NA	5.706718	4.579519	4.612159	4.592452
1	-69.29908	165.7853	0.476719	2.097032	2.162311	2.122897
2	-53.78184	29.66530*	0.311061*	1.670054*	1.767974*	1.708853*
3	-53.45186	0.621149	0.317277	1.689760	1.820320	1.741492
4	-52.33849	2.062998	0.316262	1.686426	1.849625	1.751091
5	-51.90337	0.793464	0.321623	1.703040	1.898879	1.780638
6	-50.76923	2.034778	0.320443	1.699095	1.927574	1.789625
7	-50.51267	0.452752	0.327646	1.720961	1.982079	1.824424
8	-50.20929	0.526445	0.334585	1.741450	2.035208	1.857846

The * represents the lag order chosen by the criterion. HQ: Hannan-Quinn information criterion; SC: Schwarz information criterion; AIC: Akaike information criterion; FPE: Final prediction error; LR: sequential modified LR test statistic (each test at 5% level).

The theoretical stipulation of the interest rate channel is to the effect that changes in monetary policy rate affects market rates which in turn affects investments and eventually output or inflation. Given our focus on inflation, we consider inflation as opposed to output. We therefore specify three simultaneous equations to capture the stages of the transmission of monetary policy impulses to inflation. Equation (1) is the inflation equation which captures the effect of investment and other control variables on inflation. Equation (2) is the investment equation which captures the effect of interest rate (in our case lending rate) and other control variables on investment. We chose the lending rate on the basis of the dominance of the banking sector in Africa and the fact that many firms and, to a large extent, households depend on bank loans for capital projects and large investments. Equation (3) is the lending rate equation which captures the effect of monetary policy and other control variables on lending rate.

The theoretical expectation is that a tightening of monetary policy (increase in policy rate) in equation (3) should exert positive effect on the lending rate of banks thereby making cost of borrowing expensive. That positive effect is captured by $\gamma_1$in equation (3). An increase in the lending rate is then expected to discourage borrowing by firms and therefore a decline in investment. The lending rate is thus expected to have a negative effect on investment (equation 2) and captured by β_1. A decline in investment is expected to slow down economic activities and therefore reduce inflation (equation 1) and this is captured by α_1. The indirect effect of monetary policy on inflation is then captured by the product of γ_1, β_1 and α_1 (see Nosier & El-Karamani, 2018). Determining the statistical significance of monetary policy's indirect effect on inflation, following the multiplication of the coefficients, requires the estimation of the standard errors. Following the work of Nosier & El-Karamani (2018), we employ the delta method in equations (4) and (5) to estimate the standard errors (Oehlert, 1992) under the assumption of zero covariance between $\hat{\alpha},\ \hat{\beta}\ and\ \hat{\gamma}.$

$$SE(\hat{\vartheta}) = \sqrt{\hat{\beta}_1^2 SE(\hat{\gamma}_1^2) + \hat{\gamma}_1^2 SE(\hat{\beta}_1^2)} \tag{4}$$

$$SE(\hat{\varphi}) = \sqrt{\hat{\alpha}_1^2 SE(\hat{\vartheta}^2) + \hat{\vartheta}^2 SE(\hat{\alpha}_1^2)} \tag{5}$$

Given that our channel dynamics is one step more than what was considered in Nosier & El-Karamani (2018), we adapt to suit our present situation. We first estimate the indirect effect of monetary policy on investment $(\hat{\vartheta})$ such that $\hat{\gamma}_1 \times \hat{\beta}_1 = \hat{\vartheta}$ and the associated standard errors in equation (4) and then the eventual indirect effect on inflation $(\hat{\varphi})$ such that $\hat{\vartheta} \times \hat{\alpha}_1 = \hat{\varphi}$ and the associated standard errors in equation (5).

3.5.4.2.2 The Bank Lending Channel

$$INF_t = \partial_0 + \partial_1 GFCF_t + \partial_2 LNDR_t + \partial_3 EXCH_t + \varepsilon_t \qquad (6)$$

$$GFCF_t = \delta_0 + \delta_1 PSC_t + \delta_2 LNDR_t + \delta_3 INF_t + \varepsilon_t \qquad (7)$$

$$PSC_t = \emptyset_0 + \emptyset_1 MPR_{t-k} + \emptyset_2 GDPG_t + \emptyset_3 \, EXCH_t + \emptyset_t DPSR_t + \varepsilon_t \qquad (8)$$

Where all the variables (dependent and independent) as well as the choice of the lag of monetary policy are as previously described under the interest rate channel. Theoretically, the bank lending channel works in such a way that changes in monetary policy affects how much banks can lend and, in particular, banks that heavily depend on deposits. An effect on bank credit in turn affects investments by firms and especially firms that rely heavily on bank loans. Changes in investment then affects economic activities and inflation eventually. To capture these stages of policy transmission, we specify three simultaneous equations. Equation (6) is the inflation equation which captures the effect of investment and other control variables on inflation. Equation (7) is the investment equation which captures the effect of bank lending to the private sector and other control variables on investment. Equation (8) is the bank credit equation which captures the effect of monetary policy and other control variables on bank lending to the private sector (see Afrin, 2017).

The theoretical expectation is that a tightening of monetary policy reduces how much credit banks can extend to the private sector. Such a negative effect is captured by $\emptyset_1$ in equation (8). A decline in credit to the private sector then induces a reduction in investment by these firms (positive effect) which is captured by δ_1 in equation (7). A fall in investment then slows the economy down and overall inflation reduces. That positive effect is captured by ∂_1 in equation (6). The indirect effect of monetary policy on inflation through the bank lending channel is then captured by the product of $\emptyset_1$, δ_1 and ∂_1, such that $\widehat{\emptyset}_1 \times \hat{\delta}_1 = \hat{\pi}$ and $\hat{\pi} \times \hat{\partial}_1 = \hat{\tau}$.

We follow the logic and steps under the interest rate channel in equations (4) and (5) to estimate the standard errors in equations (9) and (10) to be able to determine the statistical significance of monetary policy's indirect effect on inflation through the bank lending channel.

$$SE(\hat{\pi}) = \sqrt{\hat{\delta}_1^2 SE\left(\widehat{\emptyset}_1^2\right) + \widehat{\emptyset}_1^2 SE(}\hat{\delta}_1^2) \tag{9}$$

$$SE(\hat{\tau}) = \sqrt{\hat{\partial}_1^2 SE(\hat{\pi}^2) + \hat{\pi}^2 SE(}\hat{\partial}_1^2) \tag{10}$$

3.6 Empirical Results and Analysis

We present the empirical findings for the interest rate channel for both countries in Table 3.5 and the results on the bank lending channel for both countries in Table 3.6.

3.6.1 The Interest Rate Channel

We begin with the effect of monetary policy on lending rates of banks, thus lending rate equation in column 4 of Table 3.5. For Ghana, we find that a percentage restriction of monetary policy leads to an approximately 0.41% increase in the lending rate of banks, with the said positive effect statistically significant at 1% level. For South Africa, bank lending rates increase by approximately 0.34% following a percentage restriction in monetary policy stance and the effect is significant statistically at 1% significance level. Increases in monetary policy rate expectedly increase market interest rates which increases the opportunity cost of funds at the disposal of banks. Interest rates or coupons on gilts equally see an upward trajectory when market interest rates begin to rise in order to attract investors to patronize government securities. Given that gilts are safer relative to lending to firms, it would take a higher interest rate (lending rate) for banks to lend to firms as opposed to putting the available funds in gilts. Increases in market interest rates also increases the cost of overnight borrowing for banks that borrow to cover their positions or to on-lend to clients. Unsurprisingly therefore, monetary policy tightening in both countries delivers an upward adjustment in the bank lending rates consistent with the theoretical prescription. The disparity in the development of the financial sectors of both countries has a telling on the extent of the bank lending rate response to monetary policy tightening. South Africa, undoubtedly has a relatively more developed financial sector than Ghana. The existence of a well-functioning capital market in South Africa with one of the well-developed stock markets compared to Ghana means that South

African banks would necessarily have to be competitive in loan pricing as larger firms have alternative sources of securing funding in the capital market. In Ghana where businesses predominantly seek external financing in the form of bank loans, it provides Ghanaian banks a greater latitude to hike lending rates in response to increasing cost of their funds.

Table 3.5: The Interest Rate Channel

GHANA	Inflation Equation	Investment Equation	Lending Rate Equation
GFCF	0.0581*** (3.59)		
LNDR	0.01094*** (4.28)	-0.0741*** (-3.97)	
EXCH	-0.0199*** (-3.43)		-0.9895*** (-2.95)
PSC		0.567*** (13.23)	
INF		6.739*** (6.00)	
MPR			0.4074*** (4.31)
GDPG			-0.2938*** (-4.12)
DPSR			0.555*** (3.67)
Constant	-1.504*** (-3.83)	11.76*** (11.78)	22.184*** (17.52)
R-squared	0.35	0.80	0.67
Indirect Effect of MPR	**-0.002** (-2.263)**		
SOUTH AFRICA			
GFCF	0.0653*** (4.46)		
LNDR	0.01045*** (6.57)	-0.03105*** (-3.65)	
EXCH	-0.00218** (-2.05)		0.04182* (1.91)
PSC		0.3883*** (16.13)	
INF		3.1716*** (4.09)	

MPR			0.3365***
			(8.90)
GDPG			0.251***
			(8.71)
DPSR			0.7787***
			(16.87)
Constant	-1.796***	16.14***	1.7188***
	(-4.46)	(22.18)	(5.59)
R-squared	0.27	0.88	0.98
Indirect Effect of MPR	**-0.001*** (-2.694)**		

In the parenthesis are the t-statistics. 1%, 5% and 10% significance levels are respectively denoted by *, ** and ***.

Lending rate increases, theoretically, are expected to negatively impact investment as businesses find borrowing cost to be prohibitive. We therefore ascertain the effect of lending rates on investment in the respective economies. We find that investment, represented by gross fixed capital formation, shrinks by 0.074% and 0.031% in Ghana and South Africa respectively following a percentage hike in the bank lending rate and the effect is significant at 1% significance level. Businesses are largely driven by margins and increasing borrowing costs and the associated servicing burden substantially shave off such margins, particularly for businesses that sell goods with high price elastic demand and incapable of passing on all costs to clients. Such businesses necessarily limit capital investments in the face of increasing interest rates in the economy.

When such investments by businesses decline in the face rising borrowing costs, the expectation is that it slows down economic activities in the economy and inflation would potentially tumble. We find that inflation in Ghana plummets by 0.058% following a percentage decline in investment. For South Africa, inflation falls by 0.065% in the wake of a percentage fall in investment. A fall in investment implies a cut back in the productive capacity of the firms and the entire economy by extension. A decline in the economy's productive capacity then implies some degree of increase in unemployment. This exacts two consequences. There is an initial decline in firm productivity and the accompanying unemployment reduces consumer spending with potential second round effect on firms' desirability to increase production given the weak demand in the economy. The combined effect is a decline in the inflation rate of the economy and economic activities slow down.

The monetary policy effect on inflation through the interest rate channel, as prescribed earlier under the theoretical foundations, is necessarily indirect. Having provided the step-by-step workings of the transmission, we now look at the overall indirect effect of monetary policy. The results, reported in column 2 of Table 3.5, indicate that the monetary policy overall effect on inflation is -0.002 in Ghana and -0.001 in South Africa. That is, a percentage tightening of monetary policy in Ghana reduces inflation by 0.002% whiles a policy tightening in South Africa reduces inflation by 0.001% and these effects are statistically significant at 5% and 1% in Ghana and South Africa respectively. Clearly, the interest rate channel is operative in both countries. Our theoretically inclined approach provides quantifiable monetary policy effect in an indirect fashion that is more intuitive compared to the widely used VAR technique where only impulse responses and variance decompositions are reported. Although authors who use structural VAR are capable of ordering the variables based by theoretical assumptions, they fall short of providing a quantitative overall indirect effect of monetary policy on inflation. Indeed, our approach enables monetary policymakers to be able to ascertain more quantitatively the effect of monetary policy at the various stages of the transmission process.

In capturing monetary policy effect on bank lending rate, we controlled for other variables such as deposit rate, exchange rate and growth of gross domestic product. We find that deposit rate, which reflects the cost of deposits taken by the banks, exerts positive and statistically significant effect on the lending rate. A percentage increase in the deposit rate increases bank lending rate by 0.56% and 0.78% in Ghana and South Africa respectively. This is expected, given that banks would add their spreads on the cost of their funds to stay profitable. For exchange rate, we find that the depreciation of the Cedi against the United States Dollar leads to a fall in the lending rate in Ghana whiles a depreciation of the Rand against the dollar elicits lending rate hikes in South Africa. A plausible explanation relates to the differences in the financial systems of the two countries. In countries where financial systems are well developed like South Africa and integrated with global financial markets, domestic firms are able to access financing from the global marketplace in foreign currencies. Such financing in foreign currencies then exposes these firms to exchange rate risk. A depreciation of the domestic currency increases such foreign exposure risks and banks adjust lending rates to reflect the deteriorated risk profile of these firms (see Francis & Hunter, 2012). In the case of Ghana, such foreign currency exposures through foreign borrowing are minimal given the less accessibility to global financial marketplace faced by Ghanaian businesses. The negative relationship between exchange rate and the lending rate in Ghana essentially relates to the trade side. Ghana is a net importer with many businesses engaged in either importation or retailing of imported goods. A depreciation of the Cedi then discourages borrowing by these firms to import goods. A fall in loan demand then exerts a downward pressure on bank loans (see Aguiar, 2005). In the investment equation where we captured the impact of lending rate, we also controlled for private sector credit and increasing prices (proxied by inflation). The rationale is that increases in the supply of bank credit to the private sector should increase investment in the economy. For the prices, the argument is that increases in prices motivates businesses to supply more to the market and therefore would increase investment. The use of inflation as opposed to inflation volatility is to capture increases in prices that motivate suppliers to make more profits as opposed to capturing stability in the economy. We find that private sector credit and prices have the expected signs for both countries. In the inflation equation where we captured the effect of investment, we controlled for the effects of interest rate and exchange rate. We find that interest rate exerts positive effect on inflation in both countries. Thus, increases in interest rates increase cost of borrowing and interest-sensitive products thereby affecting economic activities and inflation. We also find that for both countries, depreciation of the domestic currencies exert negative effect on inflation.

3.6.2 The Bank Lending Channel

In the bank lending channel, we considered the monetary policy effect on bank credit to the private sector, then the effect of bank credit to the private sector on investment and eventually the effect of investment on inflation in the two countries. For the bank credit equation where we capture the effect of monetary policy on credit, we find that private sector credit declines by 0.022% and 0.25% in Ghana and South Africa respectively following a percentage tightening of monetary policy in both countries. Monetary policy tightening affects banks' ability to extend credit. This is more pronounced for banks that rely heavily on deposits for loans. In South Africa for instance, deposits play a substantial role is the financing of banking sector assets. In 2017, deposits and liabilities such as other creditors and current accounts amounted to 86.4% of the liabilities of the sector (driven chiefly by deposits). Indeed, it was even higher in 2016, accounting for 87.6% of the liabilities of the banking sector (SARB, 2017). The story is not very different in Ghana. Total deposit in Ghana accounted for 62.83% of the financing of the total assets of the banking sector by the middle of 2017. By June 2019, it had reached an estimated 67% (Bank of Ghana, 2019b). Such is the reliance of the banking sector on deposit in these countries.

A reduction in banking sector credit, following monetary policy tightening is expected to lead to a decline in investment. Such a decline in investment is even more prominent in countries where firms rely heavily on bank loans as external financing source. We ascertain the effect of private sector credit on investment in the investment equation. We find that a percentage fall in private sector credit reduces investment by 0.52% and 0.30% in Ghana and South Africa respectively. As indicated earlier, the financial sector in South Africa is relatively more developed and therefore firms have alternative sources of external financing relative to Ghana. It is therefore unsurprising the pronounced decline in investment (in percentage terms as opposed to the actual values) in the case of Ghana following a decline in bank lending to the private sector.

Table 3.6: Bank Lending Channel

GHANA	**Inflation Equation**	**Investment Equation**	**Bank Credit Equation**
GFCF	0.1024***(7.42)		
LNDR	0.0084***(4.74)	-0.0618***(-4.49)	
EXCH	-0.0299***(-6.07)		0.6043***(17.23)
PSC		0.5164***(11.54)	
INF		8.2863***(9.07)	
MPR			-0.0218**(-2.37)
GDPG			-0.00576(-0.77)
DPSR			-0.0129(-0.86)
Constant	-2.46***(-7.48)	12.382***(11.83)	22.23***(161.49)
R-squared	0.20	0.76	0.94
Indirect Effect of MPR	**-0.0012**(-2.215)**		
SOUTH AFRICA			

GFCF	0.0962***(6.32)		
LNDR	0.0124***(7.46)	-0.0563***(-5.34)	
EXCH	-0.00284***(-3.65)		0.0178(1.19)
PSC		0.2998***(8.57)	
INF		5.0974***(6.17)	
MPR			-0.249***(-9.35)
GDPG			-0.130***(-6.53)
DPSR			0.145***(4.43)
Constant	-2.643***(-6.26)	18.803***(17.82)	29.24***(136.56)
R-squared	0.174	0.76	0.81
Indirect Effect of MPR	**-0.01***(-4.473)**		

In the parenthesis are the t-statistics. 1%, 5% and 10% significance levels are respectively denoted by *, ** and ***. DPSR is deposit rate. All the others are as previously defined.

A fall in investment is expected to occasion a decline in economic activities and eventually the price level in the economy. We therefore considered the effect of investment on inflation in the inflation equation. The results indicate that inflation declines by 0.10% and 0.096% (approximately 0.1%) in Ghana and South Africa respectively. As explained under the interest rate channel, a fall in investment slows down economic activities, fuels unemployment and exerts downward pressure on inflation in both countries.

To obtain the overall indirect effect of monetary policy on inflation, we follow the same procedure as in the interest rate channel. For Ghana, we find that inflation falls by 0.0012% following a percentage tightening of monetary policy through the lending channel. For South Africa, a percentage tightening of monetary policy reduces inflation by 0.01% through the lending channel. There is therefore an operative bank lending channel in both countries. Comparing the interest rate and bank lending channels in both countries, we observe that although the two channels are operative in the two countries, the extent of effectiveness of these channels differ in the two countries. For South Africa, we find that the lending channel delivers a larger reduction in inflation following a percentage tightening of monetary policy compared to the interest rate channel. While inflation reduces by 0.001% in the interest rate channel following a percentage tightening of monetary policy, inflation in the context of the lending channel reduces by 0.01% following a percentage tightening in monetary policy. For Ghana, we observe that whiles the interest rate channel delivers a reduction in inflation by 0.002% following a percentage tightening of monetary policy, the bank lending channel registers a 0.0012% reduction in inflation following a percentage restriction in monetary policy implying that the former (interest rate channel) is relatively more effective in Ghana. For the control variables in the bank credit equation, we find only exchange rate to be significant in the case of Ghana. Depreciation of the cedi against the dollar reduces bank credit to the private sector. For South Africa, deposit rate exerts positive effect on banking sector supply of credit as banks are motivated to lend to be able to cover cost of the funds on such deposits. We also find that growth of GDP exerts negative effect on credit to the private sector. In the investment equation, we find lending rate exerting negative effect on investment in both countries for reasons explained earlier. Prices also exert positive effect on investment in both countries for reasons indicated earlier. In the inflation equation, we find lending rate to exert positive effect and exchange rate of the respective domestic currencies exert negative effect on inflation.

Given the high r-squared in a number of the equations for both countries and in both channels, we tested for multicollinearity using the variance inflation factor (VIF). The results, in Table 3.7, indicate that our estimates do not suffer multicollinearity problems as the VIF values are far less than the threshold of 10.

Table 3.7: Variance Inflation Factor Test Results

GHANA	**VIF:** Inflation Equation	**VIF:** Investment Equation	**VIF:** Lending Rate Equation	**VIF: Bank Credit Equation**
GFCF	2.34			
LNDR	1.17	1.46		
EXCH	2.58		4.93	4.93
PSC		1.16		
INF		1.28		
MPR			4.50	4.50
GDPG			1.54	1.54
DPSR			1.57	1.57
SOUTH AFRICA				
GFCF	2.22			
LNDR	1.86	2.73		
EXCH	1.28		2.32	2.32
PSC		2.10		
INF		1.46		
MPR			5.75	5.75
GDPG			1.84	1.84
DPSR			5.20	5.20

In addition to the checks for potential multicollinearity, we also ascertained the normality of the residuals of the equations of the various channels for both countries using the Doornik-Hansen (2008) normality test. The results, in Table 3.8, indicate the residuals of the various estimations are normally distributed.

Table 3.8: Normality Test

	Channel	Test	Chi-Sq	Chi-Sq p-values
Ghana	Interest Rate	Doornik-Hansen[ǂ]	2.769	0.2504
	Bank Lending	Doornik-Hansen[ǂ]	0.510	0.7751
South Africa	Interest Rate	Doornik-Hansen[ǂ]	0.574	0.7505
	Bank Lending	Doornik-Hansen[ǂ]	4.004	0.1350

[ǂ]Doornik-Hansen (2008) normality test.

3.6.3 Robustness Checks

To test the consistency of our findings, we undertake some robustness exercise. We reckon that some other factors such as government spending and money supply are important in inflation dynamics and therefore, we vary the specifications in both the interest rate and bank lending channels. In the inflation equation, we include central government expenditure and money supply which is proxied by monetary aggregates (M2). In addition, instead of measuring exchange rate as the domestic currencies to the United States dollars, we consider the real effective exchange rate of the domestic currencies against a weighted basket of currencies of major trading partners of the two countries. Moreover, we considered a change in the sample size. Although explicit inflation targeting in Ghana started in 2007, the Bank of Ghana had actually begun implicit inflation targeting in 2002. We therefore use 2002 as the starting point of the data for both Ghana and South Africa.

Given that we are considering a different sample size, we necessarily had to test the optimal lag length of monetary policy for both countries. The results, in Table 3.9 for Ghana and Table 3.10 for South Africa, indicate that the optimal lag of monetary policy based on different lag selection criteria is two (2) for both countries. We therefore take two lags of the monetary policy variable for the purposes of the robustness estimation.

Table 3.9: Lag selection criteria for robustness – Ghana

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-173.4551	NA	16.27630	5.627585	5.661893	5.641055
1	-96.21966	149.4880	1.391694	3.168376	3.236993	3.195317
2	-86.49118	18.51550*	1.050232*	2.886812*	2.989738*	2.927223*
3	-85.90108	1.104045	1.064321	2.900035	3.037269	2.953917
4	-85.55777	0.631251	1.087294	2.921218	3.092762	2.988571
5	-85.38436	0.313256	1.116963	2.947883	3.153734	3.028705
6	-84.70851	1.199089	1.129109	2.958339	3.198499	3.052632

The * represents the lag order chosen by the criterion. HQ: Hannan-Quinn information criterion; SC: Schwarz information criterion; AIC: Akaike information criterion; FPE: Final prediction error; LR: sequential modified LR test statistic (each test at 5% level).

Table 3.10: Lag selection criteria for robustness – South Africa

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-124.2177	NA	3.324787	4.039280	4.073588	4.052750
1	-53.47251	136.9261	0.350492	1.789436	1.858053	1.816377
2	-38.75759	28.00581*	0.225196*	1.347019*	1.449945*	1.387430*
3	-38.75759	1.31e-05	0.232603	1.379277	1.516511	1.433159
4	-38.51038	0.454537	0.238362	1.403561	1.575104	1.470913
5	-37.99197	0.936489	0.242156	1.419096	1.624948	1.499918
6	-37.71852	0.485160	0.247987	1.442533	1.682693	1.536826

The * represents the lag order chosen by the criterion. HQ: Hannan-Quinn information criterion; SC: Schwarz information criterion; AIC: Akaike information criterion; FPE: Final prediction error; LR: sequential modified LR test statistic (each test at 5% level).

Having determined the lag selection, changed the measure of exchange rate and varied the specifications and the samples, we estimated the interest rate and bank lending channels for both countries. The results for the interest rate channel are reported in Table 3.11 and the results for the bank lending channel are reported in Table 3.12. Consistent with earlier findings, the interest rate and bank lending channels are operative in both countries. In the interest rate channel, a percentage restriction of monetary policy reduces inflation by 0.004% and 0.0052% in Ghana and South Africa respectively. For the bank lending channel, we find that inflation falls by 0.0023% and 0.0095% in Ghana and South Africa respectively following a percentage contraction in monetary policy in the respective countries. We also observe that consistent with the earlier results, the bank lending channel is relatively more effective in the South African context whiles the interest rate channel is more prominent in the Ghanaian context.

Table 3.11: Interest Rate Channel

GHANA	Inflation Equation	Investment Equation	Lending Rate Equation
GFCF	0.093***(6.63)		
LNDR	0.0087***(4.89)	-0.069**(-2.53)	
REER			0.0345*(1.91)
M2	-0.03435***(-6.99)		
CGE	0.0041(0.37)		

PSC		0.3143***(8.07)	
INF		9.124***(5.52)	
MPR			0.6202***(10.12)
GDPG			0.0235(0.25)
DPSR			
Constant	-1.611***(-8.77)	17.23***(15.21)	13.97***(5.98)
R-squared	0.47	0.21	0.64
Indirect Effect of MPR	**-0.004**(-2.313)**		
SOUTH AFRICA			
GFCF	0.238***(4.33)		
LNDR	0.00792***(3.72)	-0.0243***(-3.08)	
REER			-0.0646***(-8.17)
M2	-0.0896**(-2.12)		
CGE	0.00281(0.02)		
PSC		0.3682***(13.76)	
INF		2.975***(4.12)	
MPR			0.897***(29.60)
GDPG			0.401***(8.59)
DPSR			
Constant	-4.0105*(-1.73)	16.66***(20.85)	8.815***(13.52)
R-squared	0.25	0.85	0.94
Indirect Effect of MPR	**-0.0052**(-2.498)**		

In the parenthesis are the t-statistics. 1%, 5% and 10% significance levels are respectively denoted by *, ** and ***. Note: REER is real effective exchange rate, M2 is money supply (monetary aggregates), CGE is central government expenditure and all others are as previously defined.

Table 3.12: The Bank Lending Channel

GHANA	**Inflation Equation**	**Investment Equation**	**Lending Rate Equation**
GFCF	0.0901***(5.64)		
LNDR	0.0078***(5.27)	-0.0856***(-3.00)	
REER			-0.0825***(-13.12)
M2	-0.0285***(-6.28)		
CGE	-0.014(-1.32)		
PSC		0.343***(6.30)	
INF		10.55***(4.29)	
MPR			-0.0739***(-3.58)
GDPG			0.0942***(3.02)
DPSR			
Constant	-1.233***(-6.88)	16.87***(12.61)	30.67***(38.58)
R-squared	0.50	0.033	0.73
Indirect Effect of MPR	**-0.0023***(-2.699)**		

SOUTH AFRICA			
GFCF	0.252***(3.58)		
LNDR	0.00954***(4.85)	-0.03115***(-4.19)	
REER			-0.0149***(-5.32)
M2	-0.091**(-2.01)		
CGE	0.0144(0.12)		
PSC		0.331***(13.21)	
INF		3.0191***(4.47)	
MPR			-0.1137***(-10.50)
GDPG			-0.09635***(-5.87)
DPSR			
Constant	-4.674**(-2.05)	17.79***(23.81)	30.71***(132.88)
R-squared	0.23	0.85	0.82
Indirect Effect of MPR	**-0.0095***(-3.281)**		

In the parenthesis are the t-statistics. 1%, 5% and 10% significance levels are respectively denoted by *, ** and ***. Note: REER is real effective exchange rate, M2 is money supply (monetary aggregates), CGE is central government expenditure and all others are as previously defined.

3.7 Policy discussions

Monetary policy decisions are made not for their own sake but for the achievement of real sector targets. This in turn is a function of how monetary policymakers accurately gauge the transmission of such impulses to the real economy. It is therefore well acknowledged in academic and policy circles that comprehending the structure, dynamics and workings of transmission channels is a policy imperative. Although literature has, thus, dedicated substantial attention to the workings of monetary policy transmission channels, the approaches are far from the theoretical prescriptions and with simplistic assumptions that ignore complexities in the real world interactions. Our theoretically motivated approach and findings present significant policy ramifications.

For Ghana and South Africa, we unearth a step-by-step flow of monetary policy impulses to the target variable (inflation). In the case of South Africa for instance, the interest rate channel indicates that a percentage tightening of monetary policy increases the lending rate by 0.34%; a percentage increase in the lending rate reduces investment by 0.031%; a percentage reduction in investment tumbles inflation by 0.065%; and the overall effect of a percentage tightening in monetary policy on inflation is a reduction of 0.001%. The link from one stage to another has a telling on the overall effect. Essentially therefore, such systematic and stage-by-stage exposition of the transmission informs policymakers at what stage the transmission has the greatest effect and where the effect is less prominent. Understanding the strength or otherwise of the linkages between the policy decision and the overall effect on the real economy then presents a road map for policymakers to exact the desired effect.

Given the collaborative set up in the workings of inflation targeting frameworks in Ghana and South Africa, where the respective central banks work closely with their fiscal counterparts (ministries of finance) in the determination of the inflation targets, our findings unearth the complementary roles that monetary and fiscal authorities can play to achieve the inflation targets in the two countries. In Ghana for instance, the inflation target is set jointly by the fiscal and monetary authorities whiles in South Africa, the target is set by the fiscal authorities. Essentially therefore, the fiscal authorities are tied to the targeting framework. In this regard, whiles the monetary authorities can streamline the workings of the financial systems to effectively carry the monetary policy impulses to the real sector, the fiscal authorities have a critical role to play in the aspect that links the investment component to the eventual target variable of inflation. The creation of enabling business environment for firms through a number of targeted fiscal policies can go a long way to ensure that other intervening factors in the economy do not distort the effect of the monetary policy impulses carried through the financial systems to the firms and inflation eventually. Moreover, our findings that the lending channel is more effective in South Africa whiles the interest rate channel is more potent is Ghana present policy ramifications for both central banks. As indicated earlier, over 86% of assets in the banking sector is financed chiefly by deposits and other forms of liabilities. That presents substantial leverage to the South African Reserve Bank to influence how much credit the banks can extend and that can help in regulating liquidity in the economy and inflation eventually. In the case of Ghana too, the fact that the banking sector is the dominant sector in the financial system and firms necessarily have to rely on banks, a tightening of monetary policy that leads to hikes in the lending rates then discourages firms from borrowing. Decreased borrowings then limit economic activities and eventually inflation.

3.8 Conclusion

The extent to which monetary policy decisions exact the desired results in the real economy is essentially a function of the effectiveness of the channels of monetary policy transmission. Comprehending the architecture and dynamics of the workings of these channels is thus critical for the monetary policymakers as it helps them to determine how and when their decisions eventually impact the real economy and the nature of instruments to adopt. In the inflation targeting framework in particular, monetary policymakers must be well acquainted with the workings of these channels as targets are publicly announced and the public would be expected to believe that the policy authorities are capable of achieving same. Failure to gauge the transmission channels that effectively carry the policy impulses then places the achievement of the target at risk and the credibility of the authorities in particular. Given such relevance, empirical literature is, unsurprisingly, replete with phenomenal volumes of work on transmission channels of monetary policy. However, whereas the theoretical foundations of these channels point to an indirect effect of monetary policy on inflation and output, empirical literature has largely considered a more direct approach. Even those that use VAR with some theoretical assumptions in the ordering of the variables in the system, they fail to quantify the theoretically-prescribed step-by-step indirect effect of monetary policy as the focus is on impulses responses of pairs of variables. Significantly, whiles the theories prescribe important roles for aggregate demand components, empirical literature has tended to assume away such roles with consequential effect that the accompanying estimates suffer over simplicity, ignore the apparent real sector interactions and less informative in terms of the step-by-step systematic flow of the impulses right to the target variable in the real economy. We therefore revisited the monetary policy transmission mechanism through the interest rate and bank lending channels by accounting for the role of investment (a component of aggregate demand) which is at the heart of the workings of these two transmission channels. Substantially, we consider a more systematic approach to unearthing the workings of these channels and in particular we trace the theoretical prescription of the indirect effect of monetary policy on inflation. We relied on the three stage least square technique (3SLS) in a system of equations that trace the indirect effect of monetary policy on inflation through different channels. By specifying a system of equations that are simultaneously estimated, our chosen approach enables us to determine how changes in monetary policy stance eventually impacts inflation through sub components of the respective channels. The technique is robust to endogeneity and delivers consistency and efficiency in our estimates.

We find that the interest rate and the lending channels are operative in Ghana and South Africa. For the interest rate channel, a percentage contraction in monetary policy reduces overall inflation by 0.002% and 0.001% in Ghana and South Africa respectively. Specifically, a percentage restriction in monetary policy in Ghana (South Africa) increases lending rate by 0.41% (0.34%);

a percentage increase in the lending rate reduces investment by 0.074% (0.031%); and a percentage fall in investment reduces inflation by 0.055% (0.065%). For the lending channel, a percentage monetary policy restriction reduces overall inflation by 0.0012% and 0.01% in Ghana and South Africa respectively. Specifically, a percentage restriction of monetary policy in Ghana (South Africa) reduces banking sector credit by 0.022% (0.25%); a percentage fall in private sector credit reduces investment by 0.52% (0.30%); and a percentage decline in investment reduces inflation by 0.10% (0.096%). We observed that whiles the lending channel is more effective relative to the interest rate channel in South Africa, the reverse is the case in Ghana. These results are robust to different samples and specifications. The findings present important policy paradigms as to the systematic exposition of the flow of the policy impulses that helps the monetary policymakers to identify the stages at which the policy decisions exact more impact and stages where the policy effects are less prominent. Tailor-made interventions can then by instituted by the monetary and fiscal authorities in a complementary fashion to achieve the targets set by the fiscal authorities in the case of South Africa and jointly by fiscal and monetary authorities in the case of Ghana. This study has a limitation that it had to convert annual series to quarterly series for some of the variables in view of data unavailability in quarterly frequency for those variables. Future studies can consider quarterly or even monthly frequency when the data becomes available. The study could not also consider the asset price and exchange rate channels which future studies may look at.

CHAPTER FOUR

ASYMMETRY IN MONETARY POLICY-REGIONAL INFLATION NEXUS: A WAVELET-BASED QUANTILE REGRESSION ANALYSIS

4.1 Introduction

A large amount of the literature on monetary policy-inflation nexus are premised on the notion that all economic agents are confronted with homogeneous prices in the economy (Fielding & Shields, 2006) and thus situate the relationship in the context of national aggregates. Such national inflation aggregates are necessarily averages of the different prices observed in different regions of the same country. As noted by Fielding & Shields (2006), Ceglowski (2003), Cecchetti et al (2002) and Engel & Rogers (2001), different people, and for that matter different cities in a country face different prices. In this regard, situating the monetary policy-inflation nexus in the context of the national aggregates then masks the heterogeneous prices faced by different economic agents in different regions of the same country. Fielding & Shields (2006) observed that where heterogeneity exists in the prices that confront economic agents in the same economy, it presents significant ramifications for the conduct of monetary policy. Arnold & Kool (2004) argue that inflation rate differentials in different regions has implications for monetary policy that is conducted at the national level because a restrictive monetary policy may be felt differently in different regions. While it may be mildly restrictive for some regions, it may be severely restrictive for others. Indeed, such a monetary policy stance may even be accommodative for some other regions.

Anagnostou & Gajewski (2019) reckon that the effect of monetary policy, although intended to manifest at the country level, would not be the same for different locations in the same country. Regions will respond differently to changes in monetary policy as a result of differences in the structure of economies of these regions. The patterns of consumption in these regions, their industrial mix, the level of development of their respective financial sectors, performance of enterprises and the differences in demography necessarily inform the differences in the structure of these regions and for which reason monetary policy changes should not be expected to have a uniform impact across these regions (Anagnostou & Gajewski, 2019). Carlino & DeFina (1998) had made similar observations that much as monetary policy is meant to exact an effect on the whole economy, the reality is that the country is made up of different regions with differences in their responses to shocks from macroeconomic variables. Differences in the large-small firm mix across regions and the extent of their dependence on bank loans, differences in the sensitivity of industries in these regions to interest rates, and differences in banks' abilities to change their statements of financial position in the various regions are ample reasons why their respective responses to changes in monetary policy would differ. Moreover, differential responses of regions to changes in monetary policy may also result from differences in capacities of production, technological differences, differences in region-specific factors, differences in the economic agents' behaviour and differences in the economic policy implementations in these regions, especially in countries where governance is largely decentralized (Anagnostou & Papadamou, 2016).

Importantly, Carlino & DeFina (1998) point out that the nature of the theories on transmission of monetary policy themselves give an indication that different regions may be affected differently by changes in monetary policy. In the interest rate channel for instance, different firms and industries have different sensitivities to interest rates and different regions have different industrial mix. The credit channel, following the works of Bernanke & Blinder (1988) and Kashyap et al (1996), also suggest that some firms depend more on loans from banks than other firms and regions have different mix of industries and firms. Indeed, some banks have the capacity to shield their loan portfolios more than other banks (Kashyap & Stein, 1995) following restrictions on reserves through monetary policy, and banks are heterogeneous across regions.

In the light of these regional heterogeneities, the continuous focus of literature and central banking practice on general price levels, which may not reflect the reality across different regions as agents face different living costs, is problematic and may elicit sub optimality in monetary policy conduct and the overarching objective of welfare maximization. Theoretically, authors such as Gros & Hefeker (2002) and De Grauwe (2000) have demonstrated that when monetary policy rule disregards regional differentials in the face of transmission asymmetry, welfare losses would be the natural consequences (Fielding & Shields, 2006). Fratantoni & Schuh (2003) argue that for monetary policy efficiency, recognizing differences across regions are of great importance.

Although literature on monetary policy and asymmetric regional responses exist, they are largely focused on differential regional output responses to monetary policy shocks (Anagnostou & Gajewski (2019); Anagnostou & Papadamou (2016); Ridhwan et al (2014); and Carlino & DeFina (1998, 1999). Other contexts include monetary policy and regional housing equity and refinancing of mortgages in the United States (Beraja et al, 2017); monetary policy, credit availability and cost in the regions of the United Kingdom (Dow & Montagnoli, 2007); monetary policy and regional housing market in the United States (Fratantoni & Schuh, 2003); monetary policy and general macroeconomic variables (Fraser et al, 2014; and De Lucio & Izqueirdo, 1999); monetary policy and employment (Svensson, 2012); and monetary policy and real variables (Xiaohui & Masron, 2014). However, studies on monetary policy and responses of regional inflation remain limited in the empirical literature. Meanwhile, differential responses of regional inflation to monetary policy pose a critical challenge in the context of inflation targeting countries where such differences could potentially undermine the achievement of the publicly announced national target with dire consequences for credibility of policymakers.

Few studies, such as Fischer et al (2018), Aastveit & Anundsen (2017), Yang et al (2010) and Del Negro & Otrok (2007) have considered monetary policy and regional prices but only in the context of housing prices as opposed to total regional consumer prices. Meanwhile, the prices that economic agents face in the various regions of the country go beyond just the housing prices. Beck et al (2006) studied factors that explain inflation at the regional levels of selected countries in the Euro area but fell short of an explicit relationship between monetary policy and these regional prices. Choi et al (2015) considered the effect of the adoption of inflation targeting framework on regional inflation in South Korea as opposed to the impact of changes in monetary policy on regional inflation. Nagayasu (2010) studied factors that explain regional prices in China but not the heterogeneous responses of regional inflation to monetary policy changes. Alagidede et al (2014) considered persistence in regional and sectoral inflation in Ghana as opposed to the responses of regional inflation to changes in monetary policy.

To the extent that we know, the only two studies that have looked at responses of regional prices (inflation) to changes in monetary policy are Fielding & Shields (2006) in the context of South Africa and Fielding & Shields (2007) in the context of the United States. These studies are, however, limited in a number of ways. Fielding & Shields (2006) considered a hypothetical monetary policy as opposed to actual monetary policy changes with the limitation that the results obtained may be far from reality in terms of actual policy dynamics. Fielding & Shields (2007) considered the context of law of one price and how monetary policy itself contribute to the heterogeneity in regional prices. Moreover, the authors studied cities in the United States as opposed to full-fledged regions.

In addition, while these studies underscore the policy and welfare fatality of assuming homogeneity in the effect of monetary policy on the inflation of regions of a country, they surprisingly assume that the relationship between each region's inflation and monetary policy is symmetric throughout the distribution of the former. Thus, while they capture heterogeneity between regions, they overlook the heterogeneity in the relationship between monetary policy and each region's inflation. Meanwhile, the fact that monetary policy behaviour and effect, and indeed macroeconomic variables, exhibit asymmetry is well known in the literature (Liu et al, 2018; Caporale et al, 2018; Ahmad, 2016; Martin & Milas, 2013). Moreover, the economic processes of the regions are not static over time nor simplistic to expect that each region's inflation response to monetary policy remains the same across time. Importantly, if recognition of heterogeneity between regions in respect of their responses to monetary policy is crucial for policy coherence and welfare maximization, then capturing the appropriate relationship between monetary policy and each region's inflation is even more critical.

Moreover, these studies have been conducted in pure time domain that overlooks the fact that the objectives of central banks differ across long- and short-term horizons and these objectives simultaneously operate at varying scales. As argued by Aguiar-Conraria et al (2008), different economic agents take various actions with varying objectives over different horizons and it is these varying actions and objectives that inform various economic processes. As a result, time series data on various macroeconomic variables are necessarily an amalgamation of these varying objectives and horizons of economic agents. Consequently, the effect of monetary policy, for instance, would naturally differ across different horizons and frequencies. Such intricate relationship between monetary policy and other macroeconomic variables may be difficult to unearth with econometric methods that are either exclusively frequency-domain or exclusively time-domain (Aguiar-Conraria et al, 2008). Significantly, Aguiar-Conraria et al (2018) reckon that the effect of monetary policy across various horizons and particularly the cyclical frequencies should be of interest to policymakers as social welfare may be affected differently when fluctuations occur across distinct frequencies.

We make significant contributions to the monetary policy-regional inflation nexus. We consider a multi-faceted approach to capturing asymmetry in the effect of monetary policy on regional inflation in Ghana and South Africa as we unearth not just the relationship across time and frequency but also across distinct quantiles of the distributions of the respective regional inflation using the wavelet-based quantile regression technique for the first time in the literature on monetary policy and regional inflation. Whiles the quantile regression enables us to examine the monetary policy-regional inflation nexus at low, moderate and high inflationary episodes across the various regions and provinces, the decomposition of the data using the wavelet approach enables us to capture these varying monetary policy-regional inflation relationships in time and frequency domains. Such multi-layered asymmetric exposition provides a far more nuanced information that are invaluable in informing monetary policy stance.

We find that not only are the responses of the regional/provincial inflation to monetary policy distinct when compared to each other across scales and quantiles, but same region's/province's inflation respond to monetary policy differently at distinct quantiles and horizons. The findings are robust to different specifications. Section 4.2 considers the heterogeneous structure of the economies of the regions/provinces of Ghana and South Africa. Section 4.3 looks at the differential regional/provincial inflation in both countries whiles section 4.4 covers review of relevant literature. Section 4.5 covers our methodology and section 4.6 presents our empirical findings, discussions and robustness checks. We discuss policy ramifications in section 4.7 and conclude in section 4.8.

4.2 Structure of the economies of regions/provinces in Ghana and South Africa

Following the argument in the literature that when regions of a country differ, their responses to changes in monetary policy necessarily differ (Anagnostou & Gajewski, 2019; and Carlino & DeFina, 1998), we provide stylized facts on the economies of provinces in South Africa and regions in Ghana. There are nine provinces in South Africa, namely Western Cape, North West, Northern Cape, Mpumalanga, Limpopo, KwaZulu-Natal, Gauteng, Free State and the Eastern Cape. Ghana, following a referendum on December 27, 2018 on the creation of six new regions, now has sixteen (16) regions. These are Ahafo, Ashanti, Bono East, Brong Ahafo, Central, Eastern, Greater Accra, Northern, North East, Oti, Savannah, Upper East, Upper West, Volta, Western and Western North. The six new regions, which were sliced from four existing regions, include Ahafo, Bono East, North East, Oti, Savannah and Western North. North East and Savannah were sliced from the Northern region whiles Ahafo and Bono East were delineated from the Brong Ahafo region. The Oti region came out of the Volta region and Western North was demarcated from the Western region. As the six regions are new and have no separate data available on them, we focus on the regions prior to the new creations. Indeed, because these new regions were sliced from the old regions, the data we use necessarily covers the new regions.

4.2.1 Provincial output differences in South Africa

We rely on the annual and quarterly provincial GDP data released by Statistics South Africa to provide an insight into the distinctiveness of the various provinces of South Africa. Between 2000 and 2017, the Gauteng province consistently contributed more than a third of the gross domestic product (GDP) of South Africa, peaking at approximately 35% of the country's GDP in 2016. The second largest contributor to the country's GDP is the KwaZulu-Natal (KZN) province which has also contributed more than 15% of the country's GDP since 2000 with a peak of 16.1% in 2017. This is followed by the Western Cape province with a minimum contribution of 13% of GDP since 2000 and a peak of 13.9% in 2016 and 2017. These three provinces together contributed an average of 63% of the country's GDP since 2000 with Gauteng province alone contributing an average of 33.9% or 34% approximately to the national economy. The remaining six provinces (Eastern Cape, Northern Cape, Free State, North West, Mpumalanga and Limpopo) together contributed an average of 37% to the country's GDP since 2000 which is only 3% more than the contribution of Gauteng province alone. Indeed, the combined economic contributions of any five provinces out of these six provinces is less than that of the Gauteng province alone. For instance, between 2000 and 2017, the *highest* combined contributions of Eastern Cape, Northern Cape, Free State, North West and Limpopo to the real GDP of South Africa was 32% in the year 2000. Meanwhile, the *minimum* contribution of the Gauteng province *alone* over the same period was 32.8% in the same year 2000 which is 0.8% more than the *highest* combined contribution of the five provinces. Similarly, the *highest* combined contributions of Mpumalanga, Eastern Cape, Northern Cape, Free State and North West was also 32% in 2000 and 2001 over the period 2000 – 2017 which is again 0.8% less than the *minimum* contribution of Gauteng province *alone* over the same period.

The key economic sub sectors of South Africa are finance, trade (wholesale and retail), agriculture, mining, manufacturing, transportation and construction. The concentration of these sub sectors differ from province to province. The Gauteng province controls more than 40% of the value added of the country's financial sector, more than 30% of the trade sector, more than 35% of the transportation sector, more than 30% of the construction sector and more than 40% of the manufacturing sector. The only two sectors where the Gauteng province does not exert dominance are the agriculture and mining. In the agricultural sector, the KZN province leads the pack in terms of contribution to the national basket with an average of 28% over the period 2000 – 2017. KZN is followed by the Western Cape province with an average contribution of 22.2% to the national agricultural sector. Indeed, Mpumalanga and Free State provinces are ahead of the Gauteng province in terms of the agricultural sector contributions. In the mining sector, North West province dominates. It is then followed by Mpumalanga, Limpopo and Gauteng provinces. Over the period 2000 – 2017, North West contributed an average of 24% to the mining sector followed by 21% from Mpumalanga, 20% from Limpopo, 12% from the Gauteng province and 7% from the Northern Cape. The Gauteng province has witnessed a nose dive in its contribution to the mining sector over the period under review, particularly from the year 2006. Indeed, it was from 2006 onwards that Limpopo province overtook the Gauteng province in terms of contribution to the mining sector of South Africa. Since 2011, the contribution of Limpopo province to the mining sector has been more than any other province. In 2017 for instance, Limpopo's contribution to the mining sector was a whopping R86,910 million representing 37.1% of the total value added in the mining sector.

Apart from the differences in the provincial contribution to the national output and sectoral baskets, there is also considerable differences in the intra-province sectoral contributions. The economy of Western Cape is dominated by sub sectors such as finance, manufacturing, trade, transportation, agriculture and construction. Specifically, the financial sub sector (which also includes real estate and business services) dominates the economy of Western Cape province with an average annual contribution of 28% to the overall real output of the province (excluding taxes and subsidies) between 2000 and 2017. This is followed by 17% from the manufacturing sub sector, 16% from trade (including catering services and accommodation), 10% from the transportation sub sector (including storage and communication), 4.4% from the agriculture sub sector and 3.9% from the construction sub sector. For the economy of Eastern Cape, four main sub sectors are prominent. These are trade, finance, manufacturing and transportation. The trade sub sector, between 2000 and 2017, contributed an average of 20% to the economy of Eastern Cape (excluding taxes and subsidies). This is followed by 19.3% from the financial sector, 14.6% from the manufacturing sector and 8.7% from the transportation sector over the same period.

The economy of Northern Cape province is relatively small and dominated by mining activities. The mining sector contributed an average of 30.5% to the real output (excluding taxes and subsidies) of the economy of the Northern Cape province between 2000 and 2017. The second prominent sector in the province is the financial sector which contributed an average of 12.8% over the same period. This is followed by 11.9% from the trade subsector, 9.5% from transportation sector and 7.3% from agriculture. The economy of Free State province, on the other hand, is dominated by the trade sector with an average contribution of 17.2% to the province's economy. This is followed by 15.3% from the mining sector, 14.7% from the finance sector, 10.9% from the manufacturing sector, 8.6% from the transportation sector and 4.7% from agriculture. For the KwaZulu-Natal province, the manufacturing sector is the major contributor to the province's economy with an average of 19.7%. This is followed by 17.2% from the finance sector, 15.4% from trade, 12% from transportation and 4.7% from the agricultural sector.

The economy of North West province thrives heavily on the mining sector. Over the period 2000 – 2017, the mining sub sector contributed an average of 36.6% to the economy of the province. A distant second is the finance sector with an average contribution of 12.4%. This is followed by 11.8% from the trade sector, 5.9% from manufacturing and 5.7% from transportation sector. The economy of the Gauteng province, the largest in South Africa, is dominated by finance, manufacturing, trade, transport and mining sectors. The finance sector leads the pack with an average contribution of 24.8% to the province's economy. This is followed by 17.8% from the manufacturing, 13.4% from trade, 9.8% from transport and a distant 3.7% from the mining sector. Indeed, the three key sectors (finance, manufacturing and trade) contribute 56% of the real output of the province. For Mpumalanga province, the dominant sector is the mining sector with an average contribution of 27.5% to the real output of the province between 2000 and 2017. Trade sector follows with 14.5% and manufacturing with an average of 13.4%. The rest are the finance sector with 11.5% contribution on the average over the same period, 5.8% from transport and 3.3% from the agricultural sector. Although sectors such as transport, manufacturing and agriculture are prominent in the economy of the Limpopo province, with respective average contributions of 4.5%. 3% and 2.8% to the real output of the province between 2000 and 2017, the three key drivers of the economy of Limpopo are rather mining, trade and finance. The mining sector contributed an average of 30.9% over the period 2000 – 2017 to the real output of the province. This is followed by 15.2% from the trade and 14.2% from finance. The three sectors (mining, finance and trade) contributed a combined 60.3% on the average.

4.2.2 Regional heterogeneity in Ghana's economic sectors

Unlike South Africa, we do not have the complement of time series data on the output of the various regions of Ghana. The Ghana Statistical Services only publishes regional inflation data. In 2015, however, the Ghana Statistical Service, with financial support from the World Bank, the government of the Netherlands, the United Kingdom's Department for International Development (DFID) and the government of Ghana, conducted a survey of all the sectors in Ghana. The report provided a detailed sectoral structure across the then ten (10) regions of Ghana. We rely on this report in providing an insight into the regional economies in Ghana.

The Ashanti region dominates the agricultural sector with a contribution of 30.2% of the revenues of the sector. Western region is a close second with 27.8% of the sector's revenues. Northern region is third with 23.2% of the revenues of the agricultural sector in Ghana. The three regions (Ashanti, Western and Northern) together control a colossal 81.3% of the revenues from the agricultural sector of the country and a clear indication of the fact that the three regions provide the food basket of the economy. The Greater Accra region, home to the nation's capital, controls 10.1% of the revenues from the agricultural sector. The region is home to one of the vibrant fishing industries in Ghana with fishing as the mainstay of folks living along the sea coast of Accra. Interestingly, the remaining six regions combined (Central, Volta, Eastern, Brong Ahafo, Upper East and Upper West) control just 8.5% of the revenues from the agricultural sector.

In the industrial sector, the Greater Accra region alone delivers 65% of the revenues from the sector, which is 30% more than the other nine regions combined. That is not surprising though as the region is home to the national capital with concentration of major, if not all, of the key industrial undertakings. Indeed, the national capital is the industrial heartbeat of the economy. The Western region, home to the nation's oil economy, is the distant second with 14.5% of the revenues from the industrial sector. Eastern region follows with 6.6% whiles Ashanti region holds 5.7% of the industrial sector revenues. The remaining six regions (Central, Volta, Brong Ahafo, Northern, Upper East and Upper West) together control a meagre 8.2% of the industrial sector revenues.

For the services sector, the Greater Accra region again controls as much as 70.6% of the sector's revenues, more than twice the size of the service sector revenues from the other nine regions combined. This is also not surprising especially because the head offices of most, if not all, of the major service institutions such as banks, insurance companies, telecommunication companies, hotels, transport companies and a host of others are located in the capital Accra. The other regions only get branches after a certain number of years of operations in the capital. The Ashanti region is distant second with 13.4% of revenues from the services sector. The region is home to the nation's second largest city (Kumasi) and therefore tends to be one of the first cities for location of branches by the companies with head offices in Accra. Additionally, the region links the North-South divide in Ghana and therefore very strategic for the inter-regional trade and transport of commodities. The Greater Accra and Ashanti regions combined then control 84% of the services sector in the country. Western region is a farther third with 4.1% of the revenues from the services sector whiles the Brong Ahafo has 3%.

Apart from the differences between regions, we also observe heterogeneity in the intra-regional sectoral contributions. The economy of the Western region is dominated by the industrial sector largely on the back of the oil activities in the region. Revenues from the industrial sector was GHS 19.3 billion over the survey period. The services sub sector follows with GHS 13 billion whiles the agricultural sector is a distant third with revenues of GHS 1.53 billion over the same period. For the economy of Central region, the services sector is rather more prominent than the other sectors with revenues of GHS 7.7 billion. This is not surprising, given the vibrant educational services subsector in the region. The Central region boasts of some of the nation's Ivy League high schools and home to the only two education-biased public universities in Ghana (University of Education at Winneba and the University of Cape Coast at Cape Coast). Meanwhile, industrial sector revenues was GHS 1.66 billion and the agricultural sector is a farther third with GHS 60.7 million.

The Greater Accra region is dominated by the services sector on the back of the presence of head offices of all commercial banks, insurance companies, telecommunication giants and hotels in the country. The services sector recorded a revenue of GHS 224.8 billion which is more than twice the value of the revenues from the industrial sector of the region (GHS 86.6 billion). The agricultural sector generated a relatively meagre revenue of GHS 555.75 million. In the Volta region, the services sector leads the pack with revenues of GHS 2.8 billion which is closely followed by the industrial sector with revenues of GHS 2.65 billion. The agricultural sector is the least in the region with revenues of GHS 41.99 million. For the Eastern region, the industrial sector is more prominent with revenues of GHS 8.8 billion whiles the services sector recorded GHS 5.6 billion over the same period. The agricultural sector was the third with revenues of GHS 108.7 million.

The economy of the Ashanti region is largely propelled by the services sector which recorded total revenues of GHS 42.8 billion over the survey period. It is the region of first consideration for location of branches by institutions that are headquartered in Accra. Indeed, most institutions locate offices in Kumasi (Ashanti regional capital) to serve the middle and northern parts of the country. The industrial sector is the second in the region with revenues of GHS 7.55 billion. The agricultural sector is third with revenues of GHS 1.66 billion.

The Brong Ahafo and Northern regions have similar characteristics with dominance of the services sector, followed by the industry and then agriculture. However, the extent of dominance of each of these sectors differ. In the Brong Ahafo region, the revenues from the services sector was GHS

9.6 billion whiles that of the Northern region was GHS 5.7 billion. In the industrial sector, however, the revenues from the Northern region (GHS 3.6 billion) was more than the revenues from the Brong Ahafo region (GHS 1.98 billion). Similarly, the agricultural sector in the Northern region generated revenues of GHS 1.3 billion compared to only GHS 251.5 million in the Brong Ahafo region. The Upper East and Upper West regions also exhibit similar characteristics just as Brong Ahafo and Northern regions. The services sector is the dominant sector in the two upper regions although Upper East (with revenues of GHS 4.4 billion) dominates Upper West (GHS 2 billion). This is followed by the industrial sector and then agriculture. In the industrial sector, the Upper West (with revenues of GHS 514.6 million) dominates Upper East (with revenues of GHS 482.86 million). Similarly, the Upper West dominates the Upper East in the agricultural sector with respective revenues of GHS 3 million and GHS 1.75 million.

4.3 Regional and provincial inflation

Given the heterogeneity in the structure of the economies of the regions (Ghana) and provinces (South Africa), the prices in these regions/provinces would necessarily differ. Indeed, the regions/provinces have different weights in the national inflation basket. In Table 4.1, we show the various weights of the regions/provinces in Ghana and South Africa. In Ghana for instance, the Greater Accra region alone has a weight of more than a quarter of the national inflation basket. In South Africa, the weight of the Gauteng province is more than a third of the national inflation basket.

Table 4.1: Regional and provincial weights in national inflation baskets

Region (Ghana)	Weight in National CPI	Province (South Africa)	Weight in National CPI
Western	10.5%	Eastern Cape	8.04%
Central	9.6%	Free State	5.93%
Greater Accra	25.8%	Gauteng	36.25%
Eastern	5.95%	KwaZulu-Natal	12.70%
Volta	13.2%	Limpopo	5.7%
Ashanti	19.3%	Mpumalanga	6.89%
Brong Ahafo	7.2%	Northern Cape	1.93%
Northern	5.7%	North West	5.31%
Upper East	1.8%	Western Cape	17.25%
Upper West	0.9%		

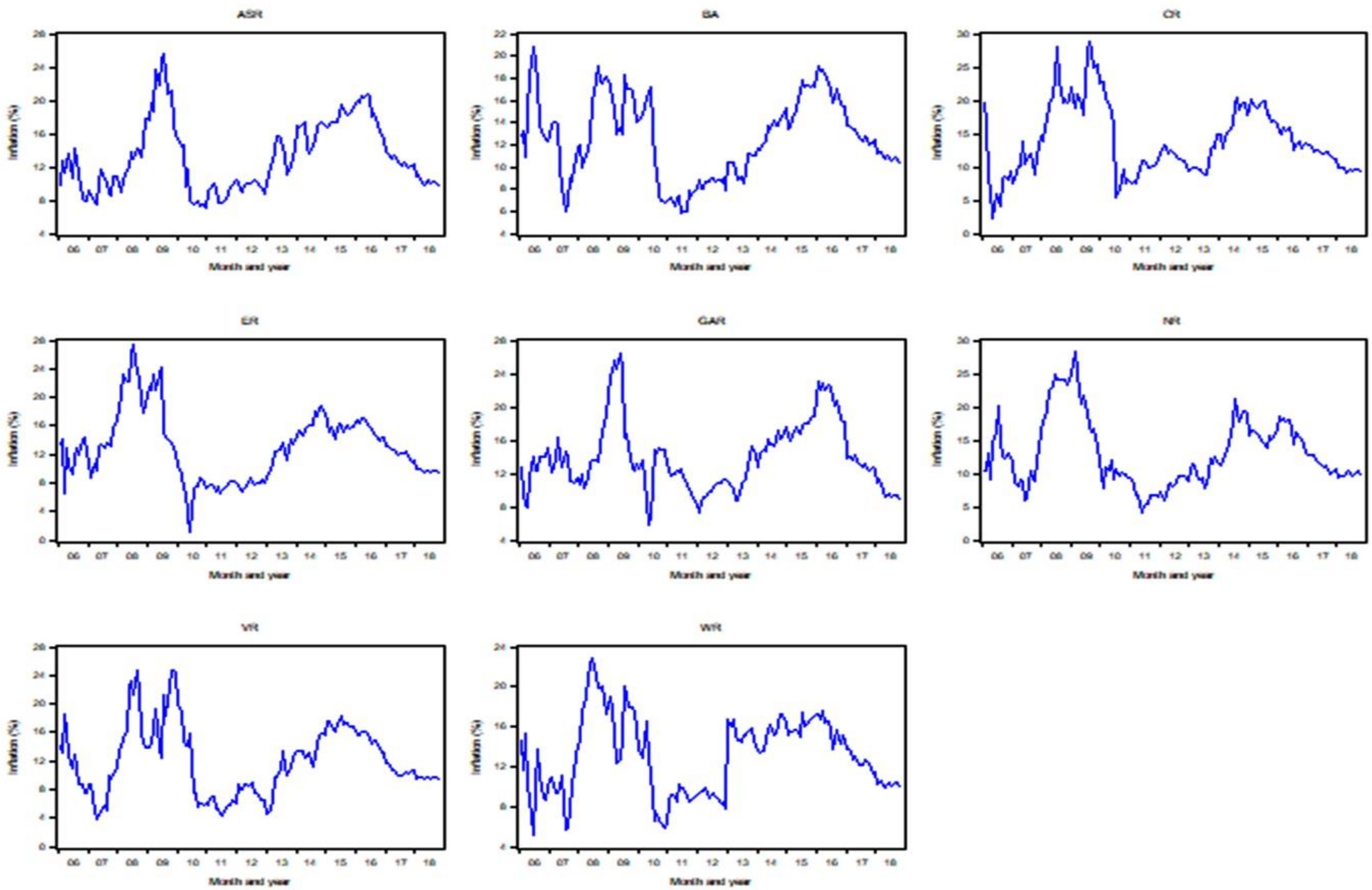
This implies that economic agents within the same country do not face the same prices. As Table 4.2 and Figures 4.1 to 4.4 show, prices in the various regions/provinces have differed over the period from each other and from the national average.

Table 4.2: Differences in regional and provincial inflation

Region/Province	Mean	Minimum	Maximum	Std. Deviation
Ghana				
Ashanti	13.23	7.1	25.5	4.22
Brong Ahafo	12.60	5.8	20.8	3.62
Central	13.82	2.3	28.9	5.24
Eastern	13.00	1.0	27.5	4.73
Greater Accra	13.90	5.7	26.5	4.12
Northern	13.08	4.2	28.3	5.10
Volta	12.04	3.8	24.7	4.87
Western	13.10	5.1	22.9	3.86
National	**13.16**	**8.4**	**20.7**	**3.61**
South Africa				
Eastern Cape	6.21	3.01	14.63	2.21
Free State	6.17	3.35	13.40	1.98
Gauteng	5.93	3.10	13.21	1.93
KwaZulu-Natal	6.00	2.46	14.19	2.36
Limpopo	6.19	2.41	14.24	2.54
Mpumalanga	6.15	3.03	15.04	2.48
Northern Cape	5.90	2.73	14.73	2.34
North West	6.02	2.75	15.65	2.61
Western Cape	6.17	2.61	14.14	2.07
National	**5.69**	**1.72**	**11.62**	**1.74**

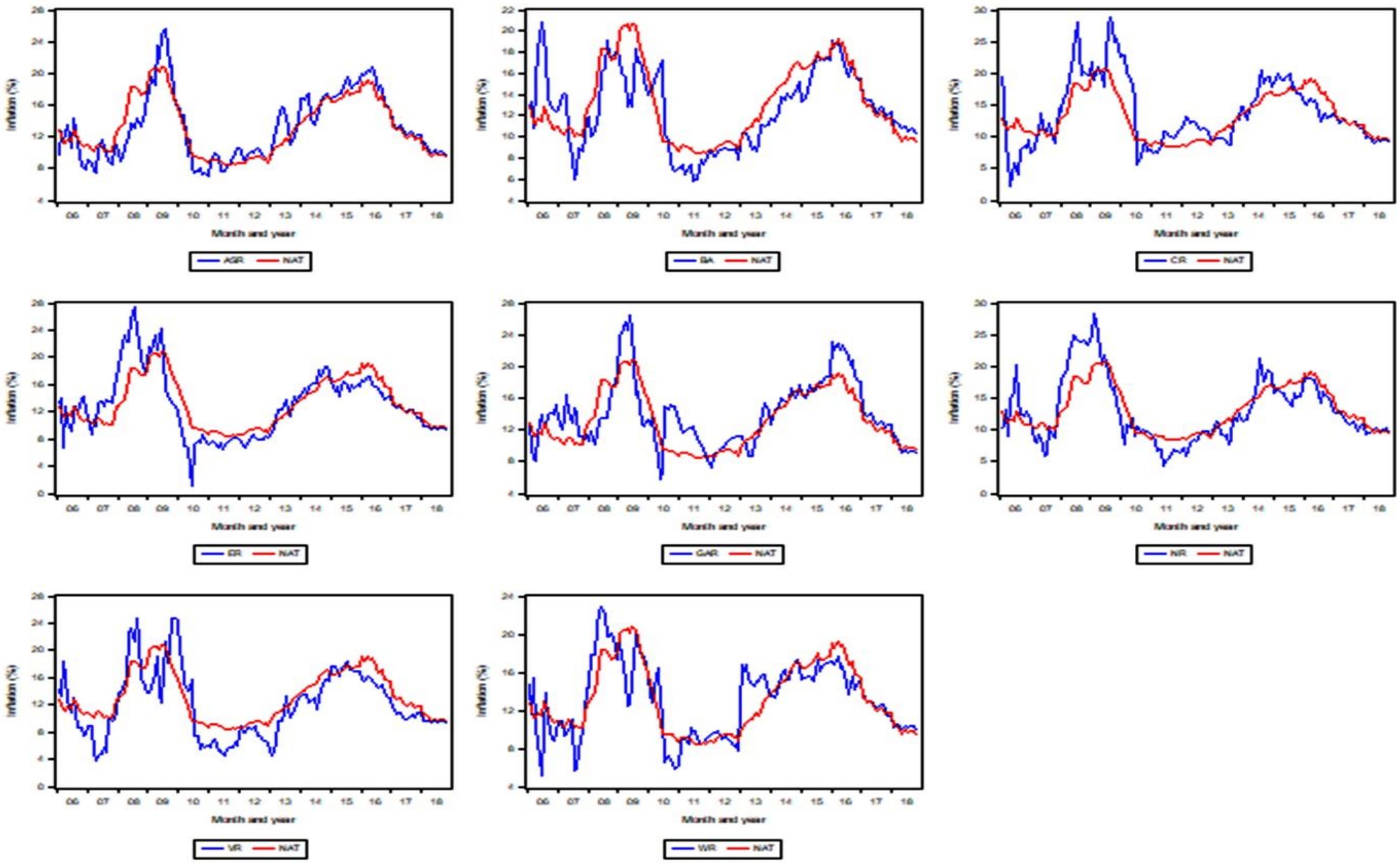
In the case of South Africa, over the period under review (2006 – 2018), the average inflation in the country was 5.69%, just 0.31% below the upper band of the target inflation range of 3% - 6%. Meanwhile, the average inflation rates for Eastern Cape, Free State, Limpopo, Mpumalanga, North West and Western Cape exceeded the upper band of the inflation target over the same period. The average inflation rate in KwaZulu-Natal was exactly the upper band of 6% whiles the rates in Gauteng and Northern Cape were within the target band. North West province exhibited the greatest volatility in inflation rates with maximum inflation over that period more than twice the upper band of the target range. This is followed by Limpopo and then Mpumalanga. For Ghana, the average inflation over the same period was 13.16% with Greater Accra, Central and the Ashanti regions recording inflation rates above the national average. The remaining seven (7) regions recorded average inflation rates below the national average. Central region exhibited the greatest volatility over the period with inflation rate swinging between 2.3% and 28.9%. This is followed by the Northern region and then the Volta region. The national and regional inflation averages were well above the upper band of the target range of 6% - 10%.

Figure 4.1: Plots of regional inflation series – Ghana



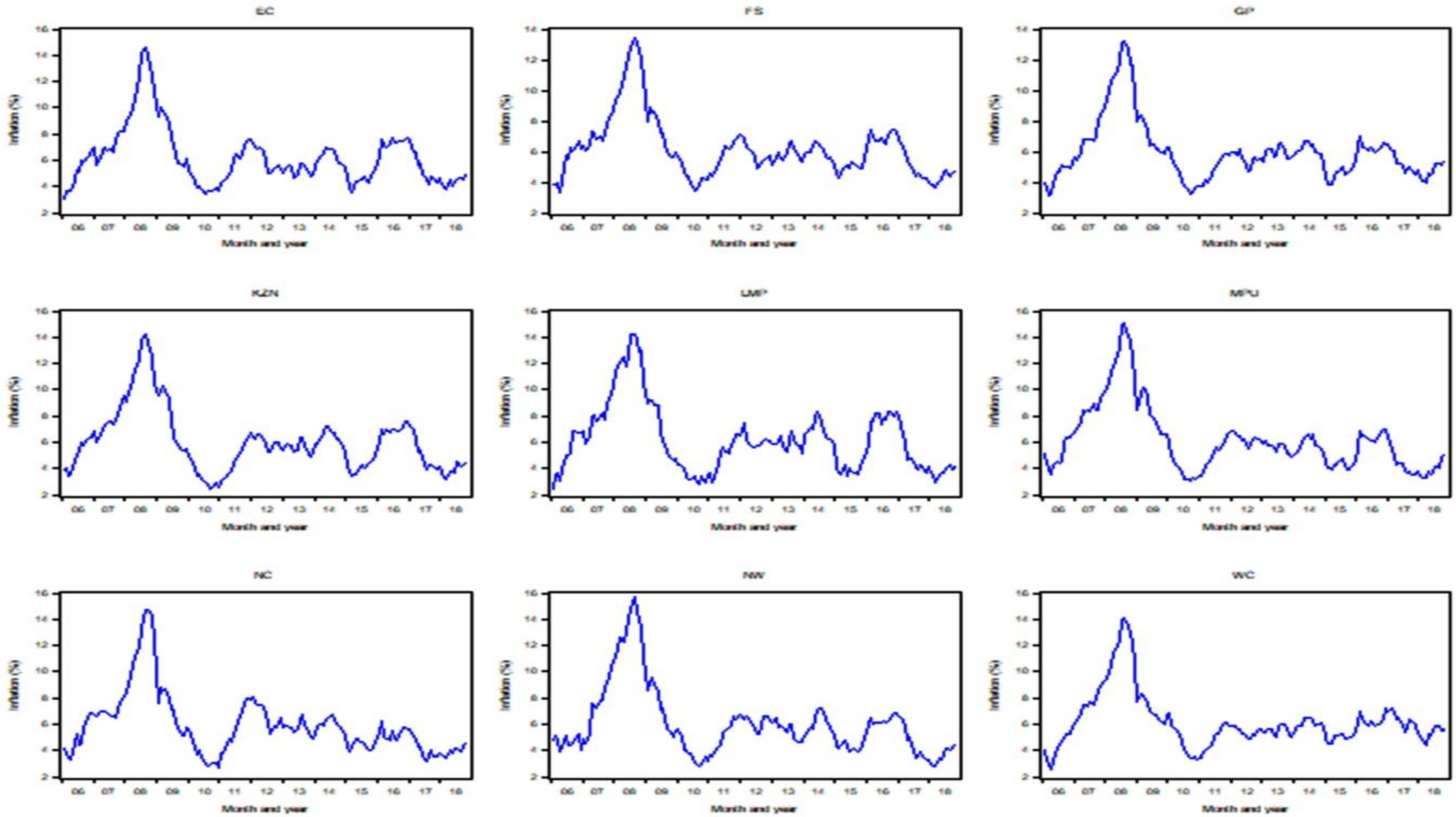
Note: ASR= Ashanti region, BA= Brong Ahafo region, CR= Central region, ER=Eastern region, GAR= Greater Accra region, NR=Northern region, VR= Volta region, WR= Western region.

Figure 4.2: Regional inflation versus national inflation – Ghana



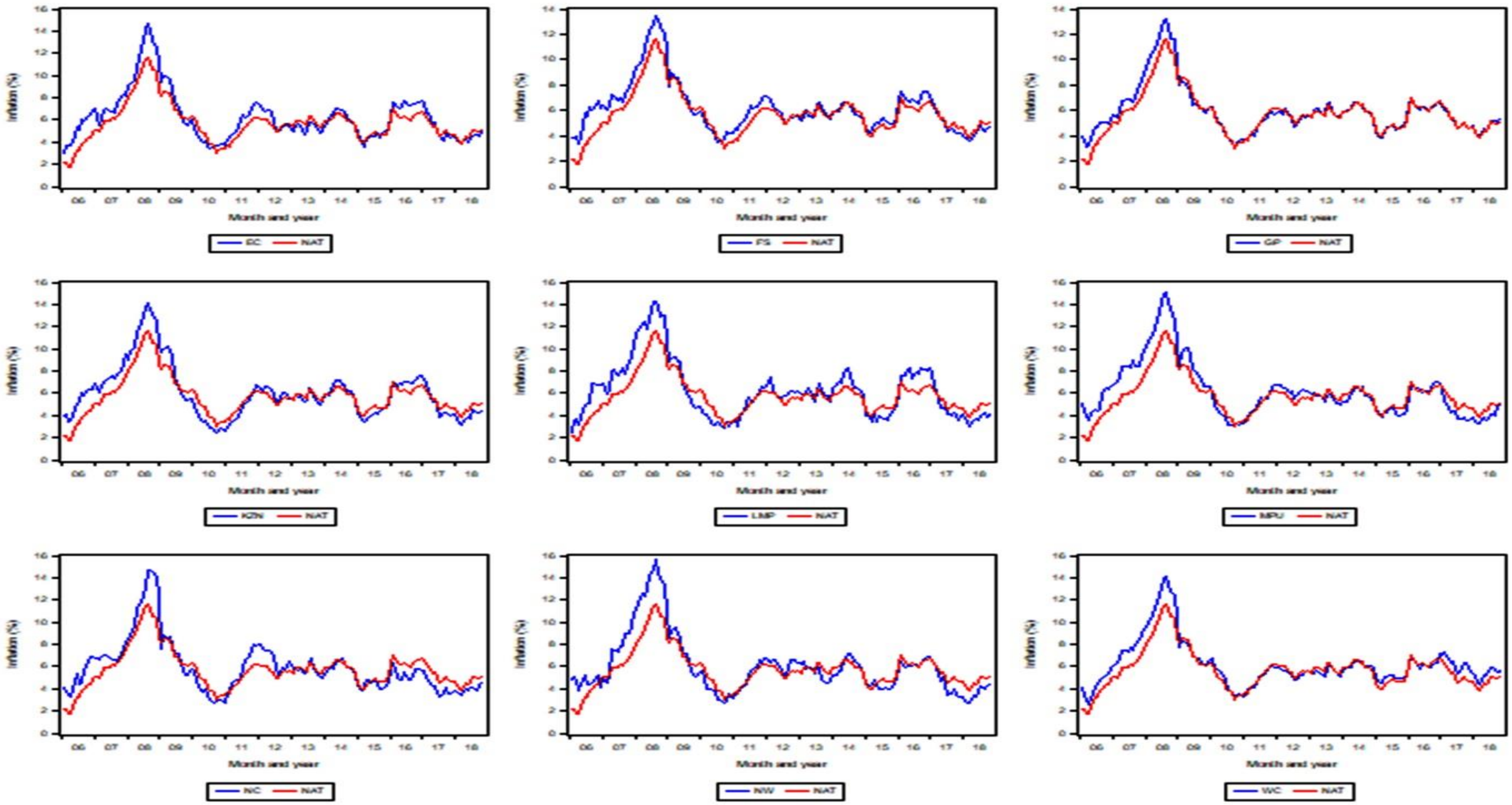
Note: ASR= Ashanti region, BA= Brong Ahafo region, CR= Central region, ER=Eastern region, GAR= Greater Accra region, NR=Northern region, VR= Volta region, WR= Western region, NAT= National.

Figure 4.3: Plots of provincial inflation series – South Africa



Note: EC= Eastern Cape, FS= Free State, GP= Gauteng province, KZN= KwaZulu-Natal, LMP= Limpopo, MPU= Mpumalanga, NC = Northern Cape, NW = North West, WC = Western Cape.

Figure 4.4: Provincial inflation versus national inflation – South Africa



Note: EC= Eastern Cape, FS= Free State, GP= Gauteng Province, KZN= KwaZulu-Natal, LMP= Limpopo, MPU= Mpumalanga, NC= Northern Cape, NW= North West, WC= Western Cape, NAT= National.

Clearly, the regions/provinces have different inflation rates and trends. The inflation rates of the various regions/provinces also differ from the national inflation of the respective countries, a fact that shakes the very foundation of the large amount of literature on the monetary policy-inflation nexus that assume that consumers across the country face homogeneous prices. Importantly, the conduct of monetary policy that targets a national average inflation then runs the risk of missing such a target in the face of price heterogeneity across regions with deleterious consequences for anchoring inflation expectations. Economic agents in the same country do not face the same prices and so monetary policy effect on inflation would necessarily differ across regions. The extent of such differential effect of monetary policy is an empirical question we investigate.

4.4 Literature Review

The asymmetric responses of regional inflation to monetary policy is grounded in the theories of monetary policy transmission channels. As noted by Carlino & DeFina (1998), the nature of the theories on transmission of monetary policy themselves give an indication that different regions may be affected differently by changes in monetary policy. We, thus, provide the theoretical expositions on the monetary policy transmission channels by drawing on the works of Mishkin (1996) and Boivin et al (2010).

4.4.1. The interest rate channel

Monetary policy changes cause real interest rates to change which then impacts the borrowing cost of firms, their investment demand and output eventually. As observed by Anagnostou & Gajewski

(2019), the extent of the effect on the investment demand of firms is a function of how sensitive these firms are to interest rate changes. Some firms, and indeed industries, exhibit more sensitivity to interest rate than others. Firms engaged in manufacturing and construction are said to have high sensitivity to interest rate changes (Anagnostou & Gajewski, 2019; and Carlino & DeFina, 1998). As a consequence, in regions where firms in these sectors are concentrated, the response of such regions' inflation to changes in monetary policy would substantially differ from the other regions.

4.4.2. The credit channel

This channel is based on the idea that banks are better placed to surmount the problem of information asymmetry inherent in the financial markets. This therefore gives banks a critical role to play in the credit channel. The argument, following the work of Kashyap & Stein (1995), is that when monetary policy changes, it affects deposits of banks and their ability to extend loans. The effect on loan volumes then affects firm investment and output eventually. Some banks, by virtue of their size, may not depend entirely on deposits for the purposes of loan extension. They are able to raise some funds from sources other than deposits and so can shield their loan portfolios from monetary policy shocks. Other banks depend heavily on deposits and so monetary policy shocks directly limit their capability to extend credit. As banks differ in sizes across regions, monetary policy shocks would affect different banks in different regions differently and the overall responses of these regions. The other argument, following the work of Kashyap et al (1996), is that some firms depend more on loans from banks than other firms and regions have different mix of industries and firms. Firms of large size are capable of securing funding from sources other than bank loans while firms of smaller size depend almost exclusively on bank loans. In regions where firms are relatively small, monetary policy shocks that inhibit bank lending then severely affects the investment plans of these firms.

4.4.3. The exchange rate channel

This channel gained prominence as economies are becoming more integrated with each other and as countries adopt flexible exchange rate regimes. The exchange rate channel involves net exports and the role of interest rates (Mishkin, 1996). In the workings of this channel, when real interest rates in the domestic country decreases, deposits and other investments denominated in the domestic currency become less attractive compared to investments and deposits denominated in foreign currencies in relative terms. This, in turn, causes the domestic currency to depreciate relative to other currencies. The exports of the domestic country become cheaper in the international market which leads to more export revenues, high net exports and then output eventually. Just as different countries are distinct in their degree of openness, regions within the same economy could equally differ. While some regions may be dominated by export oriented firms, others may be swamped by import-dependent firms. Other regions may even have little or no contribution to the nation's international trade. As a result, different regions would necessarily differ in their responses to changes in monetary policy.

4.4.4. Drivers of regional inflation heterogeneity and monetary policy

Carlino & DeFina (1998; 1999) and Fielding & Shields (2007) provide plausible reasons that inform asymmetry in regional responses to monetary policy. These are outlined below:

- *The nature of sensitivities of industries to interest rates*

Different industries exhibit different sensitivities to interest rates. Manufacturing and construction concerns are known to be more sensitive to interest rate. As a result, in regions where these industries are concentrated, their response to changes in monetary policy would necessarily be more prominent than regions where these industries are few.

- *Size of firms*

On the back of the works of Bernanke & Blinder (1988) and Gertler & Gilchrist (1993), firms of smaller size are known to be heavily dependent on loans from banks than firms of large size since the latter are capable of attracting funding sources other than bank loans. Where monetary policy directly affects bank loans, the resultant cost and availability concerns are more prominent for smaller firms. In this regard, where smaller firms dominate in a particular region relative to others, the effect of monetary policy in the smaller firm-concentrated regions would be more pronounced.

- *Size of banks*

Following the work of Kashyap & Stein (1995), literature has come to acknowledge that changes in monetary policy do not exert homogeneous effect on all banks. The argument is that a contractionary monetary policy that restricts reserves is likely to impact smaller banks more than bigger banks since the latter are better positioned to shield their loan portfolios through sources other than deposits. As a result, regions that are home to smaller banks are most likely to experience greater impact of monetary policy changes than the other regions.

- *Prices of houses*

In regions where values of housing properties are high, they exhibit larger sensitivity to changes in interest rates than other regions where values of similar properties are low (Fielding & Shields, 2007). The argument is that lower values of housing properties limit refinancing opportunities when interest rates drop. High value property owners, on the other hand, are able to enjoy opportunities of refinancing when interest rates decline. As a result, regions where values of properties are high tend to exhibit greater sensitivity to interest rates compared to other regions.

- *Demography*

Fielding & Shields (2007) argue that differences in regional demography also explain differential regional responses to changes in monetary policy. They contend that consumption substitution may be hard across age groups. Thus, except for services like education and certain types of goods meant for children that are hard to defer in the case of children or people of younger age, people in their old age seldom defer consumption given high death probability in old age.

4.4.5. Empirical evidence

The empirical literature on the asymmetric regional responses to monetary policy have largely been skewed towards regional output as opposed to regional inflation. These studies consider how economic activities and output of different regions of a country respond to the same monetary policy with the vector autoregressive (VAR) technique as a workhorse. Carlino & DeFina (1998) find asymmetry in the response of regional output to the United States monetary policy. In the following year, the authors then considered differentials in the response of output of different States in the United States (Carlino & DeFina, 1999). Arnold & Vrugt (2002) also found asymmetric effect of monetary policy on the output of different regions in the Netherlands. Rodriguez-Fuentes & Padron-Marrero (2008) studied how monetary policy affects different sectors of the economy of Spain. They find that the various sectors respond differently to monetary policy. Ridhwan et al (2014) examined the effect of monetary policy on output of different regions of Indonesia. They find monetary policy to heterogeneously affect output of these regions. The said effect is different in terms of timing and magnitude. Anagnostou & Papadamou (2016) observed asymmetry in the response of regional output to changes in monetary policy in the context of Greece. Anagnostou & Gajewski (2019) made similar findings on the regional output-monetary policy nexus in Poland.

Apart from regional output, other contexts have been looked at. For instance, Fratantoni & Schuh (2003) studied the differential impact of monetary policy on regional housing markets in the United States. They find that regional housing markets in the United States respond differently to changes in monetary policy. Dow & Montagnoli (2007) considered differential effect of monetary policy changes on credit availability and cost across different regions of the United Kingdom. Svensson (2012) studied the impact of monetary policy on employment across different regions of Sweden using the VAR technique. The author found asymmetry in the regional employment response to changes in monetary policy. De Lucio & Izqueirdo (1999) studied how macroeconomic variables in different regions of Spain respond to changes in monetary policy. They found asymmetry in regional responses to changes in monetary policy. Fraser et al (2014) used Structural VAR in the context of Australia to ascertain whether different regions respond differently to changes in monetary policy. They find asymmetry in the responses to monetary policy changes. Particularly, they find that Western Australia and Queensland are substantially different from the other states in respect of their response to changes in monetary policy. Xiaohui & Masron (2014) studied how monetary policy affects real variables of different regions of China using Structural VAR. They find that real variables respond differently in different regions to monetary policy. Beraja et al (2017) studied the impact of monetary policy on housing equity and refinancing of mortgages in various regions of the United States of America.

However, the empirical studies on the asymmetric responses of regional inflation to changes in monetary policy remains limited. In recent times, some studies that look at monetary policy and regional housing prices have emerged. Del Negro & Otrok (2007), Aastveit & Anundsen (2017) and Fischer et al (2018) all considered monetary policy and regional housing prices in the context of the United States. Yang et al (2010) considered monetary policy effect on regional housing prices in Sweden. Meanwhile, housing prices are only a fraction of the prices faced by economic agents in the various regions.

Beck et al (2006) studied the factors that explain inflation at the regional levels of selected countries in the Euro Area as well as inflation across the countries. They then made a comparison with the United States context. The authors find that common area and country-specific factors were prominent in explaining regional inflation. They however did not look explicitly at the heterogeneous effect of changes in monetary policy on inflation of different regions. Nagayasu (2010) also studied factors that explain regional prices in China. While the author controlled for monetary aggregates, the focus was on the general drivers of regional inflation as opposed to monetary policy changes and the heterogeneous response of regional inflation. The author finds that regional inflation was driven by economic fundamentals such as exchange rate, output, credit and money growth. Choi et al (2015) studied the effect of adoption of Inflation Targeting framework on inflation of 30 cities in Korea as opposed to effect of changes in monetary policy on regional inflation.

The only two studies, to the extent that we know, that have looked at heterogeneous response of regional inflation to changes in monetary policy are Fielding & Shields (2006) for South Africa and Fielding & Shields (2007) for the United States. Fielding & Shields (2006) studied the differential response of provincial inflation to changes in monetary policy. They find that monetary policy changes exert substantial differential effect on the inflation of the nine provinces. The study however considered hypothetical monetary policy as opposed to actual monetary policy changes in South Africa. A result based on hypothetical changes in monetary policy then cannot inform policy consistency and coherence given that such imaginary changes in monetary policy are disparate from the actual situation. Fielding & Shields (2007) studied the United States context and find that much as economic factors specific to various cities in the United States explain price asymmetry across these cities, distinctive responses of cities to monetary policy play a part in the price asymmetry across cities. Their study is however focused on the paradigm of the law of one price across cities and the deviations thereof. The two studies also assume homogeneity in the relationship between each region's/state's inflation and monetary policy. Meanwhile, asymmetric behaviour of monetary policy is well acknowledged in the literature. We situate our work in this context and we consider a multi-faceted approach to capturing asymmetry in the regional inflation-monetary policy nexus using the wavelet-based quantile regression.

4.5 Methodology

4.5.1 Data and sources

We use data in monthly frequency from January 2006 to November 2018 for both South Africa and Ghana. The availability of regional inflation data for Ghana informed the choice of the start of the series from 2006. The variables in our model include regional/provincial inflation, monetary policy, transportation cost, output and the weighted averages of regional/provincial prices. The choice of these variables is informed by the literature (Fielding & Shields, 2006) although we include transportation cost to capture cost of distribution of products across regions/provinces. We also include weighted averages of regional/provincial prices to capture the possibility that prices in one region could be affected by prices of other regions in the same country.

For Ghana, data on monetary policy rate and output are obtained from the monetary time series database of the Bank of Ghana. Data on regional inflation and transportation cost are obtained from the time series data produced by the Ghana Statistical Service. For South Africa, we obtained the data on provincial inflation from Statistics South Africa whiles transportation cost was sourced from the quarterly bulletins of the South African Reserve Bank. The output and the monetary policy data are obtained from DataStream.

A clarification on the regional/provincial data is in order. For South Africa, we have inflation data for all the nine provinces and so we consider all the nine provinces. In the case of Ghana, however, data availability forces us to study only eight (8) regions. There are, as indicated earlier, sixteen (16) regions in Ghana. However, six out of these sixteen regions were only created in December 2018 out of four (4) already existing regions following a referendum. There is practically no separate time series data for these six new regions. Significantly, their effect is already captured in the four existing regions they sprung from. That leaves us with ten (10) regions that had existed before December 2018. These are Ashanti, Brong Ahafo, Central, Eastern, Greater Accra, Northern, Upper East, Upper West, Volta and Western regions. However, inflation data on Upper

East and Upper West regions were combined as one region prior to 2012 by Ghana Statistical Service. It is only after 2012 that inflation data on these two regions have been separated. Given that the quantile regression approach requires large data, we drop the two Upper regions as neither the combined data for the two regions prior to 2012 nor the separate data after 2012 would meet such data requirements of our chosen estimation technique. Importantly, the combined weight of these two regions in the national inflation basket prior and after 2012 remains less than 3%.

4.5.2 Definition of variables

Regional/provincial inflation is in percentage, as measured by the primary sources, and it represents the percentage change in the consumer price index of each region/province in a particular month from the same month in the previous year.

***Weighted average of regional/provincial inflation*:** Because some regions/provinces of the same country are closer to each other and the fact that certain products are manufactured or transported from one region/province to the other, we envisage that the price development in a particular region/province may be affected by prices in other regions/provinces. In estimating the monetary policy effect on the prices of a particular region/province, we control for the prices of other regions. Rather than throwing prices of each of the other regions/provinces on the right-hand side of the model as control variables with concomitant degrees of freedom challenges, we adopt a more intuitive approach. We construct weighted averages of the inflation data of the control regions/provinces. Thus, in looking at the monetary policy effect on say the Gauteng province in South Africa, the remaining eight (8) provinces are the control provinces and so we construct the weighted average of the prices of these eight (8) provinces. The weights are based on their respective weights in the national inflation baskets officially provided by the Ghana Statistical Service and Statistics South Africa.

Monetary policy is measured in percentage and is represented by repo rate and the monetary policy rate for South Africa and Ghana respectively. These are the official monetary policy instruments in the respective countries.

***Output*:** since gross domestic product, a measure of output, is not available in monthly frequency for the countries we are studying, we rely on an alternative measure. For Ghana, we use the composite index of economic activities compiled by the Bank of Ghana to gauge the level of economic activities. In the case of South Africa, a similar measure exist which is the coincident business cycle indicator.

***Transportation cost*:** Measured in percentage, as per the primary sources, it represents a change in the transportation price index in a particular month from the same month in the previous year.

4.5.3 Test for stationarity

Table 4.3: Test for stationarity

		ADF TEST		PP TEST	
		Level	**First Diff**	**Level**	**First Diff**
Ghana					
	ASR	-1.944	-7.549***	-2.128	-13.540***
	BA	-2.266	-11.127***	-2.334	-11.064***
	CR	-2.467	-12.060***	-2.717	-12.060***
	ER	-2.232	-14.617***	-2.138	-14.607***
	GAR	-2.221	-11.455***	-2.510	-11.446***
	NR	-2.633	-4.674***	-2.379	-12.237***

	VR	-2.471	-12.714***	-2.648	-12.709***
	WR	-2.737	-12.432***	-2.795	-12.646***
	MPR	-1.268	-6.296***	-1.370	-12.698***
	TRANSP	-3.554**		-3.781**	
	OUTPUT	-11.410***		-11.441***	
South Africa					
	EC	-2.581	-9.201***	-2.883	-9.513***
	FS	-2.756	-9.296***	-2.736	-9.372***
	GP	-2.606	-8.726***	-2.497	-8.787***
	KZN	-2.440	-8.435***	-2.470	-8.506***
	LMP	-2.443	-10.360***	-2.858	-10.581***
	MPU	-2.696	-8.470***	-2.374	-8.474***
	NC	-2.854	-9.982***	-2.782	-10.047***
	NW	-3.285*	-9.718***	-2.408	-9.810***
	WC	-2.783	-8.344***	-2.398	-8.374***
	MPR	-2.472	-3.364*	-1.707	-12.569***
	TRANSP	-4.480***		-4.198**	
	OUTPUT	-3.358*	-7.510***	-2.396	-7.856***

Note: For the ADF and the PP Tests, we include both the intercept and trend at both the levels and first difference. ***, ** and * indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root.

4.5.4 The estimation approaches

4.5.4.1. The wavelet analysis

Aguiar-Conraria et al (2008) observe that although spectral analysis have enjoyed considerable usage in the economics literature to uncover relationships between various macroeconomic variables across different frequencies, apparent limitations include the loss of time information, the struggle by users to differentiate relationships that are ephemeral and the difficulty in the identification of structural breaks inherent in the series. In addition, the technique is suitable only in the cases of time series that possess properties known to be statistically stable. In other words, the technique is only applicable to time series data that are stationary. Meanwhile, economic time series are seldom stationary, exhibit complexity and fraught with considerable noise. The Fourier transform ameliorated these limitations as it disintegrates the initial time series into sub samples and then implement the Fourier transform on the respective sub samples. Such a process in a Fourier transform, however, suffers substantial inefficiencies and maintains a homogenous frequency resolution across various frequencies, a limitation that ushered in the wavelet analysis.

Rather than disintegrating the time series into smaller samples, as in the Fourier transform, the wavelet analysis produces scaled and shifted forms of a function by expanding the time series. An important virtue of the wavelet transform is the fact that it provides localized perspective of time series with endogenous variations of the wavelet lengths. Thus, in measuring movements at lower frequencies, the wavelet function expands whiles it shrinks when capturing movements at higher frequencies. Moreover, sudden or abrupt changes are inevitable in time series and wavelet is capable of adequately capturing such events by utilizing short functions. Similarly, the wavelet approach is able to capture infrequent movements or movements that are persistent by utilizing long functions (Aguiar-Conraria et al, 2008). Crowley (2007) notes that the wavelet approach is capable of providing localization in the components of a function as well as in time dimension, handle non-stationary data, provide decomposition of time series into various multiresolution constituents and examine fluctuations in macroeconomic series. The scales that are produced, following a decomposition, are necessarily a function of the number of observations (Crowley, 2007).

The fact that wavelet is capable of handling non-stationary time series data makes it all appropriate for our study. For the purposes of our study, we follow the works of Mensi et al (2016) and Yang et al (2018) who had used a wavelet-based quantile regression approach in other contexts. Wavelets, across the variants, are characterized by father (ϕ) and mother (ψ) wavelets which are defined as:

$\int \phi(t)dt = 1$ denoting father wavelet

$\int \psi(t)dt = 0$ denoting mother wavelet

Whereas the father wavelet captures the trend and integrates to 1, eccentricities from this trend are captured by the mother wavelets that integrate to 0. In this regard, it takes a number of mother wavelets in sequential fashion to be able to characterize a function whiles a single father wavelet suffices in the characterization of a function. The mother wavelets capture the high frequency or detailed parts or components of a signal whereas the low frequency or smooth component of the signal is captured by the father wavelet.

A signal, or time series in our context, given as c(t) is decomposable through wavelet transformation as:

$$c(t) = \sum_k z_{J,k}\phi_{J,k}(t) + \sum_k b_{J,k}\psi_{J,k}(t) \sum_k b_{J-1,k}\psi_{J-1,k}(t) + \cdots + \sum_k b_{1,k}\psi_{1,k}(t) \qquad (1)$$

such that the wavelet functions are represented by $\phi_{J,k}$ and $\psi_{J,k}$. Meanwhile, $z_{J,k}$ and $b_{J,k}$ up to $b_{1,k}$ represent the coefficients of the wavelet transform. In addition, the J denotes the number of levels of the multiresolution while at each level the k varies from 1 to the total coefficients. We can represent the wavelet transformation as:

$$z_{J,k} = \int \phi_{J,k}(t)c(t)dt \qquad (2)$$

$$b_{j,k} = \int \psi_{j,k}(t)c(t)dt, \quad j \textit{ varies from } 1 \textit{ to } J \qquad (3)$$

such that J represents the highest integer where 2^J assumes a figure less than the total observations. Additionally, the trend is captured by smooth coefficient represented by $z_{J,k}$. Meanwhile, $b_{J,k}$ up to $b_{1,k}$ are coefficients that capture the deviations from the aforementioned trend. Consequently, we can approximate the initial series c(t) using the wavelet series in the following expression:

$$c(t) = Z_{J,k}(t) + B_{J,k}(t) + B_{J-1,k}(t) + \ldots . + B_1(t) \tag{4}$$

such that the smooth signal or trend is given by $Z_{J,k}(t)$ whiles $B_{J,k}(t)$ up to $B_1(t)$ represent the more detailed signals that deviate from the trend. The detailed and smooth signals can respectively be represented by:

$$B_{J,k} = \sum_k b_{J,k}\Psi_{J,k}(t),\ with\ j = 1\ to\ J-1 \quad \text{and} \quad Z_{J,k} = \sum_k z_{J,k}\Phi_{J,k}(t) \tag{5}$$

4.5.4.2. The Discrete Wavelet Transform (DWT)

The high frequency or detailed components $B_1(t)$ up to $B_J(t)$ can be derived by using the coefficients of the wavelet filter that scales the original signal $g = (g_{1,0}, \ldots, g_{1,L-1,}, 0, \ldots, 0)^T$. Given that $h_1 = (h_{1,0}, \ldots, h_{1,L-1,}, 0, \ldots, 0)^T$ signifies the Daubechies wavelet filter coefficients (Daubechies, 1992) that are supported compactly for a unit scale which is zero padded to **N** length such that for $l > L$, $h_{1,0} = 0$ subject to the following conditions:

$\sum_{i=0}^{L-1} h_{1,l} = 0; \sum_{l=0}^{L-1} h_{1,l}^2 = 1 \sum_{l=0}^{L-1} h_{1,l}h_{1,l+2n} = 0$ for all integers n which are not zero (Tiwari et al, 2013). The essence of the above condition is to the effect that a wavelet filter should possess a unit energy, have zero mean or its sum should be zero and should exhibit orthogonality to its own shifts that are even (Tiwari et al, 2013).

Let define $g_1 = (g_{1,0}, \ldots, g_{1,L-1,}, 0, \ldots, 0)^T$ as scaling coefficients that are also zero padded with $g_{1,l} = (-1)^{l+1}h_{1,L-l-1}$ and the time series is given by $x_{0,\ldots\ldots,}x_{N-1}$. We can filter the time series with the aid of h_j that delivers the coefficients of the wavelets for scales that have $N \geq L_j$ such that $L_j = (2^j - 1)(L-1) + 1.$ Thus:

$$W_{j,t} = 2^{j/2} \widehat{W}_{j,2^j(t+1)+1}, \quad \left[(L-2)\left(1-\frac{1}{2^j}\right)\right] \leq t \leq \left[\frac{N}{2^j} - 1\right] \tag{6}$$

such that

$$\widehat{W_{J,t}} = \frac{1}{2^{j/2}} \sum_{2^{j/2}}^{L_{j-1}} h_{j,l} X_{t-1}, \qquad t = L_j - 1, \dots \dots . N-1$$

We derive the coefficients for $\widehat{W_{J,t}}$ that are related to variations on a scale that has a length $\vartheta_j = 2^{j-1}$ through the sub sampling of each 2^jth of coefficients of $\widehat{W_{J,t}}$.

4.5.4.3. The Maximal Overlap Discrete Wavelet Transform (MODWT)

The discrete wavelet transform (DWT) is limited in view of the requirement of dyadic length or the divisibility of sample size by 2^j and so we resort to the maximal overlap discrete wavelet transform. The maximal overlap discrete wavelet transform does not impose such requirements thereby making it a preferred alternative. Importantly, the use of MODWT is superior since decimation operation make wavelet and the associated scaling coefficients to be sensitive to shifts of circular nature and therefore vary across shifts. In the MODWT, the coefficients of the wavelets represented by $\widehat{W}_{j,t}$ and the coefficients of the scales denoted by $\widehat{V}_{j,t}$ where j varies from 1 to J are derived by:

$$\widehat{W}_{j,t} = \sum_{l=0}^{L-1} {}_l \hat{g}\, \hat{v}_{j-1,t-1 \ modN} \text{ and } \widehat{V}_{j,t} = \sum_{l=0}^{L-1} {}_l \hat{h}\, \hat{v}_{j-1,t-1 \ modN} \tag{7}$$

We rescale the filters of the wavelet and scales ($\hat{g}_l$and $\hat{h}_l$) as $\hat{g}_j = g_j/2^{j/2}$ and $\hat{h}_j = h_j/2^{j/2}$. The wavelet coefficients, non-decimated, signify the distinctions between the data's generalized averages using a scale of $\vartheta_j = 2^{J-1}$.

A limitation of the DWT is the fact that it is applicable only to sample sizes of multiple of 2. For the MODWT however, it is applicable to sample of any size while it preserves all of the DWT functions. In addition, it is devoid of phase-shifts that vary events' location in time (Mensi et al, 2016). Moreover, it is invariant with respect to translations since the pattern of the coefficients of the wavelet transform do not vary following a signal shift.

4.5.4.4. The quantile regression

Having done the decomposition using the wavelet approach, we now assess the asymmetric effect of monetary on regional/provincial inflation across different scales and at different quantiles of the distributions of the respective regional/provincial inflation. To estimate the quantile regression, we define the model as:

$$f_t = x_t'\beta + u_t \tag{8a}$$

$$E(f_t|\, x_t) = x_t'\beta \tag{8b}$$

$$Q_{f_t}(\tau|\, x_t) = x_t'\beta_\tau \tag{8c}$$

$$\beta_\tau = \beta + \vartheta \mathrm{F}^{-1}(\tau) \tag{8d}$$

where the cumulative distribution function of $\{u_t\}$ is given by F and ϑ signifies a constant. In addition, τ denotes the specified quantiles we are considering and each region's inflation's conditional quantile function given the covariates is given by $Q_{f_t}(\tau|\, x_t)$. Given our total observations of 155, our data on regional/provincial inflation is split at 25th, 50th and the 75th quantiles such that each quantile has sufficient observations for a meaningful econometric analysis. β_τ denotes the vector of parameters at the various quantiles we specified. The parameters or coefficients at the respective quantiles represent the marginal effects of the covariates on regional inflation at a particular quantile of regional inflation. The x_t represents the vector of these covariates whiles u_t is the error term. A key virtue of the quantile regression analysis is that the errors can assume any distribution. The quantile regression technique is also robust to heteroscedasticity in the error terms (Yang et al, 2015).

We estimate the parameters in equation (8) by minimizing the following loss function:

$$\min_{\beta_\tau \in \Re^p} \sum_{t=1}^{T} \rho_\tau \left(f_t - x_t' \beta_\tau\right) \tag{9}$$

where p = dimension (β_τ). We simplify the loss function in equation (9) by expressing it as:

$$\rho_\tau(u) = u(\tau - I(u < 0))$$

Such that I represents an indicator function which takes the value 1 when $u < 0$ or 0 otherwise.

Unlike the mean-based approaches that minimize the sum of the residuals squared, the sum of the absolute values of the residuals along with asymmetric penalties are minimized in the case of quantile regression. Thus, the minimization problem showed in equation (9) is given as:

$$\min_{\beta_\tau \in \Re^p} \sum_{t=1}^{T} \tau|u_t| + \sum_{t=1}^{T}(1-\tau)|u_t| \tag{10}$$

such that $\tau|u_t|$ represents penalization for $u_t \geq 0$ whiles $u_t < 0$ is penalized by $(1-\tau)|u_t|$.

4.6. Empirical results

Following the works of Mensi et al (2016) and Yang et al (2018), we decomposed all the series in our models into scales for the respective regions/provinces. As noted by Crowley (2007), the scales produced for any given series are necessarily a function of the number of observations. For each of the series, we have 155 observations (from January 2006 to November 2018). As a result, the decomposed series delivered four (4) scales from B1 to B4. Following the work of Crowley (2007), we define these scales in Table 4.4. The scale Z4 represents the trend.

Table 4.4: Decomposed series

Scale	Monthly scale
B1	2 to 4 months
B2	4 to 8 months
B3	8 to 16 months
B4	16 to 32 months

For each of these scales, we estimated the monetary policy effect at specified quantiles. For clarity, we compare results between the regions in Ghana and then compare results between provinces in South Africa.

4.6.1. Results on regions of Ghana

We observe asymmetry in the effect of monetary policy on inflation rates of the various regions across scales and quantiles. For the central region, with results in Table 4.5, we find that over a two to four-month horizon (B1 or lowest scale) as well as the four to eight-month horizon (B2), monetary policy tightening delivers stability in the region's prices. Specifically, we find that a percentage tightening of the policy rate over the two to four-month horizon stabilizes inflation in the central region by 0.86% at the 25th quantile, 0.57% at the 50th quantile and 0.67% at the 75th

quantile. So, for the same region and over the same horizon, the effect of monetary policy differs across quantiles of the distribution of the overall inflation in the central region. Over the four to eight-month horizon, a percentage restriction of monetary policy stabilizes inflation in the central region by 0.71% at the 25th quantile and 0.61% at the 50th quantile.

Table 4.5: Results on Central Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.410**	-0.522***	-0.317
		(0.176)	(0.140)	(0.195)
	Transport cost	-0.027	0.097***	0.111**
		(0.044)	(0.035)	(0.049)
	Output	0.011***	0.006*	-0.003
		(0.004)	(0.0034)	(0.005)
	EXCR	1.348***	1.582***	1.541***
		(0.188)	(0.150)	(0.209)
	Constant	0.026	0.922	1.901
		(1.806)	(1.437)	(2.008)
	Pseudo R-squared	0.32	0.42	0.46
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.86***	-0.574***	-0.67**
		(0.295)	(0.21)	(0.30)
	Transport cost	0.194***	0.19***	0.18***
		(0.036)	(0.03)	(0.04)
	Output	0.00014	-0.0007	-0.0011
		(0.0015)	(0.001)	(0.0015)
	EXCR	-0.36	-0.102	-0.291
		(0.34)	(0.24)	(0.345)
	Constant	-0.335***	0.03	0.292***
		(0.07)	(0.05)	(0.071)
	Pseudo R-squared	0.14	0.12	0.11
B2				
	Monetary Policy	-0.711*	-0.61**	-0.31
		(0.392)	(0.27)	(0.47)
	Transport cost	0.196***	0.13***	0.15***
		(0.046)	(0.03)	(0.06)
	Output	0.0013	-0.0006	-0.002
		(0.0028)	(0.002)	(0.003)
	EXCR	0.52	0.54**	0.024
		(0.38)	(0.26)	(0.46)
	Constant	-0.453***	-0.02	0.33***
		(0.094)	(0.065)	(0.11)
	Pseudo R-squared	0.13	0.09	0.1
B3				
	Monetary Policy	0.23	0.29	-0.05

		(0.29)	(0.26)	(0.35)
	Transport cost	0.17***	0.19***	0.19***
		(0.03)	(0.03)	(0.04)
	Output	-0.0015	-0.004	0.0008
		(0.0037)	(0.003)	(0.0044)
	EXCR	-0.069	-0.04	0.83**
		(0.304)	(0.27)	(0.37)
	Constant	-0.55***	0.035	0.62
		(0.097)	(0.088)	(0.12)
	Pseudo R-squared	0.19	0.14	0.16
B4				
	Monetary Policy	1.38***	0.89**	0.65
		(0.41)	(0.42)	(0.69)
	Transport cost	0.155***	0.18***	0.11**
		(0.03)	(0.032)	(0.052)
	Output	0.026***	0.02***	0.003
		(0.0054)	(0.005)	(0.009)
	EXCR	-0.43	-0.39	0.03
		(0.26)	(0.27)	(0.44)
	Constant	-0.97***	-0.24*	1.05***
		(0.14)	(0.14)	(0.23)
	Pseudo R-squared	0.25	0.16	0.12
Z4	Monetary Policy	-0.323***	-0.643***	-0.925***
		(0.092)	(0.116)	(0.105)
	Transport cost	-0.277***	-0.190***	-0.181***
		(0.026)	(0.033)	(0.030)
	Output	0.012***	0.014***	0.021***
		(0.003)	(0.003)	(0.003)
	EXCR	1.710***	1.853***	2.062***
		(0.090)	(0.114)	(0.103)
	Constant	0.412	2.943***	4.343***
		(0.762)	(0.961)	(0.865)
	Pseudo R-squared	0.65	0.69	0.74

Note: EXCR represents the weighted average of the inflation rates of the regions excluding Central region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The central region is dominated by services sector and particularly the educational sub sector. A sizeable proportion of the urban dwellers in the region are government workers, especially teachers. This class of people depend heavily on consumer loans to purchase household durables such television sets, fridges, furniture and a host of others with direct deductions from their monthly salaries at the controller and accountant general’s department. Given the sensitivity of such consumption to interest rates, a policy rate tightening bridles consumer loan demand and the prices in the region eventually over the short horizon.

Over a longer horizon (sixteen to thirty-two months or B4) however, monetary policy restriction destabilizes prices in the central region at the 25th and 50th quantiles. A percentage restriction of monetary policy destabilizes prices in the region further by 1.38% at the 25th quantile and by 0.89% at the 50th quantile. This is expected, in view of the fact that these economic agents are able to adjust over a relatively longer horizon. The increase in monetary policy rate feeds into high cost of borrowing of firms and the wholesalers and retailers who pass on these costs to the final consumers. Additionally, the dominance of food in the consumption basket of these settings partly explain the destabilization of overall prices by monetary policy. It is well known in the literature (Bhattacharya & Jain, 2019; and Hammoudeh et al, 2015) that monetary policy restriction fuels food price destabilization and food prices potentially have second round impact on prices of other constituents of the inflation basket (De Gregorio, 2012; and Rangasamy, 2011). The weight of central region in the inflation basket of Ghana is 6.95% out of which 3.42% (almost half) is food inflation. So, although monetary policy stabilizes prices in the region over the short horizon, the switch from the consumption of the relatively more expensive interest-sensitive products to food and the potential second round impact of food prices could then explain the destabilization of the overall prices in the region over a longer horizon.

For the Greater Accra region, with results in Table 4.6, we find that a restrictive monetary policy stabilizes inflation in the region at the 50th and 75th quantiles over the two to four-month horizon

(B1). At the 50th quantile, a percentage restriction of monetary policy delivers a 0.46% stability in the prices of the region. Over the same horizon but at the 75th quantile, a percentage tightening of monetary policy exacts a 0.66% stability in the region's inflation. Thus, at a higher inflationary episode (75th quantile) in the region, monetary policy tightening by 1% induces a greater stability. The sheer concentration of the nation's industrial and service sectors in the Greater Accra region makes this finding unsurprising.

Table 4.6: Results on Greater Accra Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.736***	0.644***	0.704***
		(0.094)	(0.121)	(0.164)
	Transport cost	0.100***	0.075**	-0.143***
		(0.027)	(0.034)	(0.047)
	Output	-0.010***	-0.014***	-0.017***
		(0.002)	(0.003)	(0.004)
	EXGAR	0.160	0.307**	0.597***
		(0.115)	(0.148)	(0.200)
	Constant	-1.345	2.575*	6.668***
		(1.076)	(1.393)	(1.883)
	Pseudo R-squared	0.32	0.32	0.38
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.44	-0.46***	-0.66**
		(0.28)	(0.18)	(0.296)
	Transport cost	0.075**	0.082***	0.103***
		(0.035)	(0.022)	(0.04)
	Output	0.0005	-0.0007	.0003
		(0.0014)	(0.0009)	(0.0015)
	EXGAR	-0.921***	-1.18***	-1.604***
		(0.29)	(0.19)	(0.313)
	Constant	-0.325***	-0.035	0.312***
		(0.07)	(0.042)	(0.07)
	Pseudo R-squared	0.11	0.09	0.1
B2				
	Monetary Policy	-0.022	-0.154	-0.40
		(0.32)	(0.195)	(0.32)
	Transport cost	0.067*	0.0544**	0.03
		(0.04)	(0.024)	(0.04)
	Output	0.003	0.0025*	-0.00003
		(0.0023)	(0.0014)	(0.002)
	EXGAR	-0.72**	-0.38**	-0.77***
		(0.28)	(0.17)	(0.28)
	Constant	-0.365***	0.046	0.392***

		(0.077)	(0.047)	(0.08)
	Pseudo R-squared	0.04	0.024	0.054
B3				
	Monetary Policy	-0.05	0.18	0.36
		(0.32)	(0.22)	(0.33)
	Transport cost	0.054	0.085***	0.024
		(0.04)	(0.03)	(0.04)
	Output	0.0014	-0.002	-0.0034
		(0.004)	(0.0028)	(0.004)
	EXGAR	-1.04***	-1.14***	-1.09***
		(0.31)	(0.21)	(0.32)
	Constant	-0.05	-0.08	0.43***
		(0.32)	(0.07)	(0.11)
	Pseudo R-squared	0.09	0.115	0.09
B4				
	Monetary Policy	1.97***	1.65***	3.03***
		(0.55)	(0.51)	(0.42)
	Transport cost	-0.03	0.18***	0.01
		(0.055)	(0.051)	(0.04)
	Output	-0.008	-0.0064	-0.001
		(0.0075)	(0.0069)	(0.006)
	EXGAR	-1.11***	-1.48***	-1.4***
		(0.42)	(0.39)	(0.32)
	Constant	-1.01***	0.04	1.22***
		(0.2)	(0.18)	(0.15)
	Pseudo R-squared	0.115	0.14	0.28
Z4	Monetary Policy	0.671***	0.562***	0.479***
		(0.060)	(0.057)	(0.063)
	Transport cost	0.072***	0.102***	0.095***
		(0.020)	(0.019)	(0.021)
	Output	-0.016***	-0.016***	-0.014***
		(0.002)	(0.002)	(0.002)
	EXGAR	0.659***	0.709***	0.754***
		(0.068)	(0.065)	(0.071)
	Constant	-0.660	0.616	1.906***
		(0.567)	(0.543)	(0.598)
	Pseudo R-squared	0.70	0.74	0.78

Note: EXGAR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The region controls 65% and 70.6% of the revenues from the industrial and service sectors respectively in Ghana. As noted by Carlino & DeFina (1998) and Anagnostou & Gajewski (2019), industrial sectors are more sensitive to interest rates than the other sectors and regions with dominance of these sectors are likely to respond more to variations in monetary policy. Monetary policy tightening increases the cost of borrowing of firms in these sectors who cut back or defer investments in capital assets and projects, at least for the short horizon. This is particularly pronounced for firms that heavily rely on bank lending. At a higher scale (B4) or long horizon (over sixteen to thirty-two months), monetary policy restriction destabilizes prices in the Greater Accra region at all the specified quantiles. A percentage tightening of monetary policy destabilizes prices in the region by 1.97% at the 25th quantile, 1.65% at the 50th quantile and 3.03% at the 75th quantile.

For Western region, with results in Table 4.7, we find that monetary policy tightening only provides stability in the region's prices at the 50th quantile over the four to eight-month horizon (B2). Specifically, a percentage monetary policy tightening elicits a disinflation of 0.49% over the four to eight-month horizon at the 50th quantile. Over the longer horizon (sixteen to thirty-two months) however, monetary policy tightening is destabilizing for prices in the Western region at all the specified quantiles. A 1% restriction in the monetary policy stance fuels inflation by 0.91% at the 25th quantile, 0.64% at the 50th quantile and 0.96% at the 75th quantile.

Table 4.7: Results on Western Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.041	-0.091	-0.172
		(0.106)	(0.091)	(0.169)
	Transport cost	0.093***	0.002	0.028
		(0.027)	(0.024)	(0.044)
	Output	0.005*	0.004	0.001
		(0.0026)	(0.0022)	(0.004)
	EXWR	0.873***	1.065***	1.089***
		(0.111)	(0.096)	(0.177)
	Constant	-1.145	1.219	3.789**
		(1.110)	(0.957)	(1.767)
	Pseudo R-squared	0.47	0.50	0.40
Decomposed series (Wavelet)				

B1	Monetary Policy	0.244	-0.158	-0.151
		(0.326)	(0.115)	(0.24)
	Transport cost	0.013	0.038**	0.049
		(0.041)	(0.014)	(0.03)
	Output	0.001	-0.0003	-0.001
		(0.002)	(0.0006)	(0.0012)
	EXWR	1.016**	0.753***	0.737**
		(0.394)	(0.14)	(0.29)
	Constant	-0.294***	0.004	0.24***
		(0.075)	(0.026)	(0.05)
	Pseudo R-squared	0.07	0.085	0.06
B2				
	Monetary Policy	-0.57	-0.49**	-0.47
		(0.37)	(0.21)	(0.31)
	Transport cost	0.16***	0.094***	0.16***
		(0.04)	(0.024)	(0.04)
	Output	0.0063**	0.0035**	0.0037*
		(0.003)	(0.0015)	(0.0022)
	EXWR	0.13	0.23	0.393
		(0.34)	(0.19)	(0.28)
	Constant	-0.39***	0.061	0.39***
		(0.09)	(0.049)	(0.07)
	Pseudo R-squared	0.1	0.094	0.11
B3				
	Monetary Policy	0.33	0.276	0.149
		(0.34)	(0.23)	(0.29)
	Transport cost	0.165***	0.157***	0.149***
		(0.04)	(0.03)	(0.03)
	Output	0.001	-0.0014	-0.002
		(0.004)	(0.0029)	(0.004)
	EXWR	-0.46	-0.22	0.0003
		(0.344)	(0.23)	(0.296)
	Constant	-0.561***	0.0033	0.47***
		(0.114)	(0.077)	(0.098)
	Pseudo R-squared	0.144	0.118	0.098
B4				
	Monetary Policy	0.912***	0.639**	0.963**
		(0.313)	(0.323)	(0.392)
	Transport cost	0.171***	0.204***	0.188***
		(0.023)	(0.024)	(0.029)
	Output	0.0016	0.003	-0.002
		(0.0039)	(0.004)	(0.005)
	EXWR	-0.05	0.0848	-0.096
		(0.196)	(0.202)	(0.245)
	Constant	-0.761***	-0.028	0.598***
		(0.103)	(0.106)	(0.123)
	Pseudo R-squared	0.29	0.22	0.25)
Z4	Monetary Policy	-0.137***	-0.283***	-0.660***
		(0.021)	(0.059)	(0.132)
	Transport cost	-0.008	0.012	0.076**

		(0.006)	(0.017)	(0.038)
	Output	0.009***	0.011***	0.018***
		(0.001)	(0.002)	(0.004)
	EXWR	1.060***	1.169***	1.518***
		(0.021)	(0.056)	(0.126)
	Constant	-0.116	0.444	0.249
		(0.180)	(0.495)	(1.105)
	Pseudo R-squared	0.79	0.75	0.67

Note: EXWR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The region, although prominent in the industrial and service sectors due to the exploration of the country's oil, is a major contributor to the nation's agriculture and the food basket. Apart from the relatively developed twin-city capital of the region (Sekondi and Takoradi) which are home to key industrial and service undertakings, the mainstay of the greater proportion of the region is agriculture. This sector is relatively less sensitive to interest rates and the dominance of food creates such overall price destabilization.

The stabilizing effect of monetary policy on the inflation of Northern region is only felt over the eight to sixteen-month (B3) horizon and at the 75th quantile, as per the results in Table 4.8. Over that period, and at the 75th quantile, a percentage restriction of monetary policy enhances disinflation in the region by 0.73%. The destabilizing effect of monetary policy is rather more pronounced, particular at the highest scale (B4) or sixteen to thirty-two months horizon. At the highest scale, a 1% tightening of monetary policy induces further price hikes by 1.09% at the 25th quantile and 0.9% at the 50th quantile.

Table 4.8: Results on Northern Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.046	-0.070	-0.371**
		(0.093)	(0.155)	(0.157)

	Transport cost	0.001	-0.040	0.013
		(0.024)	(0.040)	(0.041)
	Output	0.001	-0.001	-0.004
		(0.002)	(0.004)	(0.004)
	EXNR	1.024***	1.238***	1.703***
		(0.095)	(0.159)	(0.161)
	Constant	-2.411**	0.319	1.678
		(0.985)	(1.641)	(1.659)
	Pseudo R-squared	0.45	0.49	0.55
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.16	.077	0.075
		(0.3)	(0.20)	(0.37)
	Transport cost	-0.0115	-0.034	.012
		(0.038)	(0.026)	(0.05)
	Output	-0.0008	-0.001	-0.002
		(0.0014)	(0.001)	(0.002)
	EXNR	0.31	0.63***	.504
		(0.34)	(0.23)	(0.43)
	Constant	-0.35***	-0.02	0.31***
		(0.07)	(0.05)	(0.09)
	Pseudo R-squared	0.03	0.03	0.03
B2				
	Monetary Policy	-0.13	-0.126	0.35
		(0.28)	(0.27)	(0.22)
	Transport cost	-0.01	-0.07**	-0.08***
		(0.035)	(0.033)	(0.03)
	Output	-0.0004	-0.003	-0.004**
		(0.002)	(0.002)	(0.0016)
	EXNR	0.5845**	0.82***	1.03***
		(0.26)	(0.245)	(0.20)
	Constant	-0.4***	0.002	0.35***
		(0.07)	(0.064)	(0.053)
	Pseudo R-squared	0.045	0.061	0.081
B3				
	Monetary Policy	0.22	-0.259	-0.73***
		(0.33)	(0.259)	(0.28)
	Transport cost	-0.061	-0.046	-0.0155
		(0.04)	(0.03)	(0.032)
	Output	-0.0016	-0.0034	0.0001
		(0.0041)	(0.0033)	(0.0035)
	EXNR	0.32	0.365	0.802***
		(0.33)	(0.261)	(0.28)
	Constant	-0.59***	0.014	0.471***
		(0.11)	(0.087)	(0.092)
	Pseudo R-squared	0.031	0.023	0.054
B4				
	Monetary Policy	1.09*	0.902**	0.60
		(0.58)	(0.41)	(0.71)
	Transport cost	0.185***	0.12***	0.18***
		(0.042)	(0.03)	(0.05)

	Output	-0.017**	-0.0024	-0.003
		(0.007)	(0.005)	(0.009)
	EXNR	0.51	0.422	0.839*
		(0.371)	(0.262)	(0.451)
	Constant	-0.99***	-0.061	1.10
		(0.19)	(0.131)	(0.23)
	Pseudo R-squared	0.162	0.205	0.19
Z4	Monetary Policy	-0.379***	-0.284***	-0.241*
		(0.054)	(0.110)	(0.137)
	Transport cost	0.098***	0.059*	-0.090**
		(0.016)	(0.032)	(0.040)
	Output	-0.001	-0.001	-0.004
		(0.002)	(0.003)	(0.004)
	EXNR	1.530***	1.514***	1.561***
		(0.051)	(0.102)	(0.128)
	Constant	-1.621***	-1.812*	2.517**
		(0.466)	(0.940)	(1.171)
	Pseudo R-squared	0.71	0.69	0.68

Note: EXNR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The Northern region is largely agrarian, although service and industry are gaining prominence. The region is the provider of key staple food products such as yam, sorghum, millet and other cereals. The sensitivity of the households to interest rate changes is minimal and so the destabilizing effect of monetary policy relates more to dominant food sector.

For the Eastern region, with results in Table 4.9, monetary policy has no effect on inflation over the first two scales or over the horizon covering two to eight months and across all the quantiles. Monetary policy effect manifests at the third scale or over the eight to sixteen-month horizon at the 25th quantile where a percentage tightening of monetary policy destabilizes the region's prices by 0.47%. For this region, monetary policy stabilizes prices over the longest horizon or highest scale (B4) at the 25th and 50th quantiles. Thus, over the sixteen to thirty-two-month horizon, a restrictive monetary policy of 1% elicits stability of 0.73% at the 25th quantile and 0.42% at the 50th quantile.

Table 4.9: Results on Eastern Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.069	-0.320**	-0.393**
		(0.104)	(0.130)	(0.158)
	Transport cost	0.038	0.021	0.011
		(0.027)	(0.033)	(0.041)
	Output	0.004	0.004	-0.001
		(0.003)	(0.003)	(0.004)
	EXER	0.775***	1.392***	1.414***
		(0.106)	(0.132)	(0.161)
	Constant	-1.605	-0.276	4.380***
		(1.097)	(1.363)	(1.664)
	Pseudo R-squared	0.46	0.47	0.48
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.424	-0.173	-0.067
		(0.31)	(0.16)	(0.38)
	Transport cost	0.061	0.049**	0.1**
		(0.04)	(0.013)	(0.047)
	Output	-0.0005	-0.00065	-0.0003
		(0.002)	(0.00077)	(0.002)
	EXER	0.15	0.55***	-0.048
		(0.34)	(0.17)	(0.41)
	Constant	-0.28***	0.0023	0.3***
		(0.07)	(0.036)	(0.088)
	Pseudo R-squared	0.06	0.05	0.04
B2				
	Monetary Policy	0.36	0.17	0.274
		(0.26)	(0.19)	(0.23)
	Transport cost	-0.012	-0.005	-0.013
		(0.032)	(0.023)	(0.028)
	Output	-0.0003	-0.0001	-0.0005
		(0.002)	(0.001)	(0.002)
	EXER	1.32***	0.95***	0.83***
		(0.24)	(0.17)	(0.21)
	Constant	-0.28***	0.002	0.26***
		(0.06)	(0.044)	(0.05)
	Pseudo R-squared	0.08	0.08	0.08
B3				
	Monetary Policy	0.47**	0.174	0.24
		(0.24)	(0.19)	(0.28)
	Transport cost	-0.09***	-0.09***	-0.13***

		(0.03)	(0.022)	(0.03)
	Output	0.001	0.0012	-0.0013
		(0.003)	(0.0024)	(0.004)
	EXER	1.7***	1.75***	2.02***
		(0.26)	(0.21)	(0.31)
	Constant	-0.452***	0.045	0.44***
		(0.08)	(0.064)	(0.095)
	Pseudo R-squared	0.20	0.21	0.28
B4				
	Monetary Policy	-0.734*	-0.42*	-0.49
		(0.39)	(0.24)	(0.39)
	Transport cost	0.005	-0.006	0.022
		(0.028)	(0.17)	(0.028)
	Output	.0065	0.0024	-0.0026
		(0.005)	(0.0029)	(0.0046)
	EXER	1.61***	1.11***	.945***
		(0.25)	(0.16)	(0.25)
	Constant	-0.48***	-0.05	0.45***
		(0.12)	(0.08)	(0.12)
	Pseudo R-squared	0.39	0.31	0.22
Z4	Monetary Policy	-0.454***	-0.418***	-0.296
		(0.055)	(0.136)	(0.236)
	Transport cost	0.129***	0.071*	-0.038
		(0.016)	(0.040)	(0.073)
	Output	0.016***	0.009**	-0.001
		(0.002)	(0.004)	(0.007)
	EXER	1.303***	1.342***	1.453***
		(0.051)	(0.126)	(0.230)
	Constant	-4.250***	-0.486	2.763
		(0.464)	(1.156)	(2.113)
	Pseudo R-squared	0.62	0.58	0.51

Note: EXER represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

A clear commonality among these aforementioned five regions (Central, Greater Accra, Western, Northern and Eastern) is the fact that monetary policy provides some stability to the prices in these regions at certain points in time and across certain quantiles although the effects are largely heterogeneous for the same region and between regions. The pattern of responses of inflation of these regions differ from those of the remaining three regions (Ashanti, Brong Ahafo and Volta). We find that for Ashanti, Brong Ahafo and Volta regions, with results in Tables 4.10, 4.11 and 4.12, monetary policy exacts only destabilizing effects. For the Ashanti region, we find that the only statistically significant response of inflation to changes in monetary policy is over the third scale (B3) at the 25th quantile. Thus, over the eight to sixteen-month horizon, a percentage increase in monetary policy rate leads to a destabilization of prices in the region by 0.57% at the 25th quantile. The Ashanti region, although second in terms of the size of its economy, is dominated by petty trading and medium-sized informal sector firms many of which are regarded too risky to qualify for mainstream bank lending. The presence of branches of large organizations in the region boosts the region's economy but the borrowing decisions are made in Accra at the headquarters of these organizations and so do not materially affect Ashanti region's sensitivity to interest rate changes.

Table 4.10: Results on Ashanti Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.321***	0.215***	0.039
		(0.095)	(0.066)	(0.112)
	Transport cost	0.018	0.005	-0.036
		(0.026)	(0.018)	(0.030)
	Output	0.001	-0.001	-0.002
		(0.002)	(0.002)	(0.003)
	EXASR	0.815***	1.112***	1.440***
		(0.114)	(0.079)	(0.134)
	Constant	-2.990***	-1.766***	0.529
		(1.075)	(0.079)	(1.262)
	Pseudo R-squared	0.50	0.58	0.59
Decomposed Series (Wavelet)				
B1	Monetary Policy	-0.13	0.01	-0.07
		(0.26)	(0.18)	(0.27)
	Transport cost	0.07**	0.06***	0.024
		(0.03)	(0.02)	(0.03)
	Output	-0.001	-0.002**	-0.0023*
		(0.001)	(0.001)	(0.0013)
	EXASR	-0.57**	-0.335*	-0.32
		(0.29)	(0.198)	(0.30)
	Constant	-0.27***	0.03	0.27***
		(0.06)	(0.04)	(0.061)
	Pseudo R-squared	0.06	0.041	0.033
B2	Monetary Policy	-0.314	-0.04	-0.12

		(0.29)	(0.204)	(0.32)
	Transport cost	0.046	0.042*	0.072*
		(0.035)	(0.025)	(0.04)
	Output	-0.003	0.0013	-0.0002
		(0.002)	(0.0015)	(0.002)
	EXASR	-0.08	0.45**	0.011
		(0.28)	(0.20)	(0.32)
	Constant	-0.36***	0.05	0.33***
		(0.07)	(0.05)	(0.08)
	Pseudo R-squared	0.04	0.06	0.061
B3	Monetary Policy	0.57***	0.27	0.45
		(0.22)	(0.21)	(0.34)
	Transport cost	-0.033	-0.02	-0.013
		(0.03)	(0.03)	(0.04)
	Output	-0.0087***	-0.006**	-0.008*
		(0.003)	(0.003)	(0.0043)
	EXASR	0.42	0.46*	0.02
		(0.26)	(0.25)	(0.41)
	Constant	-0.601***	-0.08	0.48***
		(0.08)	(0.07)	(0.12)
	Pseudo R-squared	0.09	0.08	0.05
B4	Monetary Policy	0.053	-0.17	0.46
		(0.43)	(0.23)	(0.41)
	Transport cost	-0.17***	-0.13***	-0.11***
		(0.04)	(0.02)	(0.03)
	Output	0.001	-0.001	-0.005
		(0.005)	(0.003)	(0.005)
	EXASR	1.78***	2.31***	1.53***
		(0.36)	(0.2)	(0.34)
	Constant	-0.59***	0.08	0.50***
		(0.14)	(0.08)	(0.13)
	Pseudo R-squared	0.23	0.30	0.35
Z4	Monetary Policy	0.070	0.108	0.163***
		(0.104)	(0.081)	(0.048)
	Transport cost	0.065**	0.006	-0.078***
		(0.032)	(0.024)	(0.014)
	Output	0.006*	0.003	0.006***
		(0.0032)	(0.002)	(0.001)
	EXASR	1.165***	1.235***	1.126***
		(0.113)	(0.087)	(0.051)
	Constant	-3.817***	-2.267***	-0.698
		(0.945)	(0.732)	(0.431)
	Pseudo R-squared	0.66	0.74	0.79

Note: EXASR represents the weighted average of the inflation rates of the regions excluding Ashanti region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

For the Brong Ahafo region, the effect of monetary policy is felt over a longer horizon (B4) across all the quantiles. Thus, over the sixteen to thirty-two-month horizon, a 1% tightening of monetary policy destabilizes inflation in the region by 0.83% at the 25th quantile, 0.62% at the 50th quantile and 0.84% at the 75th quantile.

Table 4.11: Results on Brong Ahafo Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.363***	0.295***	0.140
		(0.066)	(0.084)	(0.133)
	Transport cost	0.053***	0.002	0.049
		(0.018)	(0.022)	(0.035)
	Output	0.000	-0.003	-0.005
		(0.002)	(0.002)	(0.003)
	EXBA	0.498***	0.716***	0.699***
		(0.067)	(0.085)	(0.134)
	Constant	-2.277***	-0.585	3.473**
		(0.717)	(0.910)	(1.440)
	Pseudo R-squared	0.55	0.51	0.44
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.11	0.0095	-0.04
		(0.2)	(0.12)	(0.21)
	Transport cost	0.06**	0.019	0.02
		(0.025)	(0.015)	(0.03)
	Output	0.001	0.00114**	0.0013
		(0.001)	(0.0006)	(0.001)
	EXBA	0.39*	0.68***	0.53**
		(0.23)	(0.13)	(0.24)
	Constant	-0.21***	0.02	0.198***
		(0.05)	(0.03)	(0.05)
	Pseudo R-squared	0.09	0.10	0.09
B2				
	Monetary Policy	0.023	-0.15	-0.05
		(0.33)	(0.20)	(0.27)
	Transport cost	0.068*	0.01	0.022
		(0.04)	(0.024)	(0.033)
	Output	0.003	0.001	0.0007
		(0.002)	(0.001)	(0.002)
	EXBA	0.33	0.57***	0.44*
		(0.30)	(0.18)	(0.25)
	Constant	-0.34***	-0.01	0.30***
		(0.08)	(0.05)	(0.06)
	Pseudo R-squared	0.04	0.05	0.02
B3				
	Monetary Policy	-0.07	0.071	-0.295

		(0.29)	(0.214)	(0.30)
	Transport cost	0.15***	0.134***	0.141***
		(0.03)	(0.024)	(0.03)
	Output	-0.007*	-0.0026	-0.00015
		(0.004)	(0.0027)	(0.004)
	EXBA	-0.86***	-0.80***	-0.597**
		(0.27)	(0.20)	(0.28)
	Constant	-0.52***	-0.015	0.43***
		(0.1)	(0.072)	(0.1)
	Pseudo R-squared	0.15	0.09	0.085
B4				
	Monetary Policy	0.83**	0.62**	0.84**
		(0.33)	(0.29)	(0.33)
	Transport cost	0.15***	0.154***	0.19***
		(0.024)	(0.022)	(0.024)
	Output	-0.0024	-0.0031	-0.013***
		(0.004)	(0.0036)	(0.004)
	EXBA	0.143	0.159	0.052
		(0.204)	(0.184)	(0.204)
	Constant	-0.57***	-0.044	0.052
		(0.11)	(0.096)	(0.204)
	Pseudo R-squared	0.31	0.30	0.36
Z4	Monetary Policy	0.421***	0.467***	0.475***
		(0.026)	(0.067)	(0.104)
	Transport cost	-0.020**	-0.020	0.021
		(0.008)	(0.021)	(0.032)
	Output	-0.007***	-0.009***	-0.014***
		(0.001)	(0.002)	(0.003)
	EXBA	0.636***	0.561***	0.379***
		(0.024)	(0.062)	(0.096)
	Constant	-0.276	0.729	4.709***
		(0.233)	(0.599)	(0.932)
	Pseudo R-squared	0.78	0.71	0.67

Note: EXBA represents the weighted average of the inflation rates of the regions excluding Brong Ahafo region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The prices in the Volta region are destabilized further over mid to long term horizons (B3 and B4) and across all the quantiles over these horizons and scales. Over the eight to sixteen-month horizon (B3), a percentage tightening of monetary policy exerts inflationary momentum by 0.78% at the 25th quantile, 0.93% at the 50th quantile and 0.76% at the 75th quantile. Over the longer horizon or the highest scale (B4), a percentage tightening of monetary policy destabilizes inflation in the Volta region by 1.8% at the 25th quantile, 1.17% at the 50th quantile and 2.28% at the 75th quantile.

Thus, the severity of the destabilization of inflation in the Volta region deteriorates over longer horizons.

Table 4.12: Results on Volta Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.161	-0.018	-0.183
		(0.110)	(0.140)	(0.156)
	Transport cost	0.037	0.016	-0.095**
		(0.029)	(0.037)	(0.041)
	Output	0.002	-0.001	-0.004
		(0.003)	(0.003)	(0.004)
	EXVR	0.846***	1.210***	1.590***
		(0.122)	(0.157)	(0.174)
	Constant	-3.902***	-1.528	2.182
		(1.186)	(1.519)	(1.685)
	Pseudo R-squared	0.45	0.43	0.40
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.293	-0.17	-0.35
		(0.399)	(0.22)	(0.29)
	Transport cost	0.067	0.064**	0.031
		(0.05)	(0.028)	(0.04)
	Output	0.001	0.0003	-0.0004
		(0.002)	(0.001)	(0.0014)
	EXVR	-0.355	-0.251	-0.388
		(0.452)	(0.248)	(0.323)
	Constant	0.33***	-0.002	0.32***
		(0.09)	(0.051)	(0.07)
	Pseudo R-squared	0.024	0.023	0.02
B2				
	Monetary Policy	0.12	-0.28	-0.30
		(0.47)	(0.245)	(0.36)
	Transport cost	0.054	0.046	0.02
		(0.0563)	(0.03)	(0.04)
	Output	0.002	-0.0002	-0.0013
		(0.0033)	(0.002)	(0.0026)
	EXVR	-0.531	-0.524**	-0.505
		(0.41)	(0.22)	(0.316)
	Constant	0.403***	0.0581	0.376***
		(0.11)	(0.0580)	(0.085)
	Pseudo R-squared	0.021	0.021	0.03
B3				
	Monetary Policy	0.78***	0.925***	0.76*
		(0.26)	(0.26)	(0.396)
	Transport cost	0.08***	0.12***	0.073
		(0.03)	(0.03)	(0.046)
	Output	-0.015***	-0.013***	-0.011**

		(0.003)	(0.0033)	(0.005)
	EXVR	-0.52*	-0.461*	-0.10
		(0.27)	(0.275)	(0.42)
	Constant	-0.64***	-0.14	0.513***
		(0.09)	(0.09)	(0.14)
	Pseudo R-squared	0.17	0.14	0.14
B4				
	Monetary Policy	1.803***	1.17*	2.275***
		(0.30)	(0.63)	(0.36)
	Transport cost	0.30***	0.33***	0.285***
		(0.023)	(0.05)	(0.03)
	Output	-0.002	-0.011	-0.017***
		(0.004)	(0.008)	(0.005)
	EXVR	-0.86***	-0.46	-0.725***
		(0.19)	(0.396)	(0.22)
	Constant	-1.13***	-0.125	1.19***
		(0.104)	(0.22)	(0.122)
	Pseudo R-squared	0.38	0.26	0.37
Z4	Monetary Policy	-0.153***	-0.103	0.011
		(0.043)	(0.083)	(0.117)
	Transport cost	-0.077***	-0.096***	-0.121***
		(0.013)	(0.025)	(0.034)
	Output	0.004***	0.002	-0.0002
		(0.001)	(0.002)	(0.003)
	EXVR	1.538***	1.526***	1.355***
		(0.044)	(0.085)	(0.119)
	Constant	-3.294***	-2.317***	-0.019
		(0.375)	(0.728)	(1.019)
	Pseudo R-squared	0.77	0.74	0.72

Note: EXVR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Clearly, the effect of monetary policy on inflation of the various regions in Ghana is heterogeneous not only across regions but also in the nexus between each region's inflation and monetary policy across different horizons and quantiles. Thus, each region's inflation responds to monetary policy heterogeneously across different quantiles and over different horizons. Such multifaceted heterogeneity in the monetary policy-regional inflation nexus has not been unearthed in the literature with the consequence that the previous results obtained are rather too simplistic and unrepresentative of the complexity inherent in this nexus. Meanwhile, understanding the nature and extent of the relationship between monetary policy and inflation of various regions is critical in setting policies that yield welfare optimality, given heterogeneity in the prices that agents face in the different parts of the country.

Much as the nexus between monetary policy and regional inflation is the main objective of this chapter, we envisage that transportation cost, which also reflects changes in fuel prices in the economy, plays a role in the inflation dynamics of these regions. Importantly, given the structure of the economies of these regions, they are heterogeneously endowed thereby necessitating inter regional trade and movement of goods. We find that transportation cost exerts positive effect on inflation across different horizons and quantiles for these regions in Ghana, although the findings for Ashanti, Eastern and the Northern regions are mixed. For the Ashanti region, we find that an increase in transportation cost fuels inflation at the 25th and 50th quantiles over two to four-month horizon as well as at the 50th and 75th quantiles over the four to eight months horizon. At the highest scale (sixteen to thirty-two-month horizon) however, price levels in the Ashanti region drop at all the quantiles following a percentage increase in the cost of transportation.

For Eastern region, transportation cost exerts positive effect on the region's inflation at the 50th and 75th quantiles over the short horizon (B1). At the highest scale (B4) or longer horizon however, increases in transportation cost corresponds to disinflation in the region. For the Northern region, the negative relationship between transportation cost and the inflation of the region occurs at the 50th and 75th quantiles over the four to eight-month horizon. At the highest scale (B4) however, increases in transportation cost fuel inflation in the region. While the negative relationship between transportation cost and the inflation rates of these three regions may seem counter intuitive, the setting of transport fares has a telling on these results. Whereas transport services providers are quick to adjust transport fares upwards following hikes in fuel prices, they seldom review transport fares downwards when fuel prices are reduced. Thus, transport fares are sticky downwards. As a result, even when overall prices are driven downwards by other factors, transport cost remain at the relatively high levels.

Related to the rationale for the inclusion of transportation cost in the model is the fact that because certain goods would necessarily emanate from some regions and then transported to other regions, we envisaged that prices in a particular region may be influenced by prices in other regions of the same country. In looking at the monetary policy effect on the inflation of a particular region, we controlled for the weighted average of the prices of other regions. The weights are based on the weights of the respective regions in the national inflation basket. The results, as in appendix A, indicate that prices in each region are necessarily a function of price developments in the other regions across the various horizons, although the effects differ and naturally so.

We also investigated the effect of output or economic activities on prices of the respective regions using the composite index of economic activities compiled by the Bank of Ghana. For Ashanti region, we find that output levels exert negative effect on the prices of the region over the two to four-month horizon (B1) and the eight to sixteen-month horizon (B3), although the size of the effects are substantially small. At B1 for instance, a percentage increase in economic activities corresponds to a 0.002% drop in the region's prices at the 50th quantile and 0.0023% at the 75th

quantile. At B3, prices in the region drop by 0.0087% at the 25th quantile, 0.006% at the 50th quantile and 0.008% at the 75th quantile following a percentage increase in output. In the Brong Ahafo region, we find that the effect of output on prices is statistically significant only at the 50th quantile over the two to four-month horizon and the 25th quantile over the eight to sixteen-month horizon. Even so, the size of the effects is minimal (below 0.01% in both cases). For central region, we find that the effect of output on the region's prices is positive but only over the sixteen to thirty-month horizon and at the 25th and 50th quantiles. Following a percentage increase in output over that horizon, inflation in the region increases by 0.026% at the 25th quantile and by 0.02% at the 50th quantile. For Eastern region, we find that output variation has no statistically significant effect on the region's prices across the horizons and quantiles. The Greater Accra region's inflation responds positively to variations in output but only at the 50th quantile over the four to eight-month horizon. Indeed, the effect is statistically significant only at 10% significance level with coefficient as small as 0.0025. The Western region is not different as the effect of output on prices is significant only over the four to eight-month horizon but across all the quantiles. Following a percentage increase in output, prices in the region increase by 0.006% at the 25th quantile, 0.0035% at the 50th quantile and 0.0037% at the 75th quantile. For the Northern region, output effect manifest only at the 75th quantile over the four to eight-month horizon and then at 25th quantile over the sixteen to thirty-two-month horizon. In Volta region, the effect of output on the region's prices is negative and significant at all the quantiles over the eight to sixteen-month horizon and at the 75th quantile over the sixteen to thirty-two-month horizon.

4.6.2. Results on provinces of South Africa

Similar to the heterogeneity observed in the case of Ghana, we find that different provinces respond differently to changes in monetary policy in South Africa. The inflation of Gauteng province, the economic heartbeat of South Africa, responds to changes in monetary policy over the longest horizon (sixteen to thirty-two months) and at the 75th quantile, as per the results in Table 4.13. Specifically, a percentage tightening in monetary policy stabilizes prices in the Gauteng province by 0.114% at the 75th quantile over the sixteen to thirty-two-month horizon. The negative response of the province's inflation to monetary policy changes is not surprising, given the presence of large industrial and service concerns in the province. These firms are relatively more sensitive to interest rate changes.

Table 4.13: Results on Gauteng Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.041	-0.007	-0.050
		(0.027)	(0.037)	(0.035)
	Transport cost	0.009	-0.003	0.004
		(0.007)	(0.009)	(0.008)
	Output	-0.008	0.013	0.014
		(0.008)	(0.012)	(0.011)
	EXGP	1.324***	1.397***	1.423***
		(0.038)	(0.052)	(0.048)
	Constant	1.612*	-0.757	-0.489
		(0.922)	(1.272)	(1.173)
	Pseudo R-squared	0.77	0.78	0.83
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.11	0.069	0.093
		(0.133)	(0.09)	(0.128)
	Transport cost	0.024**	0.030***	0.031***
		(0.011)	(0.007)	(0.01)
	Output	0.027	0.023	0.013
		(0.038)	(0.026)	(0.037)
	EXGP	1.159***	1.022***	1.154***
		(0.150)	(0.10)	(0.144)
	Constant	-0.064***	-0.002	0.061***
		(0.013)	(0.009)	(0.012)
	Pseudo R-squared	0.37	0.39	0.38

B2	Monetary Policy	-0.033	0.012	-0.060
		(0.168)	(0.14)	(0.148)
	Transport cost	0.031***	0.028***	0.021***
		(0.007)	(0.005)	(0.006)
	Output	0.045	0.029	0.027
		(0.029)	(0.024)	(0.0255)
	EXGP	1.112***	1.163***	1.211***
		(0.101)	(0.082)	(0.088)
	Constant	-0.062***	-0.001	0.063
		(0.0124)	(0.01)	(0.011)
	Pseudo R-squared	0.60	0.58	0.61
B3	Monetary Policy	0.103	0.004	-0.022
		(0.067)	(0.06)	(0.099)
	Transport cost	0.029***	0.039***	0.029***
		(0.0068)	(0.006)	(0.01)
	Output	0.008	0.012	0.012
		(0.0135)	(0.012)	(0.02)
	EXGP	1.295***	1.234***	1.322***
		(0.06)	(0.053)	(0.89)
	Constant	-0.068***	0.003	0.066***
		(0.012)	(0.0103)	(0.017)
	Pseudo R-squared	0.73	0.72	0.71
B4	Monetary Policy	-0.052	-0.096	-0.114*
		(0.064)	(0.091)	(0.068)
	Transport cost	0.035***	0.036***	0.030***
		(0.007)	(0.01)	(0.007)
	Output	0.040***	0.052***	0.070***
		(0.0075)	(0.011)	(0.008)
	EXGP	1.256***	1.316***	1.373***
		(0.054)	(0.08)	(0.06)
	Constant	-0.124***	-0.019	0.113***
		(0.014)	(0.020)	(0.015)
	Pseudo R-squared	0.75	0.74	0.77
Z4	Monetary Policy	0.013	-0.008	-0.036
		(0.024)	(0.030)	(0.024)
	Transport cost	-0.019**	-0.005	0.015*
		(0.009)	(0.011)	(0.009)
	Output	-0.012	0.002	0.003
		(0.009)	(0.012)	(0.009)
	EXGP	1.296***	1.360***	1.368***
		(0.034)	(0.043)	(0.034)
	Constant	1.945**	0.447	0.684
		(0.973)	(1.255)	(0.977)
	Pseudo R-squared	0.85	0.85	0.90

Note: EXGP represents the weighted average of the inflation rates of the provinces excluding Gauteng province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Another province where monetary policy provides stability in the prices is the Mpumalanga province although with distinct responses from Gauteng. In Mpumalanga, monetary policy stabilizes prices over B3 and B4 scales which correspond to eight to sixteen month and sixteen to thirty-two-month horizons respectively as per the results in Table 4.14.

Table 4.14: Results on Mpumalanga Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.024	0.081	0.109*
		(0.032)	(0.062)	(0.064)
	Transport cost	-0.055***	-0.020	-0.000
		(0.008)	(0.015)	(0.016)
	Output	0.048***	0.023	-0.032
		(0.010)	(0.019)	(0.020)
	EXMPU	1.222***	1.101***	1.024***
		(0.030)	(0.058)	(0.059)
	Constant	-6.143***	-3.458	2.982
		(1.103)	(2.127)	(2.182)
	Pseudo R-squared	0.74	0.76	0.79
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.061	-0.036	-0.023
		(0.11)	(0.099)	(0.11)
	Transport cost	-0.0163*	-0.013	-0.023**
		(0.009)	(0.0082)	(0.009)
	Output	0.0032	-0.032	-0.023
		(0.031)	(0.028)	(0.031)
	EXMPU	0.975***	0.91***	0.980***
		(0.08)	(0.073)	(0.08)
	Constant	-0.065***	-0.006	0.064***
		(0.01)	(0.0097)	(0.011)
	Pseudo R-squared	0.33	0.32	0.29
B2	Monetary Policy	0.196	0.0513	0.285
		(0.22)	(0.190)	(0.190)
	Transport cost	-0.052***	-0.034***	-0.024***
		(0.009)	(0.008)	(0.008)
	Output	-0.015	-0.0285	-0.042
		(0.038)	(0.033)	(0.032)
	EXMPU	1.268***	1.156***	1.143***
		(0.087)	(0.076)	(0.075)
	Constant	-0.102***	0.0018	0.0944***
		(0.016)	(0.014)	(0.014)
	Pseudo R-squared	0.47	0.45	0.49
B3	Monetary Policy	-0.398***	-0.383***	-0.283***

		(0.140)	(0.083)	(0.1)
	Transport cost	-0.033**	-0.028***	-0.01
		(0.0145)	(0.009)	(0.01)
	Output	0.008	0.0145	0.004
		(0.029)	(0.017)	(0.021)
	EXMPU	1.101***	1.132***	1.112***
		(0.084)	(0.05)	(0.061)
	Constant	-0.103***	0.011	0.115***
		(0.024)	(0.014)	(0.018)
	Pseudo R-squared	0.54	0.57	0.58
B4	Monetary Policy	-0.315***	-0.427***	-0.427***
		(0.066)	(0.067)	(0.119)
	Transport cost	-0.025***	-0.039***	-0.035**
		(0.007)	(0.008)	(0.0135)
	Output	-0.037***	-0.032***	-0.042***
		(0.008)	(0.008)	(0.014)
	EXMPU	1.184***	1.234***	1.181***
		(0.038)	(0.0384)	(0.068)
	Constant	-0.120***	-0.0283*	0.104***
		(0.015)	(0.0153)	(0.027)
	Pseudo R-squared	0.77	0.77	0.78
Z4	Monetary Policy	0.112**	0.176***	0.092*
		(0.047)	(0.045)	(0.049)
	Transport cost	-0.050***	-0.007	0.011
		(0.018)	(0.017)	(0.019)
	Output	0.053***	0.025	-0.002
		(0.018)	(0.017)	(0.019)
	EXMPU	1.142***	1.048***	1.092***
		(0.045)	(0.043)	(0.047)
	Constant	-6.927***	-4.012**	-0.606
		(1.989	(1.900)	(2.074)
	Pseudo R-squared	0.78	0.81	0.86

Note: EXMPU represents the weighted average of the inflation rates of the provinces excluding Mpumalanga province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Over the eight to sixteen-month horizon, a percentage tightening of monetary policy delivers price stability of 0.4% at the 25th quantile, 0.38% at the 50th quantile and 0.28% at the 75th quantile. Over the sixteen to thirty-two-month horizon, a percentage restriction of monetary policy exacts price stability of 0.32% at the 25th quantile and 0.43% at the 50th and 75th quantiles respectively in Mpumalanga. The province's economy thrives on mining, trade (wholesale and retail) and manufacturing. Firms in these sectors are relatively more sensitive to interest rates.

For North West province where mining activities, trade and manufacturing also dominate in terms of the economic structure of the province, we find that the stabilizing effect of restrictive monetary policy manifests over the eight to sixteen-month horizon and across all the quantiles as per the results in Table 4.15. Specifically, prices in the province stabilize by 0.35% at the 25th quantile, 0.33% at the 50th quantile and 0.34% at the 75th quantile over the eight to sixteen-month horizon following a percentage tightening of monetary policy.

Table 4.15: Results on North West Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.108*	-0.010	0.017
		(0.055)	(0.051)	(0.066)
	Transport cost	-0.062***	-0.050***	0.001
		(0.014)	(0.013)	(0.016)
	Output	0.041**	0.043***	0.029
		(0.017)	(0.016)	(0.021)
	EXNW	1.470***	1.362***	1.282***
		(0.055)	(0.051)	(0.066)
	Constant	-5.964***	-5.948***	-4.037*
		(1.890)	(1.752)	(2.272)
	Pseudo R-squared	0.71	0.74	0.78
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.243	-0.158	0.024
		(0.205)	(0.142)	(0.173)
	Transport cost	0.012	0.029**	0.034**
		(0.017)	(0.012)	(0.014)
	Output	-0.072	-0.131***	-0.116**
		(0.059)	(0.041)	(0.05)
	EXNW	1.158***	0.950***	0.967***
		(0.168)	(0.116)	(0.142)
	Constant	-0.099***	-0.005	0.103***
		(0.02)	(0.014)	(0.017)
	Pseudo R-squared	0.28	0.29	0.30
B2	Monetary Policy	-0.055	0.033	-0.0008
		(0.275)	(0.199)	(0.280)
	Transport cost	-0.001	-0.014*	-0.0014
		(0.01)	(0.008)	(0.012)
	Output	-0.009	-0.003	-0.0145
		(0.048)	(0.035)	(0.049)
	EXNW	1.136***	1.147***	1.01***
		(0.119)	(0.086)	(0.121)
	Constant	-0.112***	0.002	0.0896***

		(0.02)	(0.0146)	(0.021)
	Pseudo R-squared	0.37	0.37	0.40
B3	Monetary Policy	-0.346**	-0.328***	-0.341***
		(0.147)	(0.079)	(0.121)
	Transport cost	0.035**	0.0356***	0.0346***
		(0.015)	(0.008)	(0.012)
	Output	0.0245	-0.0001	-0.009
		(0.030)	(0.016)	(0.025)
	EXNW	0.881***	0.950***	1.003***
		(0.092)	(0.049)	(0.076)
	Constant	-0.108***	-0.008	0.087***
		(0.025)	(0.014)	(0.021)
	Pseudo R-squared	0.52	0.55	0.55
B4	Monetary Policy	-0.062	0.004	0.061
		(0.168)	(0.20)	(0.186)
	Transport cost	0.051***	0.064***	0.092***
		(0.019)	(0.022)	(0.021)
	Output	-0.036*	-0.005	0.034
		(0.0198)	(0.0234)	(0.022)
	EXNW	1.196***	1.036***	0.928***
		(0.101)	(0.120)	(0.112)
	Constant	-0.235***	0.012	0.317***
		(0.038)	(0.045)	(0.042)
	Pseudo R-squared	0.54	0.58	0.63
Z4	Monetary Policy	-0.039*	-0.072**	-0.130***
		(0.022)	(0.035)	(0.016)
	Transport cost	-0.104***	-0.051***	0.001
		(0.008)	(0.013)	(0.006)
	Output	0.097***	0.077***	0.051***
		(0.008)	(0.013)	(0.006)
	EXNW	1.520***	1.500***	1.485***
		(0.023)	(0.036)	(0.016)
	Constant	-12.020***	-9.665***	-6.573***
		(0.919)	(1.450)	(0.658)
	Pseudo R-squared	0.86	0.87	0.92

Note: EXNW represents the weighted average of the inflation rates of the provinces excluding North West province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

For other provinces such as Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape however, we find that restrictive monetary policy is rather destabilizing. In the case of Eastern Cape, with results in Table 4.16, we find that the destabilizing effect of restrictive monetary policy manifests over three successive scales (B2, B3 and B4) and across different quantiles. Over the four to eight-month horizon (B2), we find that a percentage tightening of monetary policy increases prices by 0.398% at the 25th quantile, 0.371% at the 50th quantile and 0.468% at the 75th quantile. For B3, a percentage increase in monetary policy destabilizes prices by 0.247% at the 25th quantile and 0.28% at the 50th quantile.

Table 4.16: Results on Eastern Cape Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.006	0.009	-0.000
		(0.042)	(0.050)	(0.062)
	Transport cost	-0.004	0.012	-0.014
		(0.010)	(0.012)	(0.015)
	Output	-0.052***	-0.065***	-0.013
		(0.013)	(0.016)	(0.019)
	EXEC	1.022***	1.051***	1.100***
		(0.043)	(0.051)	(0.062)
	Constant	5.585***	6.839***	1.996
		(1.438)	(1.719)	(2.110)
	Pseudo R-squared	0.70	0.72	0.75
Decomposed series (Wavelet)				
B1	Monetary Policy	0.086	0.134	0.119
		(0.153)	(0.165)	(0.145)
	Transport cost	-0.013	-0.002	0.015
		(0.013)	(0.014)	(0.012)
	Output	0.093**	0.0731	0.052
		(0.044)	(0.047)	(0.042)
	EXEC	1.009***	0.996***	1.063***
		(0.127)	(0.137)	(0.121)
	Constant	-0.103***	0.0181	0.102***
		(0.015)	(0.0162)	(0.014)
	Pseudo R-squared	0.25	0.24	0.305
B2	Monetary Policy	0.398**	0.371*	0.468**
		(0.190)	(0.197)	(0.22)
	Transport cost	-0.007	-0.011	-0.022**
		(0.008)	(0.0082)	(0.009)
	Output	0.045	0.013	0.010
		(0.033)	(0.034)	(0.038)
	EXEC	1.126***	1.185***	1.175***
		(0.086)	(0.09)	(0.098)
	Constant	-0.093***	-0.0001	0.093***
		(0.014)	(0.0145)	(0.016)
	Pseudo R-squared	0.475	0.471	0.483
B3	Monetary Policy	0.247**	0.280***	0.149

		(0.096)	(0.075)	(0.101)
	Transport cost	-0.031***	-0.045***	-0.04***
		(0.0099)	(0.008)	(0.01)
	Output	0.009	0.0055	-0.006
		(0.020)	(0.015)	(0.021)
	EXEC	1.139***	1.225***	1.180***
		(0.064)	(0.05)	(0.067)
	Constant	-0.098***	-0.004	0.084***
		(0.017)	(0.013)	(0.018)
	Pseudo R-squared	0.63	0.65	0.67
B4	Monetary Policy	0.222***	0.229**	0.387***
		(0.065)	(0.116)	(0.126)
	Transport cost	-0.039***	-0.0345***	-0.002
		(0.007)	(0.013)	(0.0144)
	Output	-0.120***	-0.11***	-0.103***
		(0.008)	(0.014)	(0.015)
	EXEC	1.278***	1.347***	1.180***
		(0.041)	(0.074)	(0.08)
	Constant	-0.182***	-0.026	0.144***
		(0.015)	(0.026)	(0.03)
	Pseudo R-squared	0.75	0.74	0.75
Z4	Monetary Policy	0.025	0.029	-0.185***
		(0.026)	(0.048)	(0.062)
	Transport cost	0.007	0.017	0.019
		(0.010)	(0.018)	(0.023)
	Output	-0.060***	-0.063***	-0.028
		(0.010)	(0.018)	(0.024)
	EXEC	1.004***	0.992***	1.191***
		(0.027)	(0.050)	(0.064)
	Constant	6.350***	6.797***	4.035
		(1.091)	(2.001)	(2.575)
	Pseudo R-squared	0.80	0.79	0.82

Note: EXEC represents the weighted average of the inflation rates of the provinces excluding Eastern Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

At the highest scale (B4), we find that a percentage restriction of monetary policy elicits price increases of 0.22% at the 25th quantile, 0.23% at the 50th quantile and 0.387% at the 75th quantile. For KwaZulu-Natal province, we find that at B2, the province's prices destabilize by 0.267% at only the 50th quantile following a percentage tightening of monetary policy as per the results in Table 4.17. At B3, a percentage policy restriction fuels instability in the province's prices by 0.22% at the 50th quantile. At the highest scale (B4) however, the destabilizing effect of restrictive monetary policy is felt across all the quantiles, with a percentage restriction occasioning a destabilization of 0.235% at the 25th quantile, 0.347% at the 50th quantile and 0.446% at the 75th quantile.

Table 4.17: Results on KwaZulu-Natal Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.110***	-0.122***	0.038
		(0.031)	(0.047)	(0.058)
	Transport cost	0.040***	0.033***	0.032**
		(0.008)	(0.012)	(0.014)
	Output	-0.040***	-0.070***	-0.068***
		(0.009)	(0.015)	(0.018)
	EXKZN	1.279***	1.274***	1.216***
		(0.033)	(0.050)	(0.063)
	Constant	3.591***	7.040***	6.468***
		(1.040)	(1.598)	(1.981)
	Pseudo R-squared	0.78	0.78	0.80
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.149	-0.027	-0.107
		(0.169)	(0.125)	(0.143)
	Transport cost	0.042***	0.049***	0.038***
		(0.014)	(0.01)	(0.012)
	Output	-0.074	-0.010	-0.024
		(0.049)	(0.036)	(0.041)
	EXKZN	0.739***	0.726***	0.593***
		(0.14)	(0.102)	(0.12)
	Constant	-0.088***	0.012	0.094***
		(0.017)	(0.0123)	(0.014)
	Pseudo R-squared	0.26	0.30	0.32
B2	Monetary Policy	0.184	0.267*	0.101
		(0.171)	(0.151)	(0.195)
	Transport cost	0.009	0.015**	0.015*
		(0.007)	(0.006)	(0.008)
	Output	-0.036	-0.052**	-0.007
		(0.03)	(0.026)	(0.034)
	EXKZN	1.037***	1.031***	0.995***
		(0.079)	(0.07)	(0.09)
	Constant	-0.074***	-0.006	0.077***
		(0.013)	(0.011)	(0.014)
	Pseudo R-squared	0.52	0.51	0.52
B3	Monetary Policy	0.157	0.222***	0.104
		(0.108)	(0.084)	(0.081)
	Transport cost	-0.003	-0.0147*	-0.013

		(0.011)	(0.009)	(0.0084)
	Output	-0.002	-0.0085	-0.009
		(0.223)	(0.017)	(0.017)
	EXKZN	1.033***	1.033***	1.116***
		(0.075)	(0.058)	(0.056)
	Constant	-0.092***	0.004	0.0936***
		(0.019)	(0.015)	(0.014)
	Pseudo R-squared	0.59	0.61	0.62
B4	Monetary Policy	0.235***	0.347***	0.446***
		(0.086)	(0.104)	(0.136)
	Transport cost	0.013	0.006	0.0008
		(0.01)	(0.012)	(0.015)
	Output	-0.109***	-0.123***	-0.127***
		(0.01)	(0.0122)	(0.016)
	EXKZN	1.132***	1.066***	1.111***
		(0.057)	(0.069)	(0.09)
	Constant	-0.145***	-0.044*	0.157***
		(0.02)	(0.024)	(0.03)
	Pseudo R-squared	0.74	0.73	0.74
Z4	Monetary Policy	-0.237***	-0.194***	-0.131***
		(0.020)	(0.034)	(0.027)
	Transport cost	0.055***	0.079***	0.105***
		(0.007)	(0.013)	(0.010)
	Output	-0.068***	-0.079***	-0.070***
		(0.007)	(0.013)	(0.010)
	EXKZN	1.427***	1.342***	1.288***
		(0.022)	(0.038)	(0.030)
	Constant	6.620***	7.943***	6.984***
		(0.806)	(1.419)	(1.106)
	Pseudo R-squared	0.89	0.88	0.91

Note: EXKZN represents the weighted average of the inflation rates of the provinces excluding KwaZulu-Natal province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Turning to Limpopo province, with results in Table 4.18, we find that the only statistically significant monetary policy effect on the province's inflation is at the highest scale (B4) and at the 50th and 75th quantiles only. At the 50th quantile, prices in the province increase by 0.3% following a percentage tightening of monetary policy. At the 75th quantile, prices in the province destabilize by 0.507% in response to a percentage monetary policy tightening.

For the Northern Cape province, with results in Table 4.19, we find the effect of monetary policy on prices of the province to be statistically significant at B3 and B4 scales. Specifically, a percentage restriction of monetary policy destabilizes prices over eight to sixteen-month horizon (B3) by 0.46% at the 25th quantile and by 0.361% at the 50th quantile. At B4 however, prices in the province destabilize by 0.345% at the 25th quantile, 0.395% at the 50th quantile and 0.446% at the 75th quantile following a percentage restriction of monetary policy.

Table 4.18: Results on Limpopo Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.200***	-0.082	-0.030
		(0.072)	(0.066)	(0.073)
	Transport cost	0.006	0.009	-0.004
		(0.018)	(0.016)	(0.018)
	Output	0.021	0.036*	0.037
		(0.023)	(0.021)	(0.023)
	EXLMP	1.352***	1.377***	1.356***
		(0.072)	(0.066)	(0.073)
	Constant	-2.859	-4.839**	-4.626*
		(2.470)	(2.253)	(2.495)
	Pseudo R-squared	0.67	0.71	0.74
Decomposed series (Wavelet)				
B1	Monetary Policy	0.067	-0.188	-0.232
		(0.245)	(0.235)	(0.246)
	Transport cost	0.033	0.012	-0.005
		(0.02)	(0.019)	(0.02)
	Output	0.185***	0.112*	0.059
		(0.07)	(0.067)	(0.071)
	EXLMP	1.029***	0.974***	1.186***
		(0.199)	(0.191)	(0.20)
	Constant	-0.131***	0.005	0.170***
		(0.024)	(0.023)	(0.024)
	Pseudo R-squared	0.19	0.185	0.20
B2	Monetary Policy	-0.539	-0.227	-0.538
		(0.418)	(0.293)	(0.402)
	Transport cost	-0.028	-0.0201*	-0.034**
		(0.0173)	(0.012)	(0.017)
	Output	-0.043	-0.027	-0.004
		(0.073)	(0.051)	(0.07)
	EXLMP	1.351***	1.106***	1.151***
		(0.181)	(0.127)	(0.174)
	Constant	-0.137***	-0.007	0.133***

		(0.031)	(0.022)	(0.03)
	Pseudo R-squared	0.31	0.30	0.29
B3	Monetary Policy	-0.0175	0.148	-0.126
		(0.154)	(0.135)	(0.133)
	Transport cost	-0.0252	-0.028**	-0.035**
		(0.016)	(0.014)	(0.014)
	Output	0.005	-0.012	-0.045
		(0.032)	(0.0278)	(0.027)
	EXLMP	1.027***	1.02***	1.139***
		(0.1)	(0.087)	(0.086)
	Constant	-0.145***	-0.002	0.147***
		(0.027)	(0.024)	(0.023)
	Pseudo R-squared	0.48	0.46	0.50
B4	Monetary Policy	0.125	0.301*	0.507***
		(0.215)	(0.155)	(0.182)
	Transport cost	0.003	-0.002	0.022
		(0.024)	(0.017)	(0.02)
	Output	-0.05*	-0.0344*	-0.078***
		(0.025)	(0.018)	(0.021)
	EXLMP	1.143***	1.032***	1.126***
		(0.132)	(0.095)	(0.112)
	Constant	-0.239***	-0.016	0.256***
		(0.048)	(0.035)	(0.041)
	Pseudo R-squared	0.57	0.59	0.64
Z4	Monetary Policy	-0.245***	-0.172***	-0.079
		(0.031)	(0.050)	(0.048)
	Transport cost	0.028**	0.051***	0.093***
		(0.011)	(0.019)	(0.018)
	Output	0.055***	0.046**	-0.032*
		(0.012)	(0.019)	(0.018)
	EXLMP	1.537***	1.430***	1.280***
		(0.032)	(0.051)	(0.049)
	Constant	-6.930***	-5.763***	2.528
		(1.283)	(2.071)	(1.990)
	Pseudo R-squared	0.84	0.83	0.85

Note: EXLMP represents the weighted average of the inflation rates of the provinces excluding Limpopo province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.19: Results on Northern Cape Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.211***	-0.149***	-0.011
		(0.065)	(0.049)	(0.126)
	Transport cost	-0.035**	-0.012	-0.002
		(0.016)	(0.012)	(0.031)

	Output	0.040*	0.013	0.034
		(0.021)	(0.015)	(0.039)
	EXNC	1.176***	1.133***	1.143***
		(0.062)	(0.047)	(0.120)
	Constant	-3.960*	-1.211	-3.887
		(2.240)	(1.687)	(4.317)
	Pseudo R-squared	0.61	0.64	0.65
Decomposed series (Wavelet)				
B1	Monetary Policy	0.077	0.211	0.008
		(0.158)	(0.143)	(0.225)
	Transport cost	-0.008	-0.018	0.0012
		(0.013)	(0.012)	(0.019)
	Output	-0.094**	-0.077*	-0.125*
		(0.045)	(0.041)	(0.065)
	EXNC	0.845***	1.034***	0.967***
		(0.124)	(0.113)	(0.177)
	Constant	-0.097***	-0.012	0.109***
		(0.015)	(0.014)	(0.022)
	Pseudo R-squared	0.25	0.23	0.21
B2	Monetary Policy	0.367	-0.001	0.207
		(0.422)	(0.195)	(0.249)
	Transport cost	0.0005	0.002	-0.009
		(0.017)	(0.008)	(0.010)
	Output	0.0152	-0.034	-0.06
		(0.073)	(0.034)	(0.0434)
	EXNC	1.008***	1.046***	1.155***
		(0.178)	(0.082)	(0.11)
	Constant	-0.084***	0.008	0.108***
		(0.031)	(0.014)	(0.0183)
	Pseudo R-squared	0.33	0.35	0.37
B3	Monetary Policy	0.460***	0.361***	0.236
		(0.12)	(0.115)	(0.183)
	Transport cost	-0.006	-0.0045	-0.023
		(0.0124)	(0.012)	(0.019)
	Output	-0.024	-0.014	-0.056
		(0.025)	(0.024)	(0.038)
	EXNC	1.10***	1.11***	1.221***
		(0.074)	(0.071)	(0.113)
	Constant	-0.118***	-0.022	0.128***
		(0.021)	(0.02)	(0.032)
	Pseudo R-squared	0.56	0.55	0.53
B4	Monetary Policy	0.345*	0.395***	0.446***
		(0.189)	(0.103)	(0.165)
	Transport cost	-0.067***	-0.072***	-0.069***
		(0.021)	(0.012)	(0.019)
	Output	-0.041*	-0.028**	-0.047**
		(0.0222)	(0.0122)	(0.0194)

	EXNC	1.226***	1.180***	1.108***
		(0.11)	(0.06)	(0.096)
	Constant	-0.141***	-0.002	0.205***
		(0.043)	(0.024)	(0.038)
	Pseudo R-squared	0.62	0.67	0.70
Z4	Monetary Policy	-0.184**	-0.187***	-0.369***
		(0.071)	(0.065)	(0.070)
	Transport cost	-0.018	0.015	0.063**
		(0.027)	(0.024)	(0.026)
	Output	0.057**	-0.009	0.009
		(0.027)	(0.025)	(0.027)
	EXNC	1.244***	1.198***	1.391***
		(0.070)	(0.064)	(0.069)
	Constant	-6.356**	0.940	-0.491
		(2.986)	(2.739)	(2.939)
	Pseudo R-squared	0.64	0.69	0.77

Note: EXNC represents the weighted average of the inflation rates of the provinces excluding Northern Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

To the Western Cape province, with results in Table 4.20, we find that monetary policy effect is significant only over the eight to sixteen-month horizon and at the 25th quantile. Specifically, prices in the province soar by 0.374% at the 25th quantile over the eight to sixteen-month horizon following a percentage tightening of monetary policy in South Africa.

Table 4.20: Results on Western Cape Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.097	0.207***	0.389***
		(0.061)	(0.052)	(0.054)
	Transport cost	-0.037**	-0.014	0.002
		(0.015)	(0.013)	(0.014)
	Output	0.031	0.005	0.009
		(0.020)	(0.017)	(0.017)
	EXWC	1.125***	1.005***	0.781***
		(0.068)	(0.058)	(0.060)
	Constant	-3.569*	-0.702	-0.989
		(2.132)	(1.833)	(1.890)
	Pseudo R-squared	0.65	0.68	0.76
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.084	-0.131	0.056
		(0.123)	(0.081)	(0.097)
	Transport cost	-0.0007	0.001	-0.005

		(0.010)	(0.007)	(0.008)
	Output	0.017	0.045*	0.044
		(0.035)	(0.0231)	(0.028)
	EXWC	1.032***	1.150***	1.066***
		(0.110)	(0.072)	(0.087)
	Constant	-0.060***	0.006	0.065***
		(0.012)	(0.008)	(0.001)
	Pseudo R-squared	0.35	0.39	0.43
B2	Monetary Policy	-0.168	-0.059	0.003
		(0.193)	(0.164)	(0.164)
	Transport cost	0.013	0.0112*	0.013*
		(0.008)	(0.007)	(0.007)
	Output	0.041	0.022	0.059**
		(0.034)	(0.029)	(0.029)
	EXWC	1.066***	1.047***	0.946***
		(0.094)	(0.08)	(0.08)
	Constant	-0.068***	-0.004	0.066***
		(0.014)	(0.012)	(0.012)
	Pseudo R-squared	0.53	0.53	0.54
B3	Monetary Policy	0.374**	-0.019	0.054
		(0.144)	(0.108)	(0.11)
	Transport cost	-0.002	0.0054	0.001
		(0.015)	(0.011)	(0.011)
	Output	0.0577*	0.044**	0.017
		(0.0293)	(0.022)	(0.022)
	EXWC	1.253***	1.154***	1.282***
		(0.107)	(0.081)	(0.082)
	Constant	-0.132***	0.0168	0.127***
		(0.025)	(0.0189)	(0.019)
	Pseudo R-squared	0.58	0.59	0.63
B4	Monetary Policy	-0.043	0.104	0.058
		(0.190)	(0.088)	(0.117)
	Transport cost	-0.038*	-0.021**	-0.0165
		(0.022)	(0.01)	(0.0134)
	Output	0.092***	0.087***	0.082***
		(0.023)	(0.011)	(0.014)
	EXWC	1.123***	0.992***	1.022***
		(0.128)	(0.060)	(0.079)
	Constant	-0.109**	0.002	0.197***
		(0.043)	(0.020)	(0.027)
	Pseudo R-squared	0.55	0.59	0.63
Z4	Monetary Policy	0.245***	0.260***	0.280***
		(0.021)	(0.040)	(0.050
	Transport cost	-0.078***	-0.052***	-0.029
		(0.008)	(0.015)	(0.019)
	Output	0.023***	0.022	0.030
		(0.009)	(0.016)	(0.020)

	EXWC	0.971***	0.934***	0.880***
		(0.025)	(0.046)	(0.057)
	Constant	-2.615***	-2.348	-2.903
		(0.928)	(1.725)	(2.176)
	Pseudo R-squared	0.80	0.79	0.84

Note: EXWC represents the weighted average of the inflation rates of the provinces excluding Western Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

The findings for the Free State province are mixed, as per the results in Table 4.21. At the lower scale (B1) or over two to four months horizon, a restrictive monetary policy is destabilizing for prices in the Free State province at the 75th quantile. Prices in the province are destabilized by 0.312% following a percentage restriction of monetary policy. At B3 or eight to sixteen-month horizon however, prices in the province stabilize by 0.14% following a percentage monetary policy restriction.

Table 4.21: Results on Free State Province

Scales	**Variables**	**25th Quantile**	**50th Quantile**	**75th Quantile**
Raw/Initial data				
	Monetary Policy	-0.008	-0.036	-0.001
		(0.028)	(0.045)	(0.051)
	Transport cost	-0.004	-0.011	-0.008
		(0.007)	(0.011)	(0.013)
	Output	-0.011	-0.009	0.010
		(0.009)	(0.014)	(0.016)
	EXFS	0.984***	1.012***	0.973***
		(0.028)	(0.044)	(0.050)
	Constant	1.411	1.566	-0.029
		(0.957)	(1.538)	(1.754)
	Pseudo R-squared	0.76	0.75	0.79
Decomposed series (Wavelet)				
B1	Monetary Policy	0.15	0.176	0.312**
		0(0.158)	(0.115)	(0.152)
	Transport cost	-0.01	0.001	-0.024*
		(0.013)	(0.009)	(0.0125)
	Output	-0.036	-0.014	-0.017
		(0.045)	(0.033)	(0.044)
	EXFS	0.847***	0.734***	0.888***
		(0.126)	(0.092)	(0.122)
	Constant	-0.073	0.002	0.071***
		(0.0154)	(0.011)	(0.015)

	Pseudo R-squared	0.27	0.25	0.25
B2	Monetary Policy	-0.128	-0.015	-0.113
		(0.221)	(0.137)	(0.225)
	Transport cost	0.013	0.015***	0.016*
		(0.01)	(0.006)	(0.0093)
	Output	-0.001	-0.036	-0.019
		(0.039)	(0.024)	(0.0395)
	EXFS	0.946***	0.947***	0.936***
		(0.096)	(0.06)	(0.098)
	Constant	-0.078***	-0.005	0.086***
		(0.016)	(0.01)	(0.017)
	Pseudo R-squared	0.51	0.495	0.48
B3	Monetary Policy	-0.088	-0.140**	-0.122
		(0.062)	(0.065)	(0.11)
	Transport cost	-0.0076	-0.012*	-0.018
		(0.006)	(0.007)	(0.011)
	Output	-0.0082	-0.007	-0.016
		(0.013)	(0.0132)	(0.022)
	EXFS	1.098***	1.08***	1.057***
		(0.04)	(0.04)	(0.069)
	Constant	-0.088***	-0.0123	0.085***
		(0.011)	(0.011)	(0.019)
	Pseudo R-squared	0.69	0.68	0.67
B4	Monetary Policy	0.083	0.012	0.12
		(0.073)	(0.087)	(0.146)
	Transport cost	-0.026***	-0.025**	-0.007
		(0.0083)	(0.01)	(0.0166)
	Output	-0.027***	-0.026**	-0.004
		(0.0086)	(0.01)	(0.017)
	EXFS	1.136***	1.13***	0.953***
		(0.045)	(0.053)	(0.089)
	Constant	-0.142***	-0.05**	0.161***
		(0.017)	(0.02)	(0.03)
	Pseudo R-squared	0.70	0.71	0.71
Z4	Monetary Policy	-0.043*	0.029	0.018
		(0.024)	(0.032)	(0.043)
	Transport cost	-0.005	-0.004	-0.015
		(0.009)	(0.012)	(0.016)
	Output	-0.008	-0.008	-0.001
		(0.009)	(0.012)	(0.017)
	EXFS	1.028***	0.932***	0.913***
		(0.025)	(0.032)	(0.043)
	Constant	1.220	1.502	1.221
		(1.021)	(1.321)	(1.792)
	Pseudo R-squared	0.83	0.83	0.86

Note: EXFS represents the weighted average of the inflation rates of the provinces excluding Free State province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

In respect of transportation cost, which also reflects changes in prices of fuel and the cost of moving goods within the country, we find differential effect on overall inflation of the respective provinces. For the Gauteng province, we find that increases in the cost of transportation exert upward pressure on the overall inflation at all the scales and across all the quantiles. Thus, transportation cost is necessarily a major contributor to inflationary momentum in the province. This is not surprising given the fact that the province is the melting pot of the South African economy with significant proportion of good paying jobs concentrated in the province. The availability of such jobs in the province attracts numerous people to the province with enormous opportunities for the transportation sub sector as workers require some form of transportation to commute between work places and homes. Indeed, the province is the most populous in the country with its attendant opportunities of high demand for food and household consumables. These food items are either transported from other provinces or from production centres in the province to the malls and shops. As a result, transportation cost necessarily plays a critical role in the price dynamics of the region.

For Eastern Cape, Limpopo, Mpumalanga and Northern Cape provinces, we find that transportation cost rather exerts negative effect on their respective inflation rates but across distinct scales and quantiles. Thus, their inflation rates increase in response to falling transportation cost in the country. Meanwhile, the findings for Free State, KwaZulu-Natal, North West and Western Cape provinces are mixed. For Free State province, with results in Table 4.14, we find that over the two to four-month horizon, a percentage increase in the cost of transportation corresponds to a fall in overall inflation by 0.024% at the 75th quantile. Similarly, prices in the province fall in response to rising transportation cost at the 50th quantile over eight to sixteen-month horizon as well as at the 25th and 50th quantiles of the sixteen to thirty-two-month horizon.

However, over the four to eight-month horizon, rising transport cost fuel inflationary momentum in Free State at the 50th and 75th quantiles. For KwaZulu-Natal, we find that transportation cost has largely exerted positive effect on the province's inflation, particularly over the two to four-month horizon and across all the quantiles in that scale. Similarly, the province's inflation has responded positively to rising transportation cost over the four to eight-month horizon and at the 50th and 75th quantiles. The positive effect implies that rising transportation cost fueled inflationary momentum in the province. It is only 50th quantile over the eight to sixteen-month horizon that rising transportation cost exerted negative effect on the prices of the province. The relationship is similar in the case of North West province as well. In the North West province, we find that at the 50th and 75th quantiles in B1, and all the quantiles in B3 and B4, transportation cost exerted upward inflationary momentum in the province. It is only at the 50th quantile in B2 where transportation cost elicited disinflation. For the Western Cape province, we find that transportation cost exerted positive effect on prices of the provinces at the 50th and 75th quantiles in B2 while it exerted negative effect at the 25th and 50th quantiles in B4.

In respect of the effect of output, for Eastern Cape province, we find that over the two to four-month horizon, falling output spurred disinflation at the 25th quantile. Specifically, a percentage fall in output corresponds to 0.093% decline in inflation in Eastern Cape at that quantile. At a higher scale (B4), however, falling output in the nation by a percentage point saw hikes in the inflation rates of the Eastern Cape province by 0.12% at the 25th quantile, 0.11% at the 50th quantile and 0.103% at the 75th quantile. For Free State province, the effect of changes in output on inflation is felt only over the longer horizon or the highest scale (B4) where a percentage decline in output elicits increases in prices of the region by 0.027% at the 25th quantile and by 0.26% at the 50th quantile. To the Gauteng province, we find that the effect of output is statistically significant only at the highest scale (B4). Specifically, a percentage decline in output precipitates disinflation in the Gauteng province by 0.04% at the 25th quantile, 0.052% at the 50th quantile and 0.07% at the 75th quantile.

For KwaZulu-Natal, Mpumalanga, Northern Cape and North West provinces, changes in output exert negative effect on their respective inflation rates although they differ in terms of horizons and quantiles at which these effects are significant. For KwaZulu-Natal province, the effect is prominent at scales B2 and B3 while for Northern Cape and North West, the effect is significant in scales B1 and B4 although they differ at quantiles. In the case of Mpumalanga, the negative effect is statistically significant in scale B4. For Western Cape, we find that a percentage increase in output fuel inflationary momentum at the 50th quantile in scale B1, 75th quantile in scale B2, 25th and 50th quantiles in scale B3 and across all the quantiles in scale B4. For Limpopo province, we find that over the two to four-month horizon, prices increase by 0.185% at the 25th quantile and by 0.112% at the 50th quantile following a percentage increase in output. Over a longer horizon (B4) however, prices in the province increase by 0.05% at the 25th quantile and by 0.078% at the 75th quantile following a percentage fall in output. For all the provinces, across all the horizons and quantiles, we find that prices in each province is positively and significantly impacted by prices in other provinces. Thus, variations in the prices of each province are necessarily underpinned by developments in the prices of other provinces. This is expected, given the fact that provinces depend on each other for one form or another of goods and services in view of the heterogeneity of their endowments.

4.6.3 Robustness Checks

We ascertain the robustness of our findings by considering a different specification that includes exchange rate. The idea is that some firms may be more oriented to international trade (imports and exports) than others in an economy, and different regions have different mix of these firms. As a result, movements in exchange rates would have a telling on the operations of different firms and their pricing strategies that eventually feed into the consumer prices in the regions. We measure the exchange rate as the values of the domestic currencies of Ghana and South Africa (Cedi and Rand) against a United States dollar as the dollar is the major foreign currency that is traded in these countries. The findings, presented in the Appendix for the purposes of space, indicate that our earlier findings are robust. For monetary policy in particular, the findings remain largely robust in terms of the signs and statistical significance.

Starting with regions in Ghana, we observe that the findings on monetary policy in the case of Brong Ahafo, Northern and Volta regions remain robust in terms of the significance and sign across all the scales and all the specified quantiles. For Ashanti region, the only change is at the 75^{th} quantile in scale B4 where monetary policy is now significant statistically but the sign remains the same. For the Central region, the only changes are in scales B1 and B2. Whiles monetary policy was significant at all quantiles in scale B1, it is now significant at the 50^{th} and 75^{th} quantiles but not the 25th quantile. The sign, however, remains the same. In scale B2, while monetary policy was significant at 25th and 50th quantiles, they are no longer significant. The sign though remains the same. For the Eastern region, monetary policy is now significant at the 75th quantile in scale B2 and 25th quantile in scale B3. The sign remains the same. For Greater Accra region, the only change is in scale B1 where monetary policy is no longer significant but the sign remains the same. For Western region, the only changes are in scale B2 at the 50th quantile and in scale B4 at the 25th and 75th quantiles.

To South Africa, we observe similar robust results. The sign and statistical significance of monetary policy remain robust with the few changes relating to only statistical significance but not sign occurring at the 75th quantile in scale B3 for Eastern Cape province; 75th quantile in scale B1, 50th quantile in scale B3 and 75th quantile in scale B4 for Free State province; 75th quantile in scales B2 and B4 for the Gauteng province; 50th quantile in scale B3 for KZN; 75th quantile in scale B2 for the Mpumalanga province; 75th quantile in scale B3 for Northern Cape and North West provinces; and the 50th and 75th quantiles in scale B3 for the Western Cape province. Overall, the results are robust for all the regions and provinces in Ghana and South Africa. We find exchange rate to be important for the inflation dynamics of the regions with varying impacts across regions/provinces and over different horizons and quantiles.

4.7 Policy Discussions

Undoubtedly, economic agents in the same country are confronted with distinct prices by virtue of their geographical locations. The flagrant disregard for such heterogeneity in many of the studies on monetary policy-inflation nexus that assume price homogeneity is a worrying empirical and policy conundrum. As our study has demonstrated, different regions/provinces do not only face different prices but their prices also respond heterogeneously to monetary policy. While monetary policy tightening provide stability in the prices of some regions/provinces, other regions/provinces and for that matter the economic agents therein witness further inflationary momentum following the same national level monetary policy. These findings then present implications for welfare. Monetary policy is supposed to deliver optimality in the welfare of the economic agents in the country. With these agents facing distinct prices across different locations in the same country implies that a monetary policy that focuses on national inflation averages may be welfare damaging for a substantial number of the very economic agents in whose interest the policy decisions are supposed to have been taken. This is because a restrictive monetary policy that is meant to rein in national level inflation may be too restrictive for some regions/provinces and the economic agents therein.

Moreover, the differential responses of regional/provincial inflation to monetary policy pose a risk to the achievement of publicly announced inflation targets in the context of inflation targeting countries. In the case of Ghana for instance, the finding that restrictive monetary policy meant to rein in inflation is rather destabilizing for Ashanti, Brong Ahafo and Volta regions is worrying. The combined weight of these three regions in the national inflation basket is 39.7% or approximately 40% and that is non-trivial in the overall dynamics of steering price levels to the announced target range. For South Africa, a restrictive monetary policy is destabilizing for as many as five provinces (Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape), and that is substantial in derailing stabilization efforts of the monetary policy authorities. Different factors drive the heterogeneity in the prices that various economic agents face in these regions/provinces. As a result, the observed inflation outcome at the national level would be heterogeneously determined by varying factors across horizons since they are necessarily an average of the divergent inflation outcomes of the various regions/provinces. A monetary policy decision that is focused on the national price level to the neglect of the underlying heterogeneity at the regional/provincial level then risks missing the publicly announced inflation target as the regional level differences could potentially induce significant deviations in the observed national price level. The heterogeneous regional/provincial inflation responses to the monetary policy pose even greater challenge as such distinctive responses exacerbate the eccentricities in the regional level inflation with spillover effect on the national price level. In the presence of such eccentricities, gauging the desired policy impact ex ante becomes even more daunting.

Meanwhile, missing the publicly announced inflation target has dire consequences for the credibility of monetary policy authorities, particularly in the context of inflation targeting. Credibility is an important building block in the foundation of inflation targeting framework. Economic agents must have confidence in the ability and credibility of the monetary policy authorities to steer price levels to the announced target. This helps to then anchor the inflation expectations of these economic agents to give potency to the policy framework. In this regard, monetary policymakers must comprehend the heterogeneous drivers of price levels in the regions/provinces to inform appropriate forecast of inflation in these regions, how they underpin the national price level and the accompanying responses to monetary policy.

4.8. Conclusion

The fact that different regions/provinces have different economic structures and endowments is an ample reason to expect that price developments in these regions/provinces would necessarily be distinct. Thus, economic agents in these regions/provinces would naturally be confronted with heterogeneous prices. Surprisingly, empirical studies and many policy decisions assume that these economic agents in an economy face homogeneous prices in looking at the monetary policy-inflation nexus. Such homogeneous price assumption is welfare-damaging for economic agents who face prices that are substantially distinct from the target of policy authorities. Although some studies on heterogeneous regional response to monetary policy exist, they are largely in the context of regional output response to monetary policy. Regional price response to monetary policy changes remain limited in the empirical literature. Meanwhile, heterogeneous regional price response is even more germane, especially in the context of inflation targeting countries. Few studies have considered distinct regional price responses to monetary policy but suffer the limitation that they assume each region's inflation relates symmetrically to monetary policy. Meanwhile, monetary policy-inflation nexus is seldom symmetric. This chapter makes significant stride in the regional inflation-monetary policy nexus. We provide a multi-layered asymmetric exposition on regional inflation-monetary policy relationship by using the wavelet-based quantile regression approach for the first time in this strand of the literature. We decomposed our original series into scales using the wavelet technique whiles we apply the quantile regression technique in each scale to unearth the asymmetric relationship between regional inflation and monetary policy.

We find that regions/provinces respond differently to changes in monetary policy. For Ghana, we find that for Central, Eastern, Greater Accra, Northern and Western regions, a restrictive monetary policy exacts mixed effect. Whiles monetary policy delivered stability across distinct quantiles in some scales, it fueled inflationary momentum in other scales, especially the higher scales or longer horizons. The responses are also distinct across scales and quantiles for each region and across regions. In the case of Ashanti, Brong Ahafo and Volta regions, we find that restriction in monetary policy only destabilizes prices across quantiles and in distinct scales. For South Africa, we find that whiles restrictive monetary policy delivers stability in the prices of Gauteng, Mpumalanga and North West provinces, it is destabilizing for prices in Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape provinces. For Free State province, the effect of a restrictive monetary policy on prices is mixed, depending on the horizon and the quantile involved. Importantly, these provinces (in the case of South Africa) and regions (in the case of Ghana) respond distinctively at various quantiles and over distinct horizons. We also find that regions/provinces respond differently to transportation cost and output in the respective economies. Significantly, we find that prices in each region/province is necessarily a function of price developments in the other regions/provinces. The findings are robust to different specifications.

We recommend that monetary policy decisions should take into consideration regional/provincial heterogeneity in prices and price developments. In forecasting inflation levels that inform monetary policy stance, monetary authorities must understand that the expected inflation outcome is heterogeneously influenced by distinct factors across regions/provinces. Ignoring such heterogeneity is a sure recipe for welfare destruction and policy fatality. It must be pointed out that the analysis of regional inflation-monetary policy nexus in this chapter has been hampered by data unavailability. In the case of Ghana for instance, we are only able to obtain time series data on regional inflation, as that is what is officially available. It would have been invaluable to control for region-specific factors such as size and distribution of firms, region-specific credit data, household income and consumption patterns. For South Africa, apart from provincial inflation and output, data on these other aforementioned factors could not be obtained. Availability of data on these factors in the future would substantially improve the discourse.

CHAPTER FIVE

MONETARY POLICY AND FOOD INFLATION: A QUANTILE REGRESSION ANALYSIS

5.1 Introduction

The effect of food prices on the overall inflation dynamics of countries is well acknowledged in the literature (Hammoudeh et al, 2015; Catao & Chang, 2015; Anand et al, 2015). For inflation targeting central banks in particular, food prices pose a problem not only for the overall inflation but also dents the forecasting accuracy meant to inform policy stance (Šoškić, 2015). As a result, central banks that target inflation give a considerable attention to food price evolution (Catao & Chang, 2015). However, literature recognizes that the extent of the impact of food inflation on the overall inflation dynamics is a function of income levels of countries (Pourroy et al, 2016), and the proportion of food in the consumption basket of the country (Catao & Chang, 2015). For developing and low income economies where food occupies a significant portion of the consumption basket and where expenditure on food takes a substantial portion of the already meagre income, rising food prices is important not just for the current inflation but also underpins future inflation through expectations and wage negotiations (Pourroy et al, 2016; and Anand et al, 2015). Importantly, Hanif (2012) reckons that because expenditure on food by households in low income economies is enormous (based on Engel's law), rising food prices is inimical to their welfare.

A critical question that has been posed in the literature is whether food inflation should inform monetary policy stance. The argument is that because food price effects are ephemeral, driven by supply side shocks and exhibit extreme volatility (Alper et al, 2016; Anand et al, 2015; Šoškić, 2015; Moorthy & Kolhar, 2011; and Anand & Prasad, 2010), it falls beyond the control of monetary policymakers. A counter argument in the literature has been that demand side factors such as income (Pourroy et al, 2016; and Šoškić, 2015) can also drive up prices of food and for which aggregate demand moderation (within the remit of central banks) can prove to be an effective panacea. In addition, to consider only the direct and contemporaneous effect of food prices is to underestimate its lethal second round impact on the other constituents of the CPI basket and the overall inflation eventually (De Gregorio, 2012). Hammoudeh et al (2015) reckon that to the extent that prices of commodities contain information regarding possible upward or downward inflation momentum, they become an important consideration that should inform the stance of monetary policy, a recognition made earlier by Bernanke & Gertler (1999).

An important consensus in the literature is that because expenditure on food in low income economies is a behemoth and the fact that food dominates their consumption baskets, to ignore food price inflation in such countries is to erroneously estimate the living cost and the prices that ordinary households encounter in these countries (Alper et al, 2016). Prices of food is therefore very prominent in the inflation dynamics and policy stance of central banks in these countries, especially the inflation targeting central banks. Indeed, the theoretical literature (Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015) posit that monetary policy can only deliver true welfare maximization in low income economies and those with dominance of food in the consumption basket by targeting headline inflation (that includes food).

While theoretical literature (Pourroy et al, 2016; Anand et al, 2015; Catao & Chang, 2015; Soto, 2003; and Aoki, 2001) provide the foundation for optimal monetary policy to impact food inflation, empirical investigation into this nexus remains limited (Bhattacharya & Jain, 2019). A considerable amount of the empirical literature (Hammoudeh et al, 2015; Scrimgeour, 2014; Anzuini et al, 2010; and Akram, 2009) have looked at monetary policy and commodity price index. Few studies (Hammoudeh et al, 2015; and Akram, 2009) have gone beyond the commodity price index to look at the effect of monetary policy on disaggregated components such as food and oil. Even so, the focus has been the context of the United States and a selected advanced and emerging economies (Bhattacharya & Jain, 2019; Hammoudeh et al, 2015; Scrimgeour, 2014; Akram, 2009; and Frankel, 2008).

Meanwhile Africa, where poverty levels are high and with dominance of food in the consumption basket, remains unexplored empirically. In Sub Saharan Africa, food constitutes 40% of the consumption basket as compared to 15% in the advanced economies (Alper et al, 2016). Additionally, the prevalence of poverty in Africa means that food is a major priority and a colossus in the overall expenditure of households. Out of the 736 million extremely poor individuals across the world, as many as 413 million (more than half) lived in Sub-Saharan Africa alone as at 2015 (World Bank, 2018, 2019). In addition, out of the 28 countries regarded as poorest in the world, as many as 27 countries (representing 96.4%) are located in Sub-Saharan Africa (World Bank, 2018, 2019). Understanding the monetary policy-food price nexus in the context of Sub-Saharan Africa could not be more critical. While studies by Alper et al (2016) and Rangasamy (2011) in the context of Africa provide important insights on food inflation and its dynamics, they failed to explicitly model the impact of monetary policy on food inflation.

Importantly, the few studies on monetary policy and food inflation in the context of advanced and emerging countries are fraught with considerable limitations. These studies used the vector autoregressive (VAR) technique or the structural VAR. Although the VAR models have been a workhorse for studies on monetary policy, the right approach for the identification of monetary policy innovations in VARs remains a critical point of disagreement in the literature. In view of such disagreements, empirical results have tended to differ significantly (Bernanke et al, 2004). In addition, the VAR methodology only captures the impact of surprise (Bernanke et al, 2004) in monetary policy as opposed to the invaluable impact of a more systematic monetary policy decisions.

Significantly, the use of VAR in these studies on countries such as New Zealand, Canada, Chile, Mexico, India and UK (Bhattacharya & Jain, 2019; Frankel, 2008) which are all inflation targeting countries is problematic. We argue that, in inflation targeting regimes where policy transparency is a sine qua non of the policy framework, the widespread usage of VARs which captures only policy surprises is counterintuitive. Surprises in monetary policy contradicts the need for credibility, transparency and anchoring inflation expectations which are the bedrocks of inflation targeting framework.

Furthermore, the argument in the literature that food inflation exhibits extreme volatilities especially when driven by extreme weather and other supply side shocks (Alper et al, 2016; Anand et al, 2015; Šoškić, 2015; Moorthy & Kolhar, 2011; and Anand & Prasad, 2010) implies that food price distribution necessarily exhibits tail dynamics which mean-based approaches such as VAR would naturally be incapable of capturing. Meanwhile, such tail dynamics are likely to exert substantial effect on the overall inflation trajectory and pose enormous risk to the achievement of the inflation targets. An approach that is more robust to tail dynamics would prove to be invaluable.

Notably, the use of VAR in these studies is an explicit assumption of symmetry in the monetary policy-food inflation nexus. Meanwhile, the fact that monetary policy behaviour and effect, and indeed macroeconomic variables, exhibit asymmetry is well known in the literature (Liu et al, 2018; Caporale et al, 2018; Ahmad, 2016; Martin & Milas, 2013). Given the dominant role of food prices in the trajectory of inflation in the African context and those targeting inflation in particular, getting the relationship right between monetary policy and food inflation is critical not just for the credibility of the monetary policymakers, but the resulting policy coherence is invaluable in alleviating the devastating effect of food prices on the welfare of the poor on the continent.

The current study makes a number of contributions to the literature. We become the first in the literature, to the extent that we know, to provide evidence on an explicit relationship between monetary policy and prices of food in the African context and especially on the only explicit inflation targeting countries in Sub-Saharan Africa (South Africa and Ghana). Given the argument in the theoretical and empirical literature that low income levels, dominance of food in the consumption basket and the proportion of food expenditure in the total household expenditure are pivotal factors in the monetary policy-food inflation relationship, then the current study in the context of Africa where these factors are more pronounced than anywhere else in the world is a bold step in the literature.

In providing evidence on the countries practicing inflation targeting, we depart from the existing literature by capturing the effect of regular and systematic policy on food prices as opposed to surprises in monetary policy. In inflation targeting frameworks, the scheduled meetings of the monetary policy committees are communicated in advance and the outcome of every meeting and the decision thereof are made public. In addition, in view of the supply and demand shock dichotomy and the resulting tail dynamics in the food inflation distribution, we use an approach that is capable of capturing these dynamics at the tails. To achieve this, we use the quantile regression technique by Koenker & Basset (1978). Quantile regressions also help us to capture asymmetry in the monetary policy-food inflation relationship, a significant departure from the existing literature where the techniques that have been deployed assume symmetry. The virtue of our chosen estimation technique is that unlike the OLS and the VAR techniques which lay emphasis on conditional mean, the influence of monetary policy and other regressors on food inflation across the various aspects of food inflation's distribution is provided by the quantile regression technique. Thus, the quantile regression is more informative by revealing the varying relationship between the regressors and the dependent variable across the various parts of the distribution of the latter (Benoit & Poel, 2017). The quantile regression technique is also robust to heteroscedasticity in the error terms (Yang et al, 2015). As food inflation is known to exhibit extreme volatility, outliers are inevitable. Where there are outliers or significant deviations, then the appropriateness of the mean-based approaches such as OLS and VAR become problematic (Benoit & Poel, 2017) and that is where quantile regression is more useful as it is robust to outliers.

We find that the effect of monetary policy on food prices is positive in Ghana and South Africa but with heterogeneous outcomes. Whiles the said effect in Ghana is significant only at the 25th

quantile, the monetary policy effect on food prices is significant across all the quantiles for South Africa with asymmetric effect that magnifies towards the right tail of the food distribution. Such tail dynamics and the apparent asymmetry are important information existing literature has failed to capture. We also find that the effects of transportation cost and output on prices of food are more prominent in Ghana relative to South Africa. Meanwhile, exchange rate movements and changes in the world food prices are important drivers of food prices in South Africa but not in Ghana. Our findings are robust to different specifications and measurements of variables. Section 5.2 looks at the paths of food and overall inflation in Ghana and South Africa whiles a review of the related literature is dealt with in section 5.3. Section 5.4 then focuses on the data and methodology whiles the empirical results, analysis and robustness checks are presented in section 5.5. Policy discussion is in section 5.6 whiles conclusion is in section 5.7.

5.2 Food inflation and overall inflation dynamics in Ghana and South Africa

South Africa and Ghana are the only explicit inflation targeting countries in Sub-Saharan Africa and in view of the dominance of food in the consumption baskets of these countries and the relatively high poverty levels, food price movements represent an important signal not just for the overall inflation trajectory but also the welfare dynamics in these countries. Relying on the annual reports of the South African Reserve Bank and the Bank of Ghana, we provide the observed patterns and relationship between food prices and the overall inflation over the period under study.

5.2.1. The case of Ghana

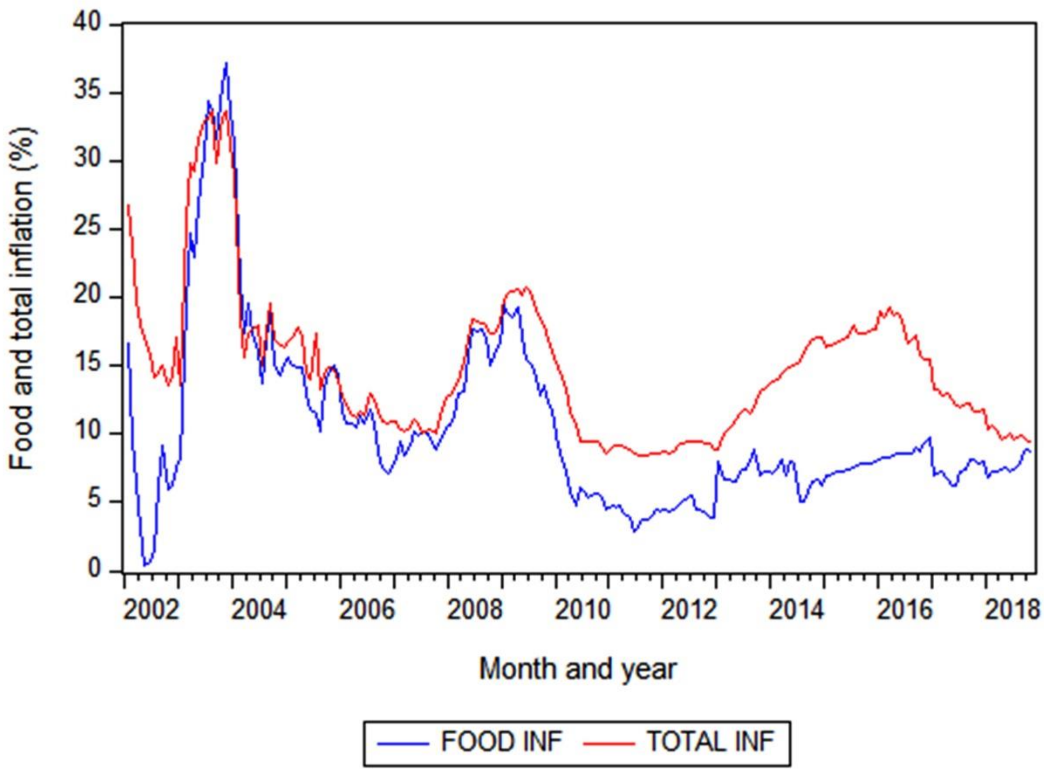
In the composition of CPI basket in Ghana, food alone constitutes 43.9%, 3.9% more than the average of Sub-Saharan Africa. The weight has been so since 2013 under the new CPI series with 2012 as the base year. Prior to that, the weight of food in the CPI basket was even more (44.91%), a clear demonstration of the dominance of food in the country's consumption basket. Unsurprisingly, the overall inflation trajectory carries the DNA and footprints of food inflation. For instance, while the year 2006 saw considerable volatility in the prices of oil on the world market thereby posing an upside risk to inflation in Ghana, inflation actually dropped to 10.5% from 14.8% in 2005 as food inflation dropped from as much as 15% in 2005 to just 6.4% in 2006.

Inflation at the end of 2007 stood at 12.8%, well above the set target. Food inflation alone contributed 41.2% to this inflationary outcome with cereals and bread as the main drivers. In 2008 when overall inflation reached 18.1% at the year end, the contribution of food alone was 46.8%. Following improvement in the production of food in 2010, food inflation plummeted to 4.5% from as high as 11.8% in 2009. Although non-food inflation in 2010 also saw a decline to 11.2% from 18.8% in 2009, it maintained its double-digit range. The massive drop in the food inflation to a single digit delivered a single digit overall inflation in the country for the first time. Inflation eased from 15.97% in 2009 to 9.5% by middle of 2010 and further down to 8.6% at the close of the year. The story was not different in 2012 where overall inflation remained within the target band to close at 8.8% as improvement in the production of food continued.

In 2015, inflation momentum picked up, sending overall inflation above the target to reach 17.7%, up from 17% in the previous year on the back of increases in food inflation. Food inflation increased by 120 basis points to reach 8% from 6.8% in the previous year. Over that same period, non-food inflation declined to 23.3%, down from 23.9% in the previous year. By the first quarter of 2016, inflation had risen to 19.2% as food inflation rose by 170 basis points to 9.7% from 8%. With non-food inflation declining in 2016, overall inflation dropped to 15.4% at the close of 2016. At the end of 2017, overall inflation had dropped to 11.8% as food inflation fell by 190 basis point over that period.

Clearly, inflationary and disinflationary processes in the country over the years have been driven by movements in food inflation. In Figure 5.1, we present a graphical account of the trajectories of food inflation and the overall inflation in Ghana over the period under study.

Figure 5.1: Food and overall inflation in Ghana



The overall inflation and food inflation have risen and fallen in unison. When overall inflation is falling, as shown in Figure 5.1, food price inflation is already below it and the same applies when overall inflation is rising.

5.2.3. The case of South Africa

From 1997 up to 2002, the weight of food in the CPI basket of South Africa was 20.3% on the basis of the expenditure patterns. In 2002, the weight increased to 24.2%, fell to 15.68% in 2009, then to 15.4% and increased to the current 17.24%. The changes in the weights are largely informed by the changes in the expenditure patterns. The contribution of food price inflation to the dynamics of overall inflation in South Africa has tended to be more than its weight in the CPI basket, a point well made by Rangasamy (2011) who also documented that food price inflation affects the rest of the constituents of the CPI basket in South Africa.

Between September 2001 and June 2002, inflation rose to 9.8% from 5.8% on the back of increasing prices of food which stood at 15.9% by the close of June 2002 and contributed 25.66% to the overall inflation. In terms of household expenditure, the contribution of food to the composition of products and services patronized by individuals within the low spending category was as high as 51.2% compared to 16.7% for individuals within the high spending category at the close of June 2002. Indeed, the harshness of the effect of rising food prices in 2002 precipitated the introduction of food relief package by the South African government to cushion the poor in the country. By the end of 2002, inflation had reached 9.3% which is 55% above the upper limit of the inflation target band of 3% - 6%. From 15.9% at the end of June 2002, food inflation dropped to 8.5% at the close of 2003 thereby driving down the overall inflation to 6.8%.

Similarly, when inflation rose from 3.9% to 4.9% between 2005 and 2006, food inflation was a major factor as it rose to 9.3% from 2.1% between November 2005 and October 2006. On the other hand, between August 2008 and June 2009, food price inflation dropped from 19.2% to 9.9% with overall inflation over the same period dropping from 13.6% (year-on-year) to just 6.9%. By the start of the second half of 2010, food inflation had dropped to 1.1% with such a significant drop taking overall inflation to within the target inflation band of 3% - 6%.

At the close of 2011, prices of food rose to 11.6% before easing to 6.8% by May the following year. Over that period, overall inflation exhibited a similar pattern, increasing initially to 6% by October 2011 before dropping to 5.7% by the end of May the following year. Similarly, although prices of food rose to 7.5% towards the end of 2012, it fell to 6.7% at the close of May 2013. Over the same period, overall inflation also exceeded the target band at the close of 2011, fell to 5.9% by April 2012 and then further down to 5.6% by the close of May 2013.

The year 2016 saw favourable prices of fuel with fuel price inflation of just 1.6% and yet overall inflation in South Africa exceeded the target band for the whole of that year except in July and August where overall inflation rates were 6% and 5.9% respectively. The major driver of the inflationary momentum was food price inflation which was 12.1% at the end of 2016 as a result of bad weather. By the start of 2018, food price inflation fell to 4.6% from the 12.1% recorded at the end of 2016. The drop in food inflation drove down overall inflation as weather conditions improved. Indeed, overall inflation was 4.7% on the average throughout 2017.

Food inflation has, undoubtedly, been phenomenal in the dynamics of overall inflation in South Africa from the foregoing historical relationship. Figure 5.2 gives a graphical representation of this relationship over the period under study.

Figure 5.2: Food and overall inflation in South Africa

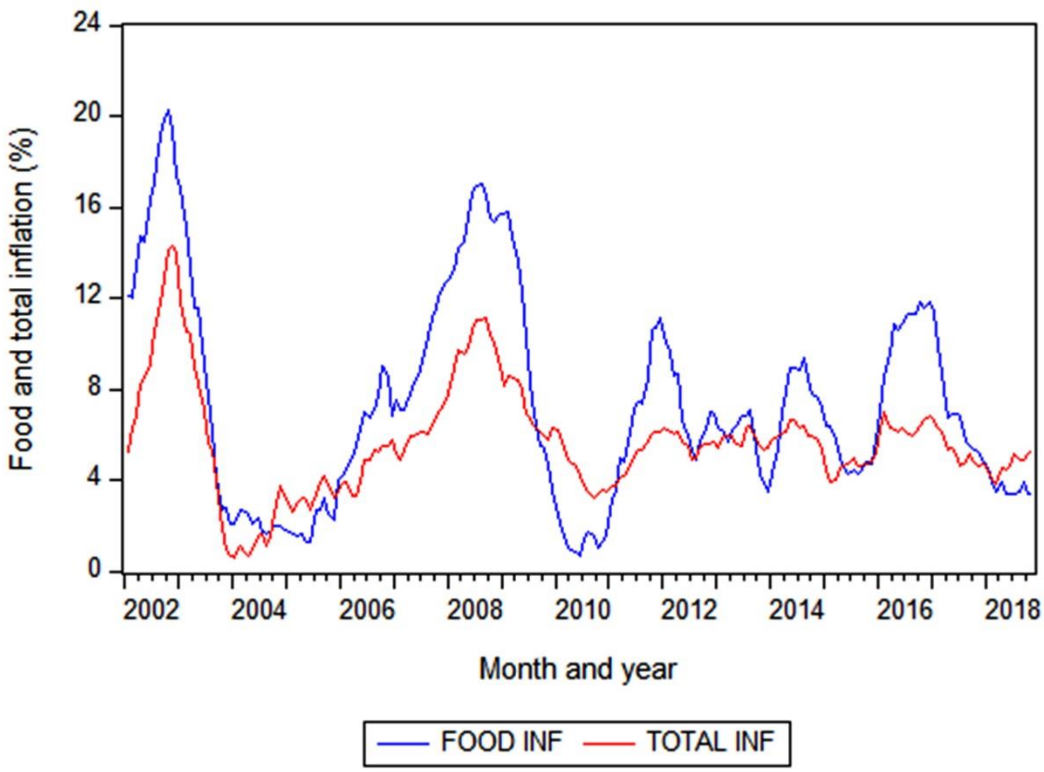


Figure 5.2 clearly shows how food price inflation has been a major driver of overall inflation in South Africa. Rises in overall inflation are preceded by rises in food price inflation and falling overall inflation are equally heralded by dips in food prices.

5.3 Literature Review

The theoretical literature on monetary policy-food inflation nexus has largely been focused on whether monetary policymakers should include food and other commodities such as oil in the measure of inflation for the purposes of targeting and welfare dynamics. Thus, the question has been whether to target headline or core inflation to deliver policy optimality and welfare maximization. In a theoretical study using DSGE approach in an open economy setting, Catao & Chang (2015) find that following a shock to global prices of food, targeting consumer price index delivers a welfare-enhancing outcome than the producer price index. This is under the condition that there is a perfect sharing of international risk and the elasticity of the country's export prices are not very small. They posit that the welfare benefits are even more prominent when expected consumer price index (as opposed to just consumer price index) is targeted. They find further that the targeting of producer price index only becomes superior under the condition that the sharing of international risk is incomplete.

Anand et al (2015) in a similar theoretical exposition find that welfare benefits are greater when central banks target headline inflation as opposed to core inflation, given the existence of financial friction. The authors situated their work in an open economy setting and allowing for financial market incompleteness. In view of the fact that many people in developing countries seldom have access to credit from the financial markets, their demand is hardly sensitive to interest rates (Anand et al, 2015).

Pourroy et al (2016), in a theoretical model using the DSGE framework, studied the response of monetary policy to shocks from world prices of food. They find that monetary policy optimality is a function of the level of income of countries. Specifically, they find that monetary policy is optimal for medium and low-income countries when the policymakers target headline inflation in view of the dominance of food in the consumption basket of these countries as well as the composition of the food basket itself (large share of goods that are not tradable). For high income countries, they find that monetary policy optimality is exacted by targeting non-food inflation.

From theoretical perspective, authors who found monetary policy to engender stability in the prices of commodities such as Scrimgeour (2014), Akram (2009) and Frankel (2008) established three main channels for this effect. The first is that when monetary policy is restrictive, the cost of storage become prohibitive, occasioning stock depletion and increasing the supply of these commodities. The second channel works such that a monetary policy rate hike makes interest bearing assets such as treasury bills attractive and therefore speculators adjust their investment portfolios by reducing holdings of commodities and in turn hold interest bearing assets. The third channel, emphasized by Scrimgeour (2014), relates to the channel of aggregate demand (Bhattacharya & Jain, 2019).

Monetary policy, theoretically, can reduce food inflation through the moderation of aggregate demand in the economy (Bhattacharya & Jain, 2019). On the basis of the Engel’s law however, the effect of a restrictive monetary policy on non-food inflation would be greater than the effect on food inflation. In addition, the effect of a restrictive monetary policy on consumption of food could be significantly less in countries where food dominates the consumption basket and particularly when the majority of the population live and consume food at the level of subsistence. Such a restrictive policy would then have its impact felt on the prices of non-food instead. As a result, the consumption pattern and the developmental stage essentially informs the extent of restrictive policy impact (Bhattacharya & Jain, 2019). Invariably therefore, if monetary policy responds in the wake of rising food prices, the combined effect on the non-food prices and to some extent the food prices would then have an impact on the overall inflation.

Although theoretical propositions differ in respect of whether core or headline inflation must be targeted when food inflation fuels general inflation, there is unanimity on the fact that when monetary policy is optimal, it helps to stabilize food inflation (Bhattacharya & Jain, 2019). Despite this theoretical consensus, the empirical evidence is not only few but also inconclusive as to whether monetary policy indeed provides stability in food prices (Bhattacharya & Jain, 2019).

Some literature in recent times have been dedicated to the factors that drive food inflation. Akram (2009) posits that increases in crude oil prices make alternative sources of fuel like biofuels more attractive in terms of cost. As these biofuels are obtained from agricultural goods, the rising demand for biofuels increases the demand for these agricultural goods and their prices. Mitchell (2008), as indicated in Bhattacharya & Gupta (2017), made a similar observation that the growth in the production of biofuels from food products, particularly oil seeds and grains, and the accompanying demand hikes have fueled increases in the prices of food in recent times.

Šoškić (2015) observed that food prices can be driven up by increasing aggregate demand that is underpinned by increasing income. Pourroy et al (2016) note that prices of food are not driven by just weather conditions but other factors also play critical roles in food price dynamics. These other factors, according to the authors, include growth in aggregate demand resulting from income rises, rising cost to farmers emanating from volatile prices of oil, trade restrictions imposed by major food exporters and the activities of speculators in the market for commodities. Bhattacharya & Gupta (2017) considered factors that drive food inflation and the effect of food inflation within the context of India. They find that whiles food inflation is significantly impacted by wages in the agricultural sector, the effect of prices of fuel on food inflation is moderate.

The empirical question of whether monetary policy stabilizes food inflation has been explored, although limited not only in terms of the volumes of research but also largely skewed to the context of advanced and selected emerging countries. With data spanning the period between 1950 and 2005 on the United States, Frankel (2008) found that an increase in real interest rate decreases commodity prices (including agricultural goods) and the indices of aggregate real prices of commodities. The author then compared the results to a number of emerging countries (such as Mexico, Chile and Brazil) and a selected number of advanced countries (such as New Zealand, Australia, Switzerland, Canada and UK). The author found similar results for these countries using data on aggregate price of commodities except Mexico where the author observed that a contraction in monetary policy impacted commodity prices positively (Bhattacharya & Jain, 2019).

Using an SVAR model in the context of the United States, Akram (2009) finds a significant rise in prices of commodities when real interest rates decline. The author finds that the response of food prices in particular to the decline in real interest rates is gradual. Anzuini et al (2010) studied the impact of the United States monetary policy on prices of commodities using the VAR model. They find that the index of commodity prices rose in reaction to an accommodative monetary policy stance. Scrimgeour (2014) considered the impact on commodity prices when monetary policy changes. The author finds that when monetary policy changes, there is immediate impact on prices of commodities. Specifically, prices of commodities decline by 0.6% when monetary policy increases by 1%.

Studying the United States context, Hammoudeh et al (2015) used data in quarterly frequency from quarter one of 1957 to quarter three of 2008 with the SVAR estimation technique. The authors studied the monetary policy impact on index of commodity prices (aggregate level) as well as the prices of the individual components including food (disaggregated level). They find that when monetary policy is restrictive in the United States, the effect on the total prices of commodities is negative and significant, although such an effect occurs with significant number of lags. On the disaggregated front, they find that an increase in the monetary policy rate impacts food inflation positively and the impact is persistent.

Using quarterly data from quarter one of 2006 to quarter two of 2016 and relying on panel VAR estimation technique, Bhattacharya & Jain (2019) studied how effective monetary policy is in providing stability in the prices of food. The author considered a set of developed and emerging countries. The author finds food inflation to be positively impacted by a restrictive monetary policy that is unexpected for both the emerging and developed countries. Specifically, the author observed that when inflation momentum in the country is underpinned by food inflation, then a restrictive monetary policy destabilizes both the food and general inflation. Bhattacharya & Gupta (2017) considered factors that drive food inflation and the effect of food inflation within the context of India. They find that whiles food inflation is significantly impacted by wages in the agricultural sector, the effect of prices of fuel on food inflation is moderate.

These studies have all been focused on advanced economies and selected emerging economies. Africa has not been explored, to the extent that we know. Meanwhile, it is the content where food dominates the consumption basket and household total expenditure tend to be skewed heavily towards food. Importantly, it is also the continent where poverty levels are high and therefore hikes in prices of food exacerbate the already precarious situation. In South Africa for instance, as indicated earlier, a quarter of the country's population wallow in food poverty (World Bank, 2019). The existing literature is also limited in terms of the estimation technique (VAR) which captures only surprises in policy changes. The technique also fails to deal with the tail dynamics of the distribution of food prices which is known to exhibit extreme volatilities. The technique also assumes symmetry in the face of complexities in real world and the observed asymmetry in the relationship between macroeconomic variables and the behaviour of monetary policy in particular.

For the African context, there are only two studies (Alper et al, 2016; and Rangasamy, 2011) related to the subject of food inflation, to the extent that we know. However, these two studies do not explicit look at the effect of monetary policy on food inflation. For instance, Alper et al (2016) compared average non-food and food inflation, their volatility and if they exhibit persistence in sub Saharan African countries. They also examined if non-food inflation is driven by food inflation in these countries. They then examined the pass through to food inflation from fuel prices, exchange rate and international food prices. They found that food inflation is greater than non-food inflation, equally persistent as the non-food inflation and its volatility is greater than non-food inflation. With granger causality tests, they found that there is no causal link between food and non-food inflation in most sub Saharan African countries. They also found international food prices as well as exchange rates to have a pass through to food prices in the domestic economy. The authors conclude that by excluding food inflation in the measure of the overall inflation in countries within Sub-Sahara Africa, policy makers would be seriously underestimating inflationary pressures in these economies.

Rangasamy (2011) on the other hand considered the implications of increasing prices of food for the conduct of monetary policy in South Africa. The author finds that the path of overall inflation in South Africa has been largely influenced by prices of food. The author also finds that the main drivers of increases in prices of food are domestic in nature. Finally, the author finds that in view of the fact that prices of food also affect other constituents of the CPI basket, monetary policymakers should accord it all the importance it deserves in arriving at their policy stance.

So, although these two studies in the African context provide important insight into the concept of food inflation, they fall short of examining the monetary policy-food inflation nexus. This is where we situate our work as we provide evidence in the context Africa and deploy an estimation technique that is capable of overcoming the limitations of the VAR technique outlined earlier.

5.4 Methodology

5.4.1. Data and Sources

Our data is in monthly frequency from January 2002 to November 2018 for both South Africa and Ghana. Although explicit inflation targeting in Ghana started in 2007, we start the data from 2002 in view of the data intensity of our estimation model. Importantly, data on monetary policy rate which reflects monetary policy stance predates the start of explicit inflation targeting in Ghana. Indeed, the Bank of Ghana had been practicing implicit inflation targeting since 2002 and so the monetary policy rate has been available as a policy tool even before the explicit targeting framework. Similarly, data on food inflation has also been available prior to both the implicit and explicit inflation targeting periods.

The variables in our model include food inflation, monetary policy, transportation cost, exchange rate, output and the world food price index. The choice of these variables is informed by the literature (Akram, 2009; Rangasamy, 2011; Hammoudeh et al, 2015; Bhattacharya & Jain, 2019; and Bhattacharya & Gupta, 2017). For Ghana, the data on monetary policy rate, output and exchange rate are obtained from the monetary time series database of the Bank of Ghana. Data on food inflation and transportation cost are obtained from the quarterly bulletins of the Ghana Statistical Service. Meanwhile, the world food price index is obtained from the United Nation's Food and Agriculture Organization (FAO). For South Africa, we obtained the data on food inflation and transportation cost from the quarterly bulletins of the South African Reserve Bank. The exchange rate, output and the monetary policy data are obtained from the datastream while the world food price index is obtained from FAO.

5.4.2. Definition of Variables

Food inflation is in percentage for both countries as measured by the primary sources and it represents the change in the food price index in a particular month from the same month in the previous year.

Monetary policy is measured in percentage and is represented by repo rate and the monetary policy rate for South Africa and Ghana respectively. These are the official monetary policy instruments in the respective countries.

Output: since gross domestic product, a measure of output, is not available in monthly frequency for the countries we are studying, we rely on an alternative measure. For Ghana, we use the composite index of economic activities compiled by the Bank of Ghana to gauge the level of economic activities. In the case of South Africa, a similar measure exist which is the coincident business cycle indicator.

Exchange rate: As the United States Dollar remains the dominant foreign currency traded in both South Africa and Ghana, we use the exchange rates between the dollar and the respective currencies of Ghana and South Africa (Cedi and Rand) as the exchange rate for our study.

Transportation cost: Measured in percentage, as per the primary sources, it represents a change in the transportation price index in a particular month from the same month in the previous year.

World food price index: Measured in index by FAO, it is used to measure movements in the prices of food on the international market.

5.4.3 Descriptive Statistics

Table 5.1: Level Series

GHANA	FOOD INF	TOTAL INF	MPR	TRANSP	OUTPUT	EXCH	WFPI
Mean	10.38	14.82	18.41	22.25	275.95	1.99	163.51
Median	8.17	14.00	18.00	22.60	246.40	1.44	168.44
Maximum	37.20	33.60	27.50	74.40	1148.83	4.81	240.09
Minimum	0.40	8.39	12.50	-4.30	14.60	0.74	85.08
Std. Dev.	6.58	5.48	4.47	14.64	138.25	1.31	42.47
Skewness	1.91	1.50	0.52	1.14	1.31	0.91	-0.17
Kurtosis	7.18	5.63	2.06	5.39	9.06	2.25	1.95
Observations	203	203	203	203	203	203	203
S. AFRICA							
Mean	7.40	5.69	7.64	5.74	100.72	9.31	163.51
Median	6.70	5.50	7.00	5.40	102.70	8.16	168.44
Maximum	20.30	14.30	13.50	24.50	108.90	16.38	240.09
Minimum	0.70	0.60	5.00	-10.10	84.40	5.73	85.08
Std. Dev.	4.60	2.42	2.36	6.40	6.12	2.72	42.47
Skewness	0.72	0.88	1.08	0.61	-1.10	0.72	-0.17
Kurtosis	2.78	4.81	3.11	4.03	3.08	2.28	1.95
Observations	203	203	203	203	203	203	203

Note: FOOD INF means food inflation rate, TOTAL INF is total inflation rate, TRANSP is transportation cost/inflation and WFPI is world food price index. All others are as previously defined.

Table 5.2: Stationary/Differenced Series

GHANA	FOOD INF	TOTAL INF	MPR	TRANSP	OUTPUT	EXCH	WFPI
Mean	-0.05	-0.06	-0.05	-0.05	275.95	0.02	0.34
Median	0.10	0.00	0.00	0.00	246.40	0.01	0.40
Maximum	11.30	12.00	2.00	50.90	1148.83	0.59	14.71
Minimum	-10.00	-10.40	-2.50	-49.90	14.60	-0.87	-24.05
Std. Dev.	1.84	1.630303	0.65	7.05	138.25	0.09	4.69
Skewness	0.34	0.80	-0.69	-0.04	1.31	-2.77	-0.55
Kurtosis	14.25	25.05	7.76	27.92	9.06	47.87	6.97
Observations	203	203	203	203	203	203	203
S. AFRICA							
Mean	-0.04	0.00	-0.02	5.74	0.10	0.17	0.34

Median	0.00	0.00	0.00	5.40	0.09	-0.17	0.39
Maximum	2.10	1.80	1.00	24.50	4.23	20.12	14.71
Minimum	-2.50	-2.20	-2.00	-10.10	-3.74	-9.71	-24.05
Std. Dev.	0.85	0.55	0.33	6.40	1.09	3.77	4.69
Skewness	-0.30	-0.50	-1.84	0.61	-0.10	0.77	-0.55
Kurtosis	3.19	5.40	14.42	4.03	4.74	6.10	6.97
Observations	203	203	203	203	203	203	203

Note: FOOD INF means food inflation rate, TOTAL INF is total inflation rate, TRANSP is transportation cost/inflation and WFPI is world food price index. All others are as previously defined.

5.4.4. The estimation approach

To estimate the quantile regression, we consider an independent identically distributed (i.i.d) setting (Koenker, 2005) and define the model as:

$$f_t = x_t'\beta + u_t \tag{1a}$$

$$E(f_t|\, x_t) = x_t'\beta \tag{1b}$$

$$Q_{f_t}(\theta|\, x_t) = x_t'\beta_\theta \tag{1c}$$

$$\beta_\theta = \beta + \gamma \mathrm{F}^{-1}(\theta) \tag{1d}$$

such that the cumulative distribution function of $\{u_t\}$ is represented by F whiles γ is a constant. Meanwhile, θ represents the quantiles of interest and food inflation's conditional quantile function given the covariates is denoted by $Q_{f_t}(\theta|\, x_t)$. In view of the data coverage with total observations of 203 for each country, we split the data on the response variable at 25th, 50th and the 75th quantiles such that each quantile has sufficient observations to avoid the problems of degrees of freedom and spurious results. β_θ represents the vector of parameters at the specified quantiles to be estimated. The parameters or coefficients at the respective quantiles represent the marginal effects of the covariates on food inflation at a particular quantile of food inflation. The x_t represents the vector of these covariates whiles u_t is the error term which can assume any distributional form, a key distinctive feature of quantile regression approach. The monetary policy variable in the vector of the covariates is a two-period lag variable. The argument is that the Monetary Policy Committees of the two central banks meet approximately every two months to take monetary policy decisions. These policy decisions are hinged on forecasts of factors that pose upside and down inflation risk. The decision is thus taken in anticipation of the path of inflation. Intuitively, the effect of the monetary policy decision on food inflation can only be with lag as opposed to contemporaneous. The choice of the lag period is thus in synchrony with the horizon prior to the subsequent meeting when fresh forecasts would then form the basis for the new decision. The use of lag of monetary policy rate (the main variable of interest) helps to deal with a possible endogeneity problem between monetary policy rate and food prices. The possible endogeneity problem arises from the fact that just as changes in monetary policy is expected to impact on food prices, changes in food prices affect overall inflation and that can influence the stance of the monetary policy committee in the determination of the monetary policy rate. By using the lag of monetary policy rate, the endogeneity problem is resolved by the fact that whereas previous monetary policy rates affect food prices today, changes in food prices today cannot possibly influence previous monetary policy rates (see Uprety et al, 2019; and Boachie et al, 2018).

We estimate the parameters in equation (1) by minimizing the following loss function:

$$\min_{\beta_\theta \in \Re^p} \sum_{t=1}^{T} \rho_\theta \left(f_t - x_t' \beta_\theta\right) \qquad (2)$$

where p = dimension (β_θ). We simplify the loss function in equation (2) by expressing it as:

$$\rho_\theta(u) = u(\theta - I(u < 0))$$

Such that I represents an indicator function which takes the value 1 when $u < 0$ or 0 otherwise.

Unlike the mean-based approaches that minimize the sum of the residuals squared, the sum of the absolute values of the residuals along with asymmetric penalties are minimized in the case of quantile regression. Thus, the minimization problem showed in equation (2) reads as:

$$\min_{\beta_\theta \in \Re^p} \sum_{t=1}^{T} \theta|u_t| + \sum_{t=1}^{T}(1-\theta)|u_t| \tag{3}$$

such that $\theta|u_t|$ represents penalization for $u_t \geq 0$ whiles $u_t < 0$ is penalized by $(1-\theta)|u_t|$.

5.4.5. Test for stationarity

As our data is time series in nature, we ascertain the stationarity properties of these data. We employ the Augmented Dickey-Fuller (ADF) Test developed by Dickey & Fuller (1981) and the Phillips Perron (PP) Test developed by Phillips & Perron (1988). For Ghana, we find that food price index, monetary policy rate, exchange rate and the world food price index are stationary only after the first difference for both the ADF and the PP tests. Output, on the other hand, is stationary at the levels for both the ADF and the PP tests. The result for transportation cost is mixed. Whiles the ADF test indicates transportation cost is stationary only after first difference, the PP test indicates it is stationary at the levels and after first difference. We therefore take the first difference since both tests converge at the same results after the first difference. As a result, food inflation, monetary policy rate, exchange rate, transportation cost and the world food price index enter the model after they have been first differenced whiles output goes into the model at the levels.

For South Africa, the PP test shows that food inflation, monetary policy rate, output and exchange rate are stationary only after first difference whiles the ADF test indicates that these variables are stationary at the levels at 10% significance. We take the first difference of these variables before they go into the model as 10% significance under the ADF test is rather marginal. For transportation cost, we find that whereas ADF indicates it is stationary only after the first difference, the PP test shows it is stationary at the levels at 1% significance. Given the overwhelming significance at 1%, we decided to confirm this using the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test developed by Kwiatkowski et al (1992). The results show a test statistic of 0.11 which is less than the asymptotic critical value of 0.216 at 1% significance and so we fail to reject the null hypothesis that transportation cost is stationary. As a result, the transportation cost variable enters the model at the levels. The treatment of world food price index is the same as explained for Ghana.

Table 5.3: Test for stationarity

		ADF TEST		**PP TEST**	
		Level	**First Diff**	**Level**	**First Diff**
Ghana	FOOD	-2.53	-7.16***	-3.10	-10.85***
	MPR	-1.78	-7.51***	-2.11	-14.83***
	TRANSP	-2.99	-8.1***	-3.81**	-15.81***
	OUTPUT	-12.68***		-12.85***	
	EXCH	-0.88	-21.69***	-1.1	-20.76***
	WFPI	-1.69	-7.74***	-1.54	-7.84***
South Africa					
	FOOD	-3.36*	-5.35***	-2.61	-8.15***
	MPR	-3.18*	-4.24***	-2.04	-13.51***
	TRANSP	-2.56	-5.58***	-4.76***	-26.13***
	OUTPUT	-3.25*	-8.57***	-2.67	-8.96***
	EXCH	-3.19*	-10.39***	-3.05	-10.35***
	WFPI	-1.69	-7.74***	-1.54	-7.84***

Note: For the ADF and the PP Tests, we include both the intercept and trend at both the levels and first difference. ***, ** and * indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root.

5.4.6. Test for structural breaks

Macroeconomic variables, especially policy instruments, exhibit structural breaks in view of changes in policy stance and shifts in policy priorities. The plots of the series in Figures 5.3 and 5.4 for Ghana and South Africa respectively give an indication of possible breaks. For Ghana in particular, we envisage that because the horizon we are looking at covers periods of both implicit and explicit inflation targeting, it is only prudent to check for breaks and control for same to avoid spurious results. Unfortunately, the ADF and the PP tests do not check for structural breaks. We therefore use the Zivot-Andrews test for structural breaks by Zivot & Andrews (1992). The results are presented in Table 5.4 below.

The minimum t-statistics of the various variables are less than the critical values at the three significance levels for South Africa, an indication that the series have unit root. For Ghana, the estimated minimum t-statistics for the variables indicate that only transportation cost and output are stationary at the levels. Whiles transport is stationary at the levels at 5% significance, output is stationary at the levels at 1% significance. Our interest though is in the determination of the structural break and when the break occurred (last column of the table) as we have already determined the stationarity or otherwise of the series using the ADF and the PP tests.

Figure 5.3: Plots of variables – Ghana

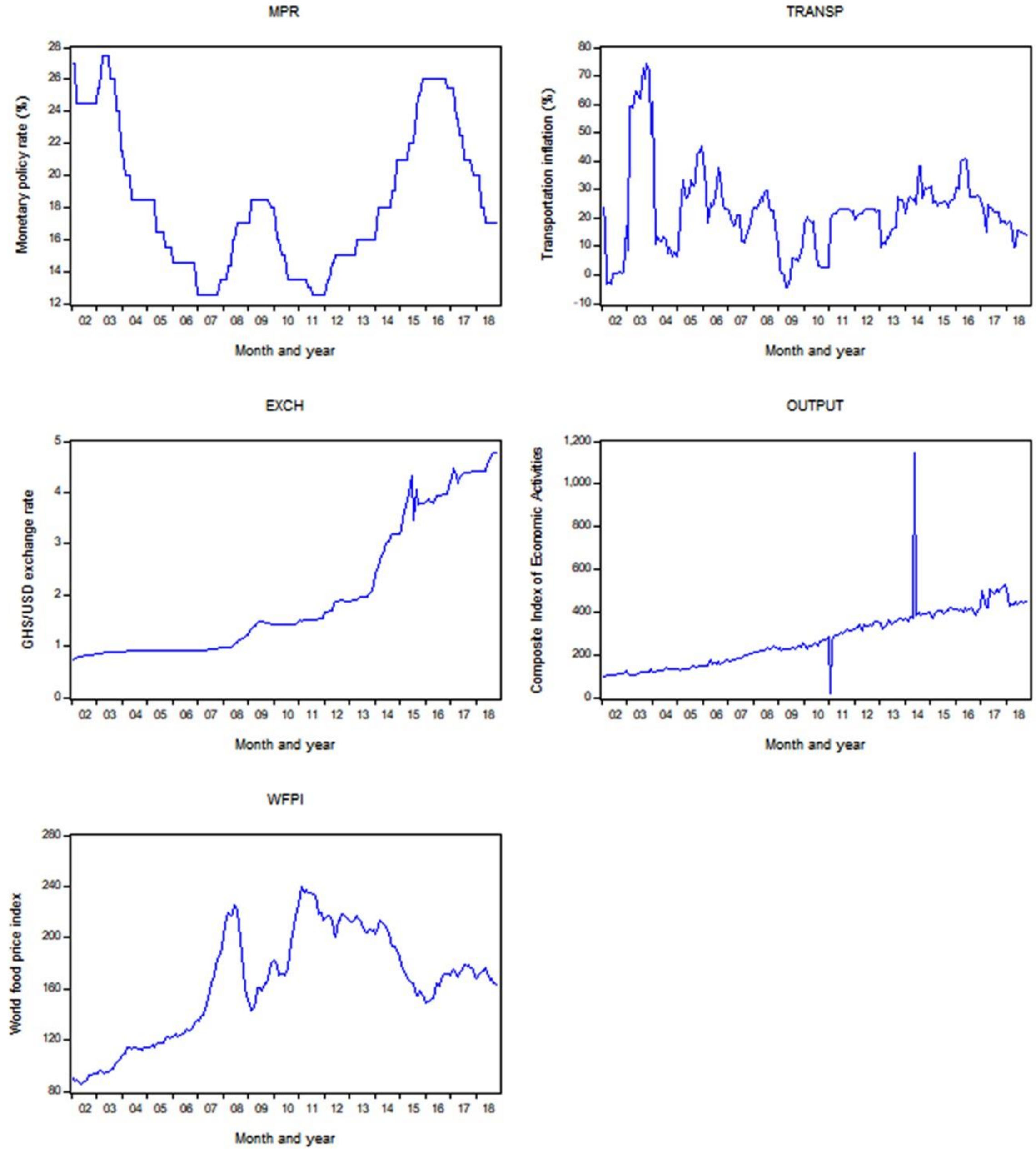


Figure 5.4: Plots of variables – South Africa

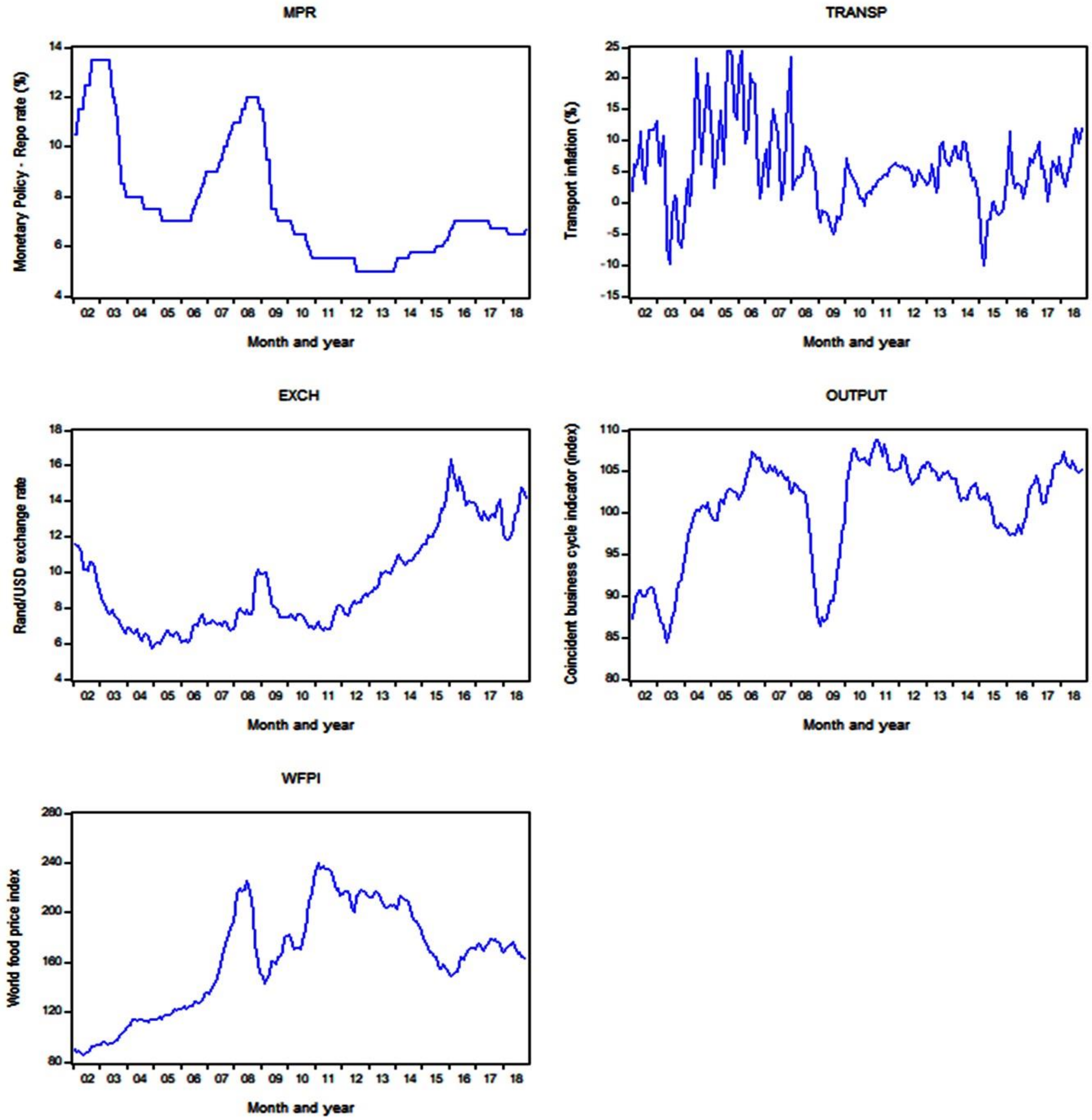


Table 5.4: Test for structural break

Variable name	Potential Break points, Allowing for Trend and Intercept	
	Ghana	South Africa
Monetary Policy Rate	-2.756 (May 2005)	-4.110 (February 2009)
Transportation Cost	-5.319 (January 2011)	-4.330 (January 2008)
Output	-13.640 (May 2014)	-4.244 (April 2007)
Exchange Rate	-4.368 (December 2013)	-3.644 (December 2014)
World Food Price Index	-4.711 (July 2010)	-4.711 (July 2010)

Note: The month and the year break occurred in parenthesis.

5.5 Empirical results and analysis

We present the results based on the ordinary least squares (OLS) and the quantile regression for Ghana and South Africa in Table 5.5. The OLS is included in the analysis for the purposes of comparison between mean-based regression and the quantile regression approaches. Since we identified structural breaks in the variables, we controlled for them at all the quantiles of the distribution of food inflation and the results are in Table 5.6. To do this, we introduced dummies for each variable on the right-hand side of the model such that the identified date of break for each of these variables takes the value 1 and all other dates are 0. This is to ascertain whether the observed breaks had a significant effect on the prices of food in both countries. As Table 5.6 shows, all the dummies are statistically insignificant at all the specified quantiles, implying that these breaks had no significant effect on prices of food in the two countries. Significantly, the results do not materially change whether we control for these breaks or not as can be seen in Tables 5.5 and 5.6. As a consequence, we base our analysis on results in Table 5.5.

Table 5.5: Quantile Regression Results – Before controlling for structural breaks

GHANA	OLS	25th Quantile	50th Quantile	75th Quantile
MPR	.40**	.45**	.18	.078
	(0.18)	(0.20)	(0.15)	(0.17)
TRANSP	.11***	.064***	.042***	.034**
	(0.02)	(0.02)	(0.01)	(0.015)
EXCH	.35	1.22	.053	-.52
	(1.25)	(1.37)	(1.03)	(1.14)
OUTPUT	.0005	.0036***	.0012*	-.002**
	(0.0009)	(0.0009)	(0.0007)	(0.0008)
WFPI	.0074	.034	-.0006	-.0023
	(0.0255)	(0.028)	(0.021)	(0.023)
Constant	-.181	-1.77***	-.42*	1.06***
	(0.265)	(0.29)	(0.22)	(0.24)
R-Squared	0.22			
Pseudo R-sq		0.14	0.03	0.04
F-statistics	10.91***			
Observations	203	203	203	203

SOUTH AFRICA

MPR	.43**	.52**	.56***	.72***
	(0.18)	(0.25)	(0.185)	(0.24)
TRANSP	.026***	.0245*	.021**	.011
	(0.009)	(0.013)	(0.009)	(0.012)
EXCH	.042***	.045**	.0344**	.021
	(0.016)	(0.022)	(0.016)	(0.021)
OUTPUT	-.031	-.098	-.028	.024
	(0.057)	(0.08)	(0.06)	(0.076)
WFPI	.05**	.04	.044*	.0575*
	(0.024)	(0.03)	(0.025)	(0.032)
Constant	-.198**	-.62***	-.166**	.381***
	(0.08)	(0.11)	(0.081)	(0.11)
R-Squared	0.13			
Pseudo R-sq		0.1	0.07	0.07
F-statistics	5.77***			
Observations	203	203	203	203

Note: ***, ** and * indicate significance level at 1%, 5% and 10% respectively. Standard error in parenthesis.

Table 5.6: Quantile Regression Results – After Controlling for Structural Breaks

GHANA	**OLS**	**25th Quantile**	**50th Quantile**	**75th Quantile**
MPR	.41**	.44**	.22	.079
	(0.19)	(0.18)	(0.164)	(0.20)
TRANSP	.11***	.062***	.027*	.035*
	(0.02)	(0.0165)	(0.015)	(0.02)
EXCH	.39	1.02	.080	-.52
	(1.27)	(1.20)	(1.11)	(1.4)
OUTPUT	.00021	.0041***	.0013	-.0018*
	(0.00099)	(0.001)	(0.001)	(0.001)
WFPI	.008	.0311	.0011	-.0046
	(0.026)	(0.025)	(0.023)	(0.028)
DUMMPR	-1.67	-.51	-1.58	-2.71
	(1.68)	(1.59)	(1.47)	(1.82)
DUMTRANSP	-1.53	.83	.27	-1.33
	(1.72)	(1.63)	(1.51)	(1.86)
DUMOUTPUT	.76	-1.96	-.045	2.007
	(1.87)	(1.78)	(1.65)	(2.03)
DUMEXCH	-.054	.1996	-.103	-.466
	(1.68)	(1.59)	(1.47)	(1.82)
DUMWFPI	.513	.865	.039	-.685
	(1.68)	(1.59)	(1.48)	(1.82)
Constant	-.0814	-1.89***	-.455*	1.125***
	(0.294)	(0.28)	(0.26)	(0.32)
R-Squared	0.23			
Pseudo R-sq		0.16	0.034	0.07
F-statistics	5.57***			
Observations	203	203	203	203

SOUTH AFRICA				
MPR	.44**	.47*	.556***	.74***
	(0.18)	(0.26)	(0.188)	(0.257)
TRANSP	.026***	.029**	.0213**	.0135
	(0.009)	(0.013)	(0.01)	(0.0132)
EXCH	.043***	.048**	.0347**	.0213
	(0.016)	(0.023)	(0.016)	(0.0226)
OUTPUT	-.033	-.0887	-.027	.0296
	(0.058)	(0.0812)	(0.059)	(0.815)
WFPI	.05**	.044	.043*	.0452
	(0.025)	(0.035)	(0.026)	(0.0351)
DUMMPR	.744	1.284	.733	.236
	(0.831)	(1.162)	(0.850)	(1.165)
DUMTRANSP	.00176	.503	.026	-.478
	(0.83)	(1.155)	(0.845)	(1.158)
DUMOUTPUT	.473	.908	.504	.082
	(0.83)	(1.153)	(0.844)	(1.157)
DUMEXCH	-.26	.091	-.277	-.656
	(0.82)	(1.152)	(0.843)	(1.155)
DUMWFPI	.769	1.266	.747	.205
	(0.821)	(1.147)	(0.839)	(1.150)
Constant	-.207**	-.686***	-.169**	.361***
	(0.081)	(0.113)	(0.083)	(0.114)
R-Squared	0.14			
Pseudo R-sq		0.12	0.083	0.08
F-statistics	3.1***			
Observations	203	203	203	203

Note: ***, ** and * indicate significance level at 1%, 5% and 10% respectively. Standard error in parenthesis.

We begin with the OLS results. For Ghana, we find that monetary policy rate and transportation cost are positive and statistically significant at 5% and 1% respectively. Specifically, we find that with a 1% monetary policy tightening, food inflation actually increases by 0.4%. In other words, a restrictive policy meant to stabilize overall inflation in Ghana actually destabilizes a key driver of overall inflation with consequential upside effect. Similarly, a 1% rise in transportation cost induces a 0.11% increase in food inflation. Exchange rate, output and world food price index are however not statistically significant. For South Africa, we find that monetary policy rate, transportation cost, exchange rate and the world food price index are statistically significant.

Specifically, we find that food inflation in South Africa rises by 0.421% following a 1% increase in monetary policy. A 1% depreciation of the Rand against the United States Dollar makes food prices 0.043% more expensive in South Africa. Following a 1% increase in transportation cost in South Africa, food prices increase by 0.026%. When the world food price index increases by 1%, food prices in South Africa increase by 0.0293%.

With the argument in the literature that monetary policy behaviour is far from symmetry and the fact that food prices exhibit volatility implying tail dynamics, the use of mean-based regression approaches is problematic as they cannot capture asymmetry and tail dynamics. We therefore turn to the results based on quantile regression. We find that at the 25th quantile, food prices increase by 0.45% and 0.52% in Ghana and South Africa respectively, following a 1% monetary policy restriction. Thus, food prices become 0.45% and 0.52% more expensive in Ghana and South Africa respectively following a 1% policy rate increase with a consequential increase in overall inflation given the dominance of food in the inflation basket of these countries. The destabilizing effect of monetary policy on food inflation and potentially the overall inflation, as was also found under the OLS, is much in tandem with the findings in the literature (Bhattacharya & Jain, 2019; and Hammoudeh et al, 2015). The argument in the literature is that following hikes in interest rates resulting from restrictive monetary policy, the cost of capital of firms that produce non-food items increases in view of the capital-intensive nature of these firms, leading to increases in the prices of products produced by these firms. In the face of rising cost of capital, the firms tend to use more of labour relative to capital which then pushes wages upwards (Bhattacharya & Jain, 2019). Given that food-producing firms rely heavily on labour, the increasing wages (emanating from the non-food sector) spread to other sectors leading to rising labour cost, the cost of production of food-producing firms and the prices of food eventually (Bhattacharya & Jain, 2019). The argument follows the perspective of cost of production channel where changes in monetary policy affect the production cost of firms. Thus, working capital cost of firms in the shape of interest expense would rise following monetary policy restriction as interest rates in general would increase. Such increases in working capital costs feed into incremental production cost and a hike in the prices of output eventually (Bhattacharya & Jain, 2019; Henzel et al, 2009; Gaiotti & Secchi, 2006; Chowdhury et al, 2006; and Barth & Ramey, 2001).

Another perspective on the price puzzle, in addition to the explanations in the food inflation literature indicated above, is the issue of fiscal dominance espoused by Sargent & Wallace (1981). The authors argue that where monetary policy is dominated by fiscal policy, monetary policymakers are confronted with substantial constraints in the conduct of monetary policy. A restrictive monetary policy designed to reduce growth of money and inflation would rather induce spiraling public debt levels as bond financing becomes the alternative route for financing fiscal deficits. The rise in public debt levels then heightens debt servicing and feeds into future budget deficits with concomitant effect on growth of money and future inflation. So, while the restriction in the monetary policy may have been intended to curb inflationary momentum, it may actually fuel further inflation in a setting where fiscal policy is dominant. For South Africa, over the period under review, the country has witnessed widening fiscal deficits.

From 2007/2008 fiscal year, budget balance has continuously been in deficit reaching ZAR 156 billion by 2016/2017 fiscal year. The continuous budget deficit has contributed to the swelling of the country's loan debt that reached ZAR 2.2 trillion during the 2016/2017 fiscal year (National Treasury, 2019; Statistics South Africa, 2019). Given the rising public loans, debt service burden has taken a toll on government expenditure and a potential source of fiscal deficits in the coming years. For instance, out of the ZAR 1.58 trillion government expenditure during the 2016/2017 fiscal year, as much as ZAR 146 billion representing 9.2% was spent on debt servicing alone which was more than the ZAR 77 billion spent on tertiary education, ZAR 105 billion expensed on hospitals and ZAR 69 billion spent on housing (Statistics South Africa, 2019). Indeed, the interest servicing burden is projected to constitute 13% of the expenditure of government by 2021/2022 fiscal year (Statistics South Africa, 2019; National Treasury, 2019). With such fiscal deficit trajectory, a restriction in monetary policy designed to subdue inflation may only stimulate inflationary pressures. For Ghana, we observed that the country's fiscal balances have consistently been in deficit, leading to accumulation of debt to unsustainable levels, ballooning debt service burden and constraining the fiscal space. From a debt to GDP ratio of 31% in 2007 when the full-fledged inflation targeting began, debt to GDP ratio reached 70.2% in 2014 and 72.2% in 2015 necessitating an IMF intervention in 2015 with a credit facility of USD 918 million under a three-year programme meant to engender restoration of sustainability of debt, provide stability to the macro economy and enhance economic growth (IMF, 2015). Meanwhile, government interest service cost as a percentage of the total revenue generated in each fiscal year rose from 28.61% in 2014 to 31.98% in 2016 and further up to 41.1% in 2017. These developments pose a significant upside risk to inflation and indeed inflation over the period has largely been above the publicly announced targets.

At the 50th and 75th quantiles, monetary policy has no statistically significant effect on food inflation in Ghana. For South Africa, however, the effect of monetary policy on food inflation is positive and statistically significant at the 50th and 75th quantiles. Indeed, the effect of increases at the upper quantiles. These findings on Ghana and South Africa clearly unearth the asymmetric relationship between monetary policy and food inflation that VAR techniques (widely used in the literature) cannot capture. In the case of South Africa for instance, food prices increase by 0.68% at the 75th quantile following a 1% increase in the repo rate implying that the mean-based technique actually underestimates the destabilizing effect of a restrictive monetary policy on food prices by as much as 61.5%. At the 25th and 50th quantile, the mean-based approach underestimated the monetary policy effect on food inflation by 23.5% and 25.9% respectively. Such underestimations are non-trivial in the context of policy coherence and credibility of the policymakers. Apart from the underestimation, the findings also reveal the tail dynamics that VAR approach is incapable of unearthing. For the purposes of policy, the findings for Ghana indicates that monetary policy effects are felt on food inflation only at the left tails or the lower distribution of food inflation. For South Africa on the other hand, the findings reveal that the destabilizing effect of a restrictive monetary policy on food inflation is severe at the right tails and potentially inimical not just to the quarter of the population who are food poor but has serious ramifications for the fight to keep inflation under the target band of 3% - 6% and their credibility eventually.

For the cost of transportation, we find that it is positive and statistically significant across all the quantiles with asymmetric effect on food inflation in Ghana whiles for South Africa it is positive and statistically significant at the 50th quantile and marginally at the 25th quantile. Specifically, at the 25th quantile, food prices increase by 0.06% following a 1% increase in the cost of transportation in Ghana. At the 50th and the 75th quantiles, a 1% increase in transportation cost in Ghana elicits food price increases of 0.042% and 0.034% respectively. For South Africa, the effect of a 1% rise in transportation cost at the 50th quantile of the food distribution is a 0.021% increase in the prices of food. Transportation cost, which reflects the costs of distribution of food products within the respective countries to the final consumer, is a function of factors such as changes in fuel prices, proximity of food production centres and farms to market places and the state of road infrastructure linking farms or food production centres to the market and the final consumer. The differences in these factors in Ghana and South Africa essentially inform the findings above. South Africa boasts of first-class road networks that link food production centres and farms to the major cities and towns. The good nature of the roads and the sheer accessibility to the market centres greatly reduce distribution costs in South Africa relative to Ghana. Whiles Ghana also boasts of relatively good road infrastructure, they tend to be focused on the urban and semi-urban centres. The roads that link the farming communities to the market centres remain agonizingly in deplorable conditions and deterioration of food products on farms is a common phenomenon that continues to derail efforts and investments of farmers. Vehicles are unable to ply these roads, particularly during rainy seasons and the few that attempt incur significant maintenance costs that feed into high transportation costs and eventually food prices. In addition, the differences in the origin of cultivation of different food crops in Ghana account for high distribution cost of food and the prices of food eventually. For instance, major staple foods in Ghana such as yam, cereals and legumes are predominantly cultivated in the northern part of the country with significant patronage in the more populous south. Similarly, specific tubers such as cassava and plantain as well as fruits are predominantly cultivated in the south and transported to the north. Not only is the distance from the north to the south exhausting, the roads linking the north-south divide are in deplorable state. Broken down trucks carting foodstuffs from the north to the south or vice versa are common scenes on the major roads in Ghana with attendant effects of damages to foodstuffs and a major contributor to road carnage in the country.

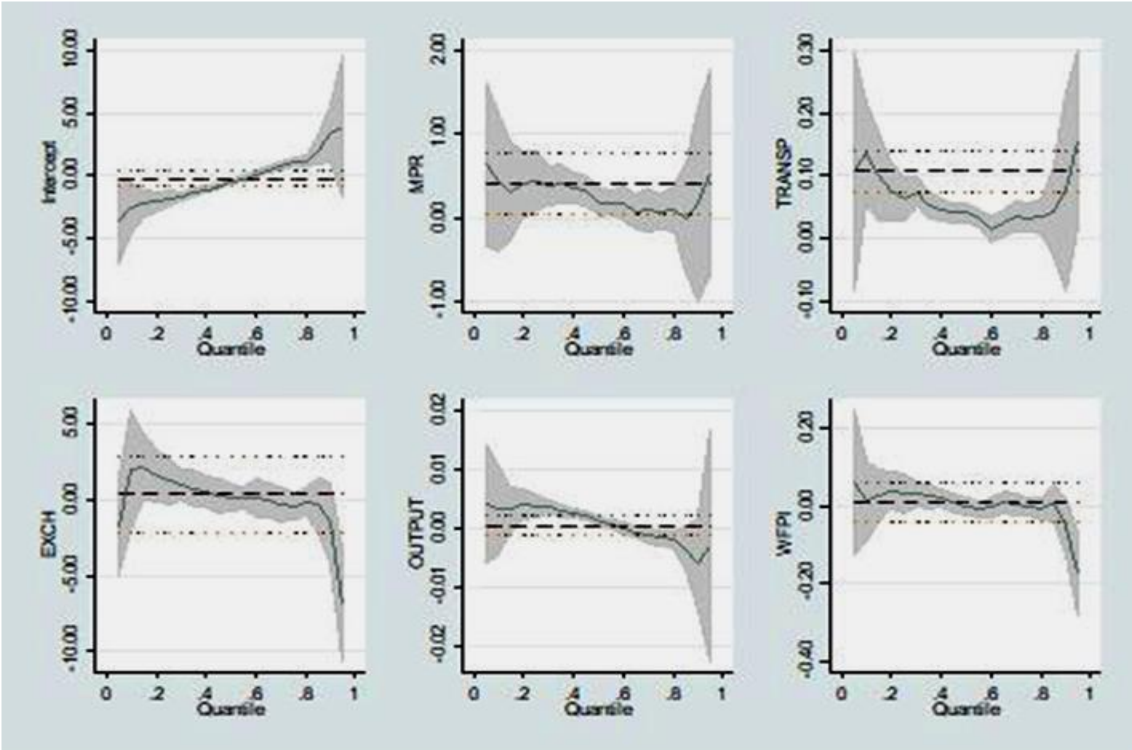
We turn to the effect of exchange rate on food inflation. For South Africa, we find that exchange rate is significant in driving food prices (although marginally at 10% significance level) at the 25th and 50th quantiles. Specifically, we find that a depreciation of the South African Rand by 1%, leads to an increase in the prices of food by 0.041% at the 25th quantile and 0.032% at the 50th quantile or median. For Ghana however, we find that exchange rate is statistically insignificant across all the specified quantiles. The effect of exchange rate on prices of food hinges, to a large extent, on two important factors. The first is the proportion of food that is imported into the domestic economy from abroad. The second is the extent to which foreign intermediate goods and technology are used in food production and farming in the domestic economy. Where food basket is dominated by imported ones, the effect of exchange rate is two ways. First, increases in prices of food abroad affect domestic food prices directly. Second, even when food prices abroad do not change, a depreciation of the domestic currency pushes domestic food prices up. The nature of food baskets in Ghana and South Africa as well as the differences in the scale and techniques of farming in these countries have a telling on the results. The predominant staple food items (tubers or roots and grains) that are consumed by typical households in Ghana are domestically cultivated and mostly at subsistence levels. As a result, changes in the exchange rate of the Cedi to the dollar have very little bearing on the prices of these staple foods. Although rice is mostly imported, it is only a component of the grains sub basket of the overall food basket in Ghana. Additionally, the scale of farming in Ghana is mostly at the subsistence level with minimal technology and commercialization drive. In South Africa, on the other hand, farming is done on large commercial scales with significant use of equipment and modern technology. Although most of these machines are procured locally, the suppliers are essentially units, agents or representatives of international companies. The pricing of these machines is necessarily aligned with those of the parent companies abroad. As a result, movements in the exchange rate affects the pricing of these machinery thereby feeding into the cost of production of most of these farms which then reflects in prices of food they produce. Additionally, the relatively advanced nature of the economy of South Africa compared to Ghana and the accompanying rising middle class and the presence of multinational firms and expatriates have a telling on the nature of food that typical rising middle-class households consume in South Africa. Unlike Ghana where tubers and grains dominate the household food consumption, processed foods are the opposite in the major cities of South Africa. Such processed foods require value addition which in turn require modern machinery and inputs. As indicated earlier, these machines and inputs are procured from local suppliers who are representatives of foreign entities with pricing policies aligned to those of the parent companies and potentially providing a role for exchange rate to influence cost of these machines. This then feeds into the production cost of the food processors and food prices eventually.

In respect of output which proxies for aggregate demand in the two countries, we find that whiles it is significant across the quantiles in Ghana, it is not in the case of South Africa. The case of South Africa is not surprising given the unspectacular output and growth paths over the last decade. The South African economy shriveled by 1.8% in 2009, grew by 1.9% by 2013 and shrunk back to 0.6% by 2016. Although some recovery was seen in 2017 with growth reaching 1.3%, it was short lived as growth slowed to 0.8% in 2018. The country is already saddled with skewed income distribution issues and falling output only exacerbates the plights of the already disadvantaged households. For Ghana, although output is statistically significant, the incremental effect on prices of food is trivial. At the 25th quantile for instance, a 1% increase in output only corresponds to 0.004% increase in the prices of food. The effect even dwindles at the median or 50th quantile with food prices increasing only by 0.0012% following a 1% rise in output with the significance level at the margin. At the 75th quantile, a 1% rise in output rather reduces prices of food by 0.002%.

For world food price index, we find that it has no effect on domestic food prices in Ghana across all the quantiles. For South Africa however, world food price index is important and significant at the 50th quantile (at 5% significance level) and at the 75th quantile (at the 10% significance level). Specifically, we find that at the 50th quantile, a 1% increase in the prices of food in the world market corresponds to a 0.029% increase in domestic food prices. At the 75th quantile, domestic food prices increase by 0.030% following a 1% rise in the world food price index. The fact that domestic food prices in South Africa respond to world food prices whiles those in Ghana do not reveals important dynamics of these two economies. The South African economy and market is far more developed and integrated with the global markets than Ghana. As a result, movements in world prices reflect in the path of domestic prices. In addition, and as indicated earlier, a greater proportion of foodstuffs consumed by typical Ghanaian households are domestically cultivated and in the form of tubers and grains as opposed to processed foods. The non-tradability of these foodstuffs implies less sensitivity to movements in the prices of food in the global market.

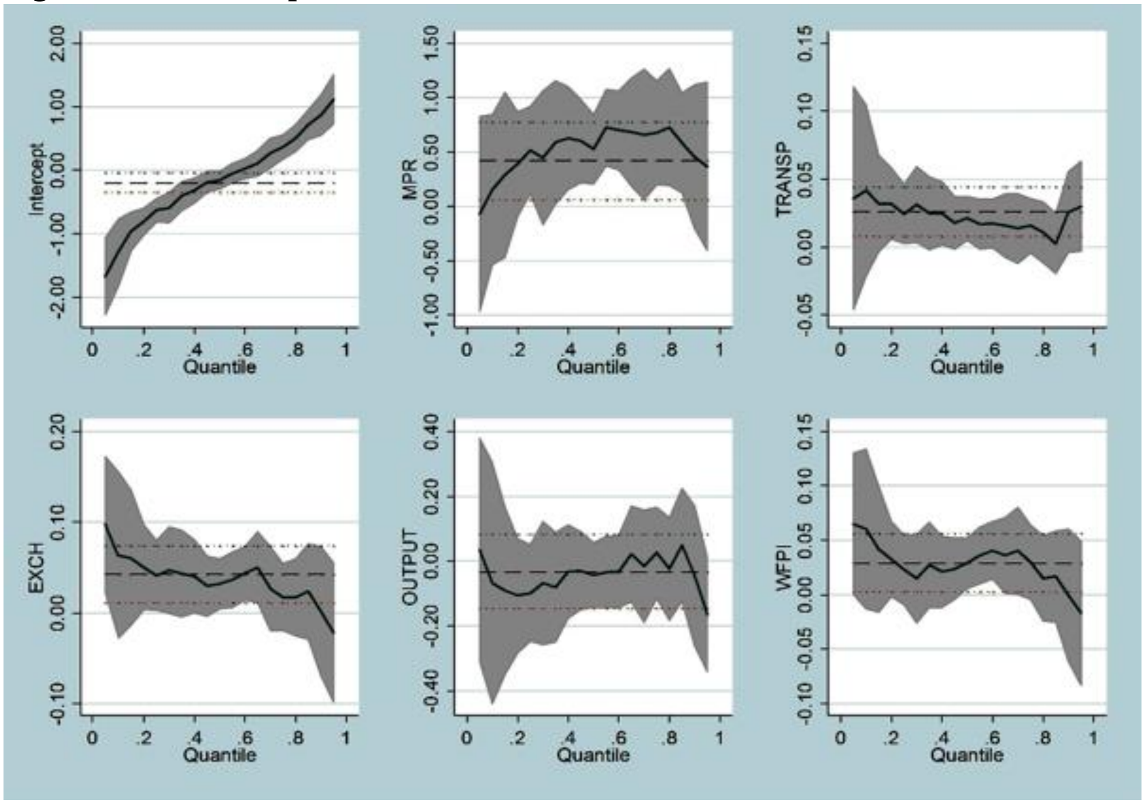
Apart from ascertaining whether the coefficients in the quantile regression models are significantly different from zero, we also ascertain whether they are significantly different from the coefficients in the OLS. In Figures 5.5 and 5.6, we present the quantile plots of the variables for Ghana and South Africa respectively. The plots compare the coefficients at the various quantiles and the OLS coefficients along with their respective confidence intervals. The thick broken horizontal lines in the figures are the OLS estimates for the various covariates whiles the thin broken horizontal lines are their corresponding confidence intervals. The graphs for the quantile estimates are then overlaid along with their confidence intervals. For Ghana (Figure 5.5), we observe that the estimate for monetary policy variable drifts away from the OLS estimate especially after the 40th percentile although it largely falls not just within its own confidence intervals but also the confidence intervals of the OLS. Although they fall within the same confidence intervals as the OLS, the virtue of the quantile estimate is the fact that it reveals where monetary policy exerts significant effect as opposed to the mean-based approaches that give an average for the entire distribution. For the transportation cost variable, we observed that substantial portions of it falls outside the confidence intervals of the OLS indicating that it is significantly different not just from zero but also from the OLS. Indeed, the transportation cost variable also exhibits a U-shape. Not only does it drift away from the OLS estimate, but significant portions of it fall outside the confidence intervals of the OLS. The estimate of the output variable also falls outside the confidence intervals of the OLS especially prior and after the median or 50th quantile. In essence, the estimate for the output variable is also significantly different not just from zero but also the OLS.

Figure 5.5: Quantile plots – Ghana



For South Africa (Figure 5.6), we observe a similar pattern as Ghana. The estimates for the monetary policy variable drifts away substantially from the OLS estimate with asymmetric effects at different quantiles and an indication that it falls out of the OLS confidence intervals before the 20th percentile, although greater portions fall within the confidence intervals for the OLS estimates. The exchange rate variable also exhibits substantial difference from the OLS particularly at the extreme tails which fall out of the OLS confidence intervals. World food price index exhibits a similar trend as exchange rate with considerable difference from the OLS at the extreme tails.

Figure 5.6: Quantile plots – South Africa



5.5.1 Robustness Checks

To ascertain the consistency of our results, we conduct some robustness exercises. Rather than the measure of exchange rate as the Cedi against the dollar in the case of Ghana and the Rand against the dollar in the case of South Africa, we use real effective exchange rate (REER) of the Cedi against a weighted basket of currencies of major trading partners of Ghana and the Rand against a weighted basket of currencies of major trading partners of South Africa. We then include Brent crude oil prices (BRENT) in the specification. The results, presented in Table 5.7, corroborate our earlier findings although the statistical significance of monetary policy effect on food inflation in the case of Ghana is now at 10%. Consistent with the earlier findings for Ghana, real effective exchange is not significant across all the quantiles. Notably, the sign alternates between the two measures consistently across all the quantiles. For South Africa, the results are equally consistent as the real effect exchange rate is significant at the 25^{th} and the 50^{th} quantiles but not the 75^{th} quantile. Indeed, the sign also alternates between the earlier measure and the new measure. Whereas the earlier measure of Cedi to the dollar and the Rand to the dollar indicate that an increase in the exchange rate is a depreciation of the two currencies against the dollar, the measure of the real effective exchange rate is such that the Cedi and Rand appreciate when the exchange rate increases. That is, the real effective exchange rate is measured in the reverse of our earlier measure of exchange rate. The fact that the signs alternate in line with theoretical expectations when these measures are alternated in the model is in itself a substantial indication of the robustness of our findings and the model in particular.

Table 5.7: Controlling for Real Effective Exchange Rate and Brent Oil Price

GHANA	**OLS**	**25^{th} Quantile**	**50^{th} Quantile**	**75^{th} Quantile**
MPR	0.421**	0.367*	0.206	0.115
	(0.186)	(0.209)	(0.164)	(0.207)
TRANSP	0.103***	0.074***	0.038**	0.0288
	(0.018)	(0.02)	(0.016)	(0.0196)
REER	0.043	-0.035	-0.0035	0.038
	(0.055)	(0.061)	(0.048)	(0.061)
OUTPUT	0.0006	0.004***	0.0012	-0.0019
	(0.0009)	(0.001)	(0.0008)	(0.033)
WFPI	0.0016	0.0264	-0.0044	-0.0065
	(0.0296)	(0.033)	(0.026)	(0.033)
BRENT	0.013	-0.00084	0.0043	0.007
	(0.024)	(0.027)	(0.021)	(0.027)
Constant	-0.188	-1.81***	-0.397*	1.151***
	(0.265)	(0.30)	(0.234)	(0.294)
R-Squared	0.22			
Pseudo R-sq		0.14	0.03	0.04
F-statistics	9.19***			
Observations	203	203	203	203

SOUTH AFRICA

MPR	0.42**	0.466**	0.561***	0.711***
	(0.18)	(0.20)	(0.18)	(0.25)
TRANSP	0.026***	0.026**	0.015	0.014
	(0.009)	(0.01)	(0.009)	(0.013)
REER	-0.0523**	-0.064***	-0.04*	-0.017
	(0.02)	(0.023)	(0.021)	(0.0283)
OUTPUT	-0.0514	-0.10	-0.069	0.003
	(0.06)	(0.07)	(0.06)	(0.08)
WFPI	0.016	0.009	0.018	0.034*
	(0.015)	(0.016)	(0.014)	(0.0198)
BRENT	0.013	0.015	0.007	-0.0012
	(0.012)	(0.013)	(0.012)	(0.016)
Constant	-0.183**	-0.64***	-0.096	0.366***
	(0.08)	(0.09)	(0.078)	(0.11)
R-Squared	0.13			
Pseudo R-sq		0.11	0.07	0.07
F-statistics	4.81***			
Observations	203	203	203	203

Note: ***, ** and * indicate significance level at 1%, 5% and 10% respectively. Standard errors (i.i.d) in parenthesis.

We also consider output gap as opposed to level or output growth. The argument is that it is the deviations from the potential output that has substantial bearing on the inflation trajectory. The results are reported in Table 5.8. For both countries, the coefficient of monetary policy maintains its sign as in previous findings. For South Africa, monetary policy effect is significant at the median and the 75th quantiles and a positive output gap exerts a positive effect on food inflation, although the effect is statistically significant only at the 25th quantile. For Ghana we find that monetary policy exerts significant effect at the 25th quantile, consistent with earlier results. We also observe that monetary policy effect on food inflation is also significant at the median (50th quantile) but only at 10% significance level. Output gap is not significant at all the quantiles.

Table 5.8: Controlling for Output Gap

GHANA	OLS	25th Quantile	50th Quantile	75th Quantile
MPR	0.421**	0.670***	0.236*	0.053
	(0.184)	(0.238)	(0.131)	(0.148)
TRANSP	0.104***	0.074***	0.032**	0.039***
	(0.0175)	(0.023)	(0.0125)	(0.014)
REER	0.0395	-0.092	-0.0046	0.0403
	(0.0537)	(0.069)	(0.038)	(0.043)
OUTPUT GAP	0.0017	0.0013	0.0012	0.0007
	(0.0019)	(0.0025)	(0.0014)	(0.002)
WFPI	0.0091	-0.0054	-0.011	0.013
	(0.0255)	(0.0329)	(0.018)	(0.0205)
Constant	-0.021	-0.775***	0.036	0.526***
	(0.117)	(0.151)	(0.083)	(0.0937)
R-Squared	0.22			
Pseudo R-sq		0.07	0.02	0.03
F-statistics	11.08***			
Observations	203	203	203	203
SOUTH AFRICA				
MPR	0.38**	0.09	0.399*	0.78***
	(0.18)	(0.23)	(0.212)	(0.264)
TRANSP	0.014	0.016	0.0144	0.005
	(0.011)	(0.013)	(0.012)	(0.015)
REER	-0.039*	-0.068***	-0.033	-0.023
	(0.021)	(0.026)	(0.025)	(0.031)
OUTPUT GAP	0.039***	0.07***	0.013	0.019
	(0.015)	(0.019)	(0.018)	(0.022)
WFPI	0.011	0.01	0.0163	0.027
	(0.022)	(0.016)	(0.015)	(0.018)
Constant	-0.12	-0.63***	-0.104	0.41***
	(0.08)	(0.104)	(0.097)	(0.12)
R-Squared	0.15			
Pseudo R-sq		0.14	0.063	0.07
F-statistics	6.97***			
Observations	203	203	203	203

Note: ***, ** and * indicate significance level at 1%, 5% and 10% respectively. Standard errors (i.i.d) in parenthesis.

Moreover, given that we have considered scenarios of independent identically distributed (i.i.d) setting, we examine the robustness of our results by considering a Huber (1967) sandwich covariance matrix to allow for the non-i.i.d setting in our quantile regression. The results are presented in Table 5.9. We find that under the non-iid setting, the results are still robust as monetary policy exerts positive and statistically significant effect on food inflation for both countries.

Table 5.9: Quantile regression based on Huber (1967) Sandwich covariance matrix (allowing for non-i.i.d)

GHANA	**OLS**	**25th Quantile**	**50th Quantile**	**75th Quantile**
MPR	0.404**	0.445***	0.179	0.077
	(0.198)	(0.138)	(0.181)	(0.159)
TRANSP	0.107***	0.064**	0.042	0.034
	(0.04)	(0.03)	(0.039)	(0.031)
EXCH	0.346	1.216	0.053	-0.522
	(0.363)	(1.063)	(0.440)	(0.802)
OUTPUT	0.0005	0.004***	0.0012*	-0.0016*
	(0.0009)	(0.001)	(0.00073)	(0.00096)
WFPI	0.0074	0.034**	-0.0005	-0.0023
	(0.020)	(0.015)	(0.019)	(0.019)
Constant	-0.181	-1.773***	-0.416	1.064***
	(0.339)	(0.282)	(0.299)	(0.352)
R-Squared	0.22			
Pseudo R-sq		0.14	0.025	0.038
F-statistics	10.91***			
Observations	203	203	203	203
SOUTH AFRICA				
MPR	0.421**	0.520***	0.53*	0.677**
	(0.174)	(0.16)	(0.32)	(0.225)
TRANSP	0.026***	0.021**	0.021**	0.016
	(0.0085)	(0.009)	(0.009)	(0.012)
EXCH	0.043**	0.041*	0.032	0.017
	(0.017)	(0.021)	(0.019)	(0.029)
OUTPUT	-0.032	-0.099	-0.043	0.025
	(0.061)	(0.065)	(0.069)	(0.084)
WFPI	0.029**	0.023	0.029*	0.03
	(0.013)	(0.015)	(0.017)	(0.02)
Constant	-0.195**	-0.632***	-0.16*	0.363***
	(0.081)	(0.1)	(0.095)	(0.11)
R-Squared	0.13			
Pseudo R-sq		0.1	0.07	0.07
F-statistics	5.86***			
Observations	203	203	203	203

Note: ***, ** and * indicate significance level at 1%, 5% and 10% respectively. Standard errors (non-i.i.d) in parenthesis. The standard errors and covariance in the OLS are also White-Hinkley (HC1) heteroscedasticity consistent.

5.6 Policy discussion

The finding that restrictive monetary policy stance in South Africa and Ghana destabilizes food inflation presents some policy conundrums in respect of inflation targeting. Undoubtedly, food prices are key drivers of overall inflation in low income countries and countries where food dominates the consumption basket. For inflation targeting central banks in particular, volatility in the prices of food pose problems not just for current inflation but forecasting future food and overall inflation then becomes a daunting task.

The findings also present challenging welfare dynamics, given the high poverty and inequality levels in Africa. In South Africa, a quarter of the country’s population, about 13.8 million individuals are said to be battling poverty relating to food (World Bank, 2019). Additionally, about 30.3 million individuals representing 55.5% of the population are said to be poor on the basis of the upper limit of poverty line at the national level which is ZAR 992. At the international level poverty classification, about 18.9% of the country’s population lived below $1.90 a day while as many as 37.6% lived below $3.20 a day as at 2015. The country’s Gini index, a measure of inequality, was a whopping 63 according to the most recent data as at 2014/2015 (World Bank, 2019). For Ghana, national level poverty classification puts 6.6 million individuals, representing 23.4% of the population below the poverty line as at 2016. At the international level of poverty classification, 3.7 million individuals (about 13.3% of the population) lived under $1.90 per day whiles as many as 8.6 million individuals (about 30.5% of the population) lived under $3.20 a day as at 2016. The country’s Gini index as at 2016 also stood at 43.5 (World Bank, 2019).

Stability in food prices is therefore a policy necessity from the perspective of the welfare of the poor and the credibility of the respective monetary policy authorities in anchoring inflation expectations in an inflation targeting setting. Bhattacharya & Jain (2019) suggest that when inflationary momentum in the economy emanates from food prices, then a monetary policy restriction that is one-off may not be sufficient to rein in inflation as it may rather destabilize not only food prices but the total inflation as well. To stabilize prices in the face of rising food prices, the authors suggest, requires a continued restriction of monetary policy that delivers far greater negative impact through the channel of aggregate demand relative to the positive impact through the channel of cost of production. Such a policy stance, however, may deliver a disproportionately negative growth trajectories in the non-food and food sectors, with the former taking the greatest impact (Bhattacharya & Jain, 2019). Ginn & Pourroy (2019), on the other hand, suggest that where food dominates the expenditure of households and where the households face substantial constraints relating to credit, then fiscal policy must be used to complement monetary policy in stabilizing food prices in a manner that would not require an overly restrictive monetary policy. Their argument is that fiscal policy in the form of food price subsidy enables consumption and prices of food to be smoothened. By smoothening consumption and prices of food, monetary policy may not have to be overly restrictive.

Although sustained restriction of monetary policy, as argued by Bhattacharya & Jain (2019), may provide some stability in food and overall prices over a period of time, the associated consequences of significant negative growth in the non-food sector (as acknowledged by the authors) may substantially hamper the much needed growth and developmental prospects of poor countries, particularly in the African context. A much benign alternative policy prescription, following the work of Ginn & Pourroy (2019), is for monetary policy to be complemented with fiscal policy in the shape of food price subsidy, given the dominance of food in the expenditure of households in Africa and the endemic poverty levels. Thus, a fiscal policy involving food price subsidy can smoothen consumption and prices of food which may then not necessitate an overly restrictive monetary policy.

The finding on transportation cost for Ghana in particular also presents an important policy implication for the government. Ghana continues to suffer significant food losses to decays of food products on the farms due to inaccessibility of the road infrastructure linking farms to the market. Clearly, the cost of transportation is a key driver of food prices in Ghana. While it is true that fuel prices influence transportation cost, the deplorable state of the roads linking farms to market centres and the accompanying high cost of maintenance are even more prominent. Farmers continue to lose investments thereby discouraging many from farming and posing an imminent danger to future food security. Much as improved road networks are essential for the urban centres, good roads linking farms to the market centres are even more critical. This would help improve accessibility to farms, reduce losses and enhance food supply. Enhancement in food supply then helps to reduce prices of food to benefit the overwhelming majority of the citizens who live on meagre incomes.

Beyond the corridors of policy, the finding that a restrictive monetary policy destabilizes food prices also has ramifications for portfolio construction by investors in the commodities market. Key food items such grains are important components of commodity portfolios and volatility in food prices that are exacerbated by monetary policy restrictions significantly add another layer of risk in the portfolio. Furthermore, the findings have ramifications for the energy sector. Biofuels which are increasingly used as an alternative to the more volatile and exorbitant crude oil are mostly obtained from oil seeds and grains. A restrictive monetary policy which destabilizes the prices of food items then affects the affordability of such grains which are inputs for biofuels.

5.7 Conclusion

Food prices continue to play an important role in the overall inflation dynamics of many countries. For inflation targeting central banks and monetary policymakers in developing and low-income countries in particular, food prices pose even more challenges both from the perspective of achieving inflation targets and the welfare of the many poor households in these economies. Surprisingly, empirical evidence on the effect of monetary policy on food inflation is not only limited in the literature, but Africa where food dominates the consumption basket and poverty levels are endemic remains unexplored. This chapter has thus sought to fill this void by providing evidence in the context of countries in Africa that practice explicit inflation targeting. Whiles literature has provided evidence on inflation targeting countries in the advanced and emerging economies, the use of VAR approach which only captures surprises in monetary policy in a targeting framework where transparency and systematic policy for directing inflation expectations are critical success factors is counterintuitive. Importantly, the sheer volatility in prices of food imply tail dynamics that the mean-based approaches such as VAR are incapable of unearthing. In departing from the literature, we used the quantile regression approach which provides superior information on the monetary policy-food nexus across various parts of the distribution of the latter.

For Ghana, we find that monetary policy exerts positive effect on food prices across all the quantiles but the said effect is only statistically significant at the 25th quantile. Specifically, a 1% policy restriction elicits a 0.45% increase in the prices of food at the 25th quantile in Ghana. For South Africa, monetary policy positively influences prices of food and the effect is significant across all the quantiles. Thus, rising food prices in these countries are destabilized even further when monetary policy response is restrictive. For South Africa in particular, the extent of the destabilization is more prominent at the right tail of the food price distribution. For Ghana, it is only the left tail of the food price distribution that is important. Such tail dynamics and the apparent asymmetry are important information existing literature has failed to capture.

We also find that whiles transportation cost, which reflects cost of food distribution, is an important driver of food prices in Ghana with positive effect that is significant across all the quantiles, it is less so for South Africa. Indeed, the effect of transportation cost on food prices in South Africa is prominent only at the median or 50th quantile, given the level of significance. The differences in the nature of food distribution, the heterogeneity in the source of different food items across regions and the state of infrastructure meant to support food distribution greatly inform the differences in the results for both countries. Furthermore, whereas output and growth in economic activities is important in driving food prices in Ghana, food prices in South Africa are not responsive to output. Output in South Africa, and growth in economic activities for that matter, has been unspectacular over the last few years with considerable fragility in business confidence.

Additionally, we find that whiles exchange rate does not drive food prices in Ghana, it is important for food prices in South Africa, especially at the 25^{th} and 50^{th} quantiles. A considerable proportion of the food basket consumed in Ghana are dominated by tubers and grains which are predominantly cultivated domestically. As a result, changes in exchange rates have little bearing on prices of these foodstuff. For South Africa, large scale of farming with its accompanying technology-intensive approaches and the dominance of processed foods in the food consumption basket means a significant role for exchange rate. Although the inputs and machines are procured locally, the suppliers are agents of foreign firms who align their pricing to those of the parent companies. Such an alignment then creates a role for exchange rate to affect the cost of production of farmers and food processors who rely on these machines and inputs, thereby affecting prices of food eventually.

We also find that whereas world food price index is important in driving domestic food prices in South Africa, it is insignificant in the case of Ghana. South Africa's economy and markets are relatively far advanced and integrated with the global markets than Ghana. Secondly, a significant portion of food items consumed in Ghana are cultivated locally and largely at subsistence levels. Such characteristic of non-tradability may well then account for the observed results.

On the policy front, while a sustained restriction of monetary policy as prescribed by Bhattacharya & Jain (2019) may eventually deliver stability in overall prices by exacting a substantial negative effect (through the aggregate demand channel) that dominates the positive effect on food prices (through the cost of production channel), the consequential negative effect on growth of such a sustained policy tightening may be problematic for the African context where economic growth is already a challenge. Complementary fiscal and monetary policies, as prescribed by Ginn & Pourroy (2019), may well be welfare-enhancing and consistent with the peculiar characteristics of Africa. Thus, a fiscal policy that subsidizes food prices would then not require monetary policy to be overly restrictive or tightened in a sustained manner. This helps to smoothen the consumption and prices of food for the many poor households in Africa. Such a fiscal intervention though may have ramifications for the fiscal budget and financing dynamics. The sheer relevance of transportation cost in driving food prices in Ghana should inform government policy on road infrastructure to help improve accessibility to farms, reduce maintenance cost feeding into lower transportation costs, reduction in food losses and prices and safeguarding food security.

Much as the current study has provided considerable impetus in the literature regarding the monetary policy-food inflation nexus in the context of Africa and inflation targeting countries in particular, the extent to which food prices hurt the poor remains a void in the literature which future studies can uncover. Importantly, with the finding that a restrictive monetary policy rather destabilizes food prices, such a future study in the context of Africa where poverty is endemic would be invaluable. Future study may consider primary data elicited from engagements with poor households in Africa to inform policy in these countries. Secondly, with data availability in the future, authors could look at more quantiles than we did. The 5th, 10th, 15th, 20th, 30th, 80th and the 90th percentiles would prove to be more informative in terms of tail dynamics. The current study was limited by data availability and could thus not explore these percentiles. Given the versatility of the quantile regression approach, future studies on inflation in South Africa and Ghana could consider using quantile regression approach to build measures of inflation risk such as Value-at-Risk (VaR) by deploying an ARCH-Quantile technique (Koenker & Zhao, 1996) or

Autoregressive-Quantile technique (Engle & Manganelli, 2004). Quantile regression can also be adopted for the construction of density forecasts (Gaglianone & Lima, 2012; and Gaglianone & Marins, 2017). This helps to provide additional information regarding the conditional density of inflation, as opposed to the single mean that emanate from vector autoregressive (VAR) approach. The virtue of such complementary investigation is that it helps to ascertain the probability of inflation reaching the upper tolerance band of the inflation target range in a given forecast horizon.

CHAPTER SIX

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

6.1 Introduction

The chapter comprises of four sub sections namely; the introduction in section one, summary and conclusion in section two, policy recommendations in section three and areas for future research in the final section.

6.2 Summary and conclusions of the study

Monetary policy characterization, debt constraint on monetary policy behaviour and the transmission effectiveness have been the preoccupation of the study. In particular, the study sought to appropriately capture the monetary policy behaviour of the South African Reserve Bank and the Bank of Ghana using an estimation technique that departs from the adhoc quadratic term imposition that is rife in the asymmetric policy rule exposition. It then ascertained whether such policy behaviour is constrained by rising public debt level. The study assessed the effectiveness of the transmission of monetary policy impulses through the interest rate and bank lending channels in a manner that accounts for the theoretical prescription of the working of channels of monetary policy transmission. Given that economic agents in any economy naturally face heterogeneous prices, the study assessed the monetary policy effect on regional (provincial) prices in Ghana (South Africa) over different time horizons and across distinct quantiles. The study then examined the monetary policy-food inflation nexus in the African context where consumption baskets are dominated by food. Essentially, the study sought to answer the research questions below:

a) Does a non-linear Taylor rule appropriately characterize the policy behaviour of the South African Reserve Bank and the Bank of Ghana? Is the behaviour constrained by spiralling public debt levels?

b) How effective are the interest rate and bank lending channels of monetary policy transmission when the theoretically prescribed role of aggregate demand components are accounted for?

c) How differently does monetary policy affect regional/provincial prices across different horizons and distinct quantiles?

d) To what extent is food inflation stabilized by monetary policy?

6.2.1 Monetary policy rule and debt constraint

With the aid of the Hansen (2000) sample splitting and threshold estimation technique, we considered an augmented nonlinear Taylor (1993) rule for the characterization of the monetary policy behaviour of the two full-fledged inflation targeting central banks in sub-Saharan Africa (Bank of Ghana and the South African Reserve Bank) as well as ascertaining whether their policy responses are constrained by high public debt levels. We find that a nonlinear Taylor rule best characterizes the monetary policy behaviour of the Bank of Ghana and the South African Reserve Bank. Specifically, we find that whiles both central banks respond to inflation gap below and above the threshold, the response from Bank of Ghana above the threshold is statistically insignificant. Meanwhile, South African Reserve Bank responds relatively more aggressive to inflation gap above the threshold. Furthermore, while the South African Bank responds to output gap above the threshold, the Bank of Ghana does not. For the debt constraint on monetary policy, our estimated threshold level of debt to GDP ratio for Ghana and South Africa are respectively 35.1% and 33.7%.

For Ghana, we find that while the Bank of Ghana is not responsive to output gap below and above the estimated debt threshold, it responds to inflation gap in the high debt regime. While the response by Bank of Ghana to inflation gap above the debt threshold shows a relative aggression, the extent of response is woefully disproportional and an indication of debt constraint and inflation accommodation on the part of a central bank that is supposed to be targeting inflation. For South Africa, we find that the policy response in the low debt regime to inflation gap is negative. The policy response was much in favour of propelling economic growth as South Africa witnessed challenging growth pattern over the period. In the high debt regime, we find that the policy response to inflation gap is significant but woefully disproportionate, given the fact that the period saw inflationary outcomes more than twice the upper limit, an indication of debt constraint on monetary policy. Notably, the accommodation of inflation was also on the back of deplorable growth performance as policymakers sought to provide impetus to growth. The response of policy to output gap was therefore significantly large. Our findings are robust to different measurement of exchange rate for both countries.

6.2.2 Monetary policy transmission channels

The study revisited the monetary policy transmission mechanism through the interest rate and bank lending channels by accounting for the role of investment (a component of aggregate demand) which is at the heart of the workings of these two transmission channels. Substantially, we considered a more systematic approach to unearthing the workings of these channels and in particular we trace the theoretical prescription of the indirect effect of monetary policy on inflation. We relied on the three stage least square technique (3SLS) in a system of equations that trace the indirect effect of monetary policy on inflation through different channels. We find that the interest rate and the lending channels are operative in Ghana and South Africa. We observed that whiles the lending channel is more effective relative to the interest rate channel in South Africa, the reverse is the case in Ghana. These results are robust to different samples and specifications.

6.2.3 Monetary policy and heterogeneous regional price responses

The study considered a multi-layered asymmetric exposition on regional inflation-monetary policy relationship by using the wavelet-based quantile regression approach for the first time in this strand of the literature. We find that regions/provinces respond differently to changes in monetary policy. For Ghana, we find that for Central, Eastern, Greater Accra, Northern and Western regions, a restrictive monetary policy exacts mixed effect. Whiles monetary policy delivered stability across distinct quantiles in some scales, it fueled inflationary momentum in other scales, especially the higher scales or longer horizons. The responses are also distinct across scales and quantiles for each region and across regions. In the case of Ashanti, Brong Ahafo and Volta regions, we find that restriction in monetary policy only destabilizes prices across quantiles and in distinct scales. For South Africa, we find that whiles restrictive monetary policy delivers stability in the prices of Gauteng, Mpumalanga and North West provinces, it is destabilizing for prices in Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape provinces. For Free State province, the effect of a restrictive monetary policy on prices is mixed, depending on the horizon and the quantile involved. Importantly, these provinces (in the case of South Africa) and regions (in the case of Ghana) respond distinctively at various quantiles and over distinct horizons. We also find that regions/provinces respond differently to transportation cost and output in the respective economies. Significantly, we find that prices in each region/province is necessarily a function of price developments in the other regions/provinces.

6.2.4 Monetary policy and food inflation

Relying on quantile regression analysis, this study examined the monetary policy-food inflation nexus in Ghana and South Africa. For Ghana, we find that monetary policy exerts positive effect on food prices across all the quantiles but the said effect is only statistically significant at the 25th quantile. For South Africa, monetary policy positively influences prices of food and the effect is significant across all the quantiles. Thus rising food prices in these countries are destabilized even further when monetary policy response is restrictive. For South Africa in particular, the extent of the destabilization is more prominent at the right tail of the food price distribution. For Ghana, it is only the left tail of the food price distribution that is important. Such tail dynamics and the apparent asymmetry are important information existing literature has failed to capture.

We also find that whiles transportation cost, which reflects cost of food distribution, is an important driver of food prices in Ghana with positive effect that is significant across all the quantiles, it is less so for South Africa. Indeed, the effect of transportation cost on food prices in South Africa is prominent only at the median or 50th quantile, given the level of significance. Furthermore, whereas output and growth in economic activities is important in driving food prices in Ghana, food prices in South Africa are not responsive to output. Additionally, we find that whiles exchange rate does not drive food prices in Ghana, it is important for food prices in South Africa, especially at the 25th and 50th quantiles. We also find that whereas world food price index is important in driving domestic food prices in South Africa, it is insignificant in the case of Ghana.

6.3 Policy Recommendations

The quantum of policy response to a rise in expected inflation by the two-inflation targeting central banks is worrying. We find this to be counterintuitive and dangerous to public confidence building and credibility of these central banks. The inflation target for Ghana in particular has largely been missed over the period under review and it is suggestive of how unrealistic and unsupportive of the economic fundamentals such a target is. The credibility of the Bank of Ghana and its ability to then anchor inflation expectations is in clear jeopardy. The target which is jointly set by the government (Ministry of Finance) and the Bank of Ghana certainly needs a revision that takes the economic fundamentals into account. Much as single digit inflation is desirable, it must be reconciled with the economic blue prints of the country. Importantly, the rationale for the joint determination of the target in Ghana has been defeated. The joint determination was meant to get government committed to the inflation target but it is all too evident from the fiscal balances that the government has failed on its part. We recommend that the Bank of Ghana takes restrictive policy stance as appropriate to subdue inflation that has largely exceeded the publicly announced target to elicit fiscal discipline on the part of the fiscal authorities as their fiscal space gets constrained further when interest service takes a significant bite. For South Africa, it is our recommendation that as an inflation targeting central bank, the SARB should put the achievement of inflation target first. Although growth may be an added priority, it should not come at the cost of inflation that exceeds twice the upper limit that has been publicly announced. Importantly, accommodating inflation in a high debt regime is inimical not only to the achievement of the targets set but derails public confidence and anchoring their inflation expectations would be difficult. Meanwhile, public confidence is a fundamental bedrock of the tenets of inflation targeting framework.

The findings that the interest rate and bank lending channels are operative in Ghana and South Africa present important policy dimensions for both countries. For Ghana and South Africa, we unearth a step-by-step flow of monetary policy impulses to the target variable (inflation). In the case of South Africa for instance, the interest rate channel indicates that a percentage tightening of monetary policy increases the lending rate by 0.34%; a percentage increase in the lending rate reduces investment by 0.031%; a percentage reduction in investment tumbles inflation by 0.065%; and the overall effect of a percentage tightening in monetary policy on inflation is a reduction of 0.001%. Essentially therefore, such systematic and stage-by-stage exposition of the transmission informs policymakers at what stage the transmission has the greatest effect and where the effect is less prominent. Understanding the strength or otherwise of the linkages between the policy decision and the overall effect on the real economy then presents a road map for policymakers to exact the desired effect. Given the collaborative set up in the workings of inflation targeting frameworks in Ghana and South Africa, where the respective central banks work closely with their fiscal counterparts (ministries of finance) in the determination of the inflation targets, our findings unearth the complementary roles that monetary and fiscal authorities can play to achieve the inflation targets in the two countries. In this regard, whiles the monetary authorities can streamline the workings of the financial systems to effectively carry the monetary policy impulses to the real sector, the fiscal authorities have a critical role to play in the aspect that links the investment component to the eventual target variable of inflation. The creation of enabling business environment for firms through a number of targeted fiscal policies can go a long way to ensure that other intervening factors in the economy do not distort the effect of the monetary policy impulses carried through the financial systems to the firms and inflation eventually. Moreover, our findings that the lending channel is more effective in South Africa whiles the interest rate channel is more potent is Ghana present policy ramifications for both central banks. As indicated earlier, over 86% of assets in the banking sector is financed chiefly by deposits and other forms of liabilities. That presents substantial leverage to the South African Reserve Bank to regulate how much credit the banks can extend and that can help in regulating liquidity in the economy and inflation eventually. In the case of Ghana too, the fact that the banking sector is the dominant sector in the financial system and firms necessarily have to rely on banks, a tightening of monetary policy that leads to hikes in the lending rates then discourages firms from borrowing. Decreased borrowings then limit economic activities and eventually inflation.

Given our findings of substantial heterogeneity in the responses of regional/provincial inflation to changes in monetary policy over different horizons and across distinct quantiles, a monetary policy stance that ignores such underlying differences then delivers sub optimal welfare when it is supposed to maximize it. We recommend that monetary policy decisions should take into consideration regional/provincial heterogeneity in prices and price developments. In forecasting inflation levels that inform monetary policy stance, monetary authorities must understand that the expected inflation outcome is heterogeneously influenced by distinct factors across regions/provinces. Ignoring such heterogeneity is a sure recipe for welfare destruction and policy fatality. In this regard, monetary policymakers must comprehend the heterogeneous drivers of price levels in the regions/provinces to inform appropriate forecast of inflation in these regions, how they underpin the national price level and the accompanying responses to monetary policy.

On monetary policy-food inflation nexus, the positive relationship present serious policy conundrums. While a sustained restriction of monetary policy as prescribed by Bhattacharya & Jain (2019) may eventually deliver stability in overall prices by exacting a substantial negative effect (through the aggregate demand channel) that dominates the positive effect on food prices (through the cost of production channel), the consequential negative effect on growth of such a sustained policy tightening may be problematic for the African context where economic growth is already a challenge. Complementary fiscal and monetary policies, as prescribed by Ginn & Pourroy (2019), may well be welfare-enhancing and consistent with the peculiar characteristics of Africa. Thus, a fiscal policy that subsidizes food prices would then not require monetary policy to be overly restrictive or tightened in a sustained manner. This helps to smoothen the consumption and prices of food for the many poor households in Africa. Such a fiscal intervention though may have ramifications for the fiscal budget and financing dynamics. The sheer relevance of transportation cost in driving food prices in Ghana should inform government policy on road infrastructure to help improve accessibility to farms, reduce maintenance cost feeding into lower transportation costs, reduction in food losses and prices and safeguarding food security.

6.4 Limitations and suggestions for future studies

A typical Taylor rule involves a response of monetary policy rate (interest rate) to inflation and output gaps which has been captured by our model. Some augmentations have also been suggested in the literature including exchange rate for small open economies which we have done as well. The inflation dynamics of the two countries we studied also reveal important factors that drive inflation in these countries but which were not explicitly measured or included as regressors in our model. These factors are crude oil prices, food inflation and fiscal balance. Future research should look at these variables in the policy rule construction. For the aspect relating to debt constraints on monetary policy, the use of interpolation to obtain quarterly debt to GDP ratio is a limitation future research may overcome as high frequency data on debt become available. For Ghana in particular, we reckon that although 42 quarters is ample enough for an empirical exercise of the kind we conducted, future research may consider an expansive data as it becomes available and when the inflation targeting window grows further. A similar limitation holds for the transmission channel exposition as some annual series were converted to quarterly series in view data unavailability in quarterly frequency for those variables. Future studies can consider quarterly or even monthly frequency when the data becomes available. The study could not also consider the asset price and exchange rate channels which future studies may look at in a similar systematic fashion.

The analysis of regional inflation-monetary policy nexus has also been hampered by data unavailability. In the case of Ghana for instance, we could only obtain time series data on regional inflation, as that is what is officially available. It would have been invaluable to control for region-specific factors such as size and distribution of firms, region-specific credit data, household income and consumption patterns. For South Africa, apart from provincial inflation and output, data on these other aforementioned factors could not be obtained. Availability of data on these factors in the future would substantially improve the discourse.

For monetary policy-food inflation nexus, the extent to which food prices hurt the poor remains a void in the literature which future studies can uncover. Importantly, with the finding that a restrictive monetary policy rather destabilizes food prices, such a future study in the context of

Africa where poverty is endemic would be invaluable. Future study may consider primary data elicited from engagements with poor households in Africa to inform policy in these countries. Secondly, with data availability in the future, authors could look at more quantiles than we did. The 5^{th}, 10^{th}, 15^{th}, 20^{th}, 30^{th}, 80^{th} and the 90^{th} percentiles would prove to be more informative in terms of tail dynamics. The current study was limited by data availability and could thus not explore these percentiles. Given the versatility of the quantile regression approach, future studies on inflation in South Africa and Ghana could consider using quantile regression approach to build measures of inflation risk such as Value-at-Risk (VaR) by deploying an ARCH-Quantile technique (Koenker & Zhao, 1996) or Autoregressive-Quantile technique (Engle & Manganelli, 2004). Quantile regression can also be adopted for the construction of density forecasts (Gaglianone & Lima, 2012; and Gaglianone & Marins, 2017). This helps to provide additional information regarding the conditional density of inflation, as opposed to the single mean that emanate from vector autoregressive (VAR) approach. The virtue of such complementary investigation is that it helps to ascertain the probability of inflation reaching the upper tolerance band of the inflation target range in a given forecast horizon.

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APPENDIX

1: RESULTS ON ROBUSTNESS CHECKS – GHANA

Table 4.22: Robustness Results on Ashanti Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.222	0.221*	0.305*
		(0.153)	(0.126)	(0.179)
	Transport cost	0.034	0.004	-0.058*
		(0.027)	(0.022)	(0.031)
	Output	0.001	-0.001	-0.002
		(0.003)	(0.002)	(0.004)
	EXCH	0.304	-0.016	-0.510
		(0.450)	(0.369)	(0.525)
	EXASR	0.866***	1.104***	1.189***
		(0.142)	(0.116)	(0.166)
	Constant	-2.823**	-1.750*	-0.170
		(1.275)	(1.046)	(1.490)
	Pseudo R-squared	0.50	0.58	0.59
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.12	0.03	-0.002
		(0.24)	(0.20)	(0.26)
	Transport cost	0.10***	0.06**	0.003
		(0.03)	(0.03)	(0.033)
	Output	-0.00	-0.0019*	-0.0023*
		(0.00)	(0.001)	(0.0012)
	EXCH	0.59	0.23	-0.61
		(0.57)	(0.47)	(0.60)
	EXASR	-0.34	-0.13	-0.37
		(0.30)	(0.24)	(0.31)
	Constant	-0.26***	0.03	0.27***
		(0.05)	(0.04)	(0.06)
	Pseudo R-squared	0.07	0.04	0.04
B2	Monetary Policy	-0.35	-0.204	-0.28
		(0.33)	(0.235)	(0.37)
	Transport cost	0.05	0.052*	0.11**
		(0.04)	(0.027)	(0.04)
	Output	-0.003	-0.001	-0.00
		(0.002)	(0.002)	(0.00)
	EXCH	0.65	0.403	0.54
		(0.64)	(0.451)	(0.70)
	EXASR	0.074	0.512**	0.11
		(0.332)	(0.233)	(0.36)
	Constant	-0.35***	0.05	0.35***
		(0.07)	(0.05)	(0.08)
	Pseudo R-squared	0.06	0.07	0.07

B3	Monetary Policy	0.571**	0.281	0.436
		(0.224)	(0.226)	(0.345)
	Transport cost	-0.033	-0.023	-0.025
		(0.027)	(0.027)	(0.041)
	Output	-0.009**	-0.006*	-0.003
		(0.0034)	(0.0034)	(0.005)
	EXCH	-0.007	-0.044	-0.475
		(0.448)	(0.450)	(0.689)
	EXASR	0.425	0.456*	0.030
		(0.265)	(0.266)	(0.407)
	Constant	-0.601***	-0.090	0.428***
		(0.076)	(0.076)	(0.116)
	Pseudo R-squared	0.09	0.08	0.06
B4	Monetary Policy	-0.116	0.029	1.083***
		(0.480)	(0.252)	(0.369)
	Transport cost	-0.201***	-0.159***	-0.161***
		(0.043)	(0.023)	(0.033)
	Output	0.008	0.004	0.007
		(0.009)	(0.005)	(0.007)
	EXCH	-1.666*	-0.960*	-1.731**
		(0.932)	(0.489)	(0.717)
	EXASR	1.912***	1.985***	1.025***
		(0.399)	(0.209)	(0.307)
	Constant	-0.476***	0.035	0.481***
		(0.152)	(0.080)	(0.117)
	Pseudo R-squared	0.25	0.33	0.39
Z4	Monetary Policy	0.503***	0.437***	0.331***
		(0.145)	(0.111)	(0.043)
	Transport cost	-0.022	-0.031	-0.046***
		(0.030)	(0.023)	(0.009)
	Output	0.028***	0.016***	0.010***
		(0.004)	(0.003)	(0.001)
	EXCH	-2.629***	-1.622***	-0.980***
		(0.526)	(0.403)	(0.156)
	EXASR	0.882***	1.002***	1.083***
		(0.126)	(0.096)	(0.037)
	Constant	-7.815***	-5.106***	-2.776***
		(1.287)	(0.985)	(0.381)
	Pseudo R-squared	0.68	0.76	0.82

Note: EXASR represents the weighted average of the inflation rates of the regions excluding Ashanti region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.23: Robustness Results on Brong Ahafo Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.196*	0.173	0.193
		(0.113)	(0.111)	(0.217)

	Transport cost	0.049**	0.028	0.040
		(0.019)	(0.019)	(0.037)
	Output	-0.005**	-0.011***	-0.010**
		(0.002)	(0.002)	(0.004)
	EXCH	0.861***	0.919***	0.346
		(0.323)	(0.320)	(0.622)
	EXBA	0.549***	0.733***	0.664***
		(0.088)	(0.087)	(0.170)
	Constant	-0.175	1.170	3.961**
		(0.912)	(0.902)	(1.755)
	Pseudo R-squared	0.56	0.53	0.45
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.116	-0.003	-0.033
		(0.189)	(0.119)	(0.200)
	Transport cost	0.063**	0.020	0.019
		(0.025)	(0.016)	(0.026)
	Output	0.001	0.001**	0.001
		(0.001)	(0.0005)	(0.001)
	EXCH	0.110	-0.215	-0.040
		(0.420)	(0.265)	(0.445)
	EXBA	0.440*	0.525***	0.498**
		(0.224)	(0.141)	(0.237)
	Constant	-0.202***	0.021	0.195***
		(0.042)	(0.026)	(0.044)
	Pseudo R-squared	0.09	0.10	0.09
B2				
	Monetary Policy	0.001	-0.240	-0.057
		(0.354)	(0.207)	(0.416)
	Transport cost	0.067*	0.021	0.038
		(0.040)	(0.024)	(0.047)
	Output	0.002	0.001	0.001
		(0.002)	(0.001)	(0.003)
	EXCH	0.364	0.620	0.652
		(0.664)	(0.388)	(0.780)
	EXBA	0.375	0.690***	0.402
		(0.321)	(0.187)	(0.377)
	Constant	-0.363***	-0.023	0.320***
		(0.078)	(0.046)	(0.092)
	Pseudo R-squared	0.05	0.05	0.024
B3				
	Monetary Policy	-0.122	-0.070	-0.332
		(0.318)	(0.207)	(0.336)
	Transport cost	0.142***	0.136***	0.140***
		(0.035)	(0.023)	(0.037)
	Output	-0.009*	0.001	0.003
		(0.005)	(0.003)	(0.005)
	EXCH	0.182	-0.613	-1.062
		(0.614)	(0.398)	(0.647)
	EXBA	-0.855***	-0.693***	-0.665**
		(0.296)	(0.192)	(0.312)

	Constant	-0.545***	0.024	0.396***
		(0.104)	(0.067)	(0.109)
	Pseudo R-squared	0.15	0.11	0.10
B4				
	Monetary Policy	0.951**	0.995***	1.588***
		(0.381)	(0.269)	(0.334)
	Transport cost	0.089***	0.092***	0.105***
		(0.032)	(0.023)	(0.028)
	Output	0.015**	0.006	0.001
		(0.007)	(0.005)	(0.001)
	EXCH	-2.290***	-2.010***	-1.959***
		(0.753)	(0.533)	(0.660)
	EXBA	0.045	-0.114	-0.499**
		(0.239)	(0.169)	(0.209)
	Constant	-0.548***	0.024	0.604***
		(0.121)	(0.086)	(0.106)
	Pseudo R-squared	0.37	0.37	0.41
Z4	Monetary Policy	0.204***	0.175**	0.023
		(0.055)	(0.084)	(0.074)
	Transport cost	-0.009	0.007	0.047***
		(0.011)	(0.017)	(0.015)
	Output	-0.016***	-0.021***	-0.030***
		(0.002)	(0.002)	(0.002)
	EXCH	1.269***	1.516***	2.243***
		(0.200)	(0.303)	(0.270)
	EXBA	0.732***	0.657***	0.714***
		(0.040)	(0.061)	(0.054)
	Constant	2.106***	4.879***	7.712***
		(0.474)	(0.721)	(0.641)
	Pseudo R-squared	0.82	0.80	0.80

Note: EXBA represents the weighted average of the inflation rates of the regions excluding Brong Ahafo region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.24: Robustness Results on Central Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.559**	-0.525**	-0.231
		(0.243)	(0.216)	(0.365)
	Transport cost	-0.010	0.096***	0.059
		(0.039)	(0.035)	(0.059)
	Output	0.007	0.007*	-0.003
		(0.0044)	(0.004)	(0.007)
	EXCH	0.532	-0.038	-0.297
		(0.668)	(0.594)	(1.001)
	EXCR	1.466***	1.587***	1.546***
		(0.204)	(0.182)	(0.306)
	Constant	0.943	0.745	2.321
		(1.874)	(1.666)	(2.810)

	Pseudo R-squared	0.33	0.42	0.46
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.475	-0.391*	-0.642**
		(0.333)	(0.231)	(0.290)
	Transport cost	0.184***	0.153***	0.134***
		(0.043)	(0.030)	(0.038)
	Output	0.000	-0.001	0.001
		(0.002)	(0.001)	(0.001)
	EXCH	-1.507**	-1.721***	-1.629**
		(0.727)	(0.506)	(0.633)
	EXCR	-0.413	-0.230	-0.308
		(0.379)	(0.263)	(0.330)
	Constant	-0.335***	-0.009	0.414***
		(0.074)	(0.052)	(0.064)
	Pseudo R-squared	0.17	0.15	0.15
B2				
	Monetary Policy	-0.194	-0.314	-0.151
		(0.396)	(0.292)	(0.524)
	Transport cost	0.142***	0.100***	0.110*
		(0.044)	(0.033)	(0.059)
	Output	0.001	-0.001	-0.002
		(0.003)	(0.002)	(0.004)
	EXCH	-2.291***	-1.811***	-2.693***
		(0.711)	(0.524)	(0.942)
	EXCR	0.363	0.357	-0.251
		(0.367)	(0.270)	(0.486)
	Constant	-0.444***	0.024	0.379***
		(0.087)	(0.064)	(0.116)
	Pseudo R-squared	0.15	0.12	0.16
B3				
	Monetary Policy	0.251	0.234	0.025
		(0.315)	(0.299)	(0.336)
	Transport cost	0.174***	0.192***	0.189***
		(0.034)	(0.033)	(0.037)
	Output	-0.004	-0.006	-0.002
		(0.005)	(0.004)	(0.005)
	EXCH	0.426	0.133	0.632
		(0.614)	(0.582)	(0.654)
	EXCR	-0.063	-0.070	0.737**
		(0.328)	(0.311)	(0.349)
	Constant	-0.560***	-0.045	0.592***
		(0.103)	(0.098)	(0.110)
	Pseudo R-squared	0.19	0.14	0.16
B4				
	Monetary Policy	1.298**	0.692	0.203
		(0.521)	(0.463)	(0.547)
	Transport cost	0.171***	0.222***	0.174***
		(0.044)	(0.039)	(0.046)
	Output	0.023**	0.005	-0.008
		(0.010)	(0.009)	(0.010)

	EXCH	0.544	2.224**	2.867**
		(1.065)	(0.946)	(1.118)
	EXCR	-0.350	-0.163	0.197
		(0.336)	(0.298)	(0.352)
	Constant	-0.960***	-0.214	0.889***
		(0.165)	(0.146)	(0.173)
	Pseudo R-squared	0.25	0.185	0.21
Z4	Monetary Policy	-0.151	-0.383**	-0.630***
		(0.144)	(0.159)	(0.137)
	Transport cost	-0.295***	-0.232***	-0.183***
		(0.028)	(0.030)	(0.026)
	Output	0.015***	0.031***	0.036***
		(0.004)	(0.004)	(0.004)
	EXCH	-0.742	-1.824***	-2.069***
		(0.494)	(0.544)	(0.471)
	EXCR	1.520***	1.709***	1.994***
		(0.114)	(0.126)	(0.109)
	Constant	0.709	-0.113	-0.274
		(1.198)	(1.319)	(1.142)
	Pseudo R-squared	0.66	0.71	0.76

Note: EXCR represents the weighted average of the inflation rates of the regions excluding Central region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.25: Robustness Results on Eastern Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.276	-0.516***	-0.199
		(0.173)	(0.191)	(0.260)
	Transport cost	0.085***	0.015	-0.001
		(0.028)	(0.031)	(0.043)
	Output	0.003	0.001	-0.001
		(0.003)	(0.004)	(0.005)
	EXCH	0.757	0.704	-0.318
		(0.481)	(0.533)	(0.722)
	EXER	1.054***	1.566***	1.340***
		(0.137)	(0.152)	(0.206)
	Constant	-1.288	0.579	2.861
		(1.347)	(1.492)	(2.021)
	Pseudo R-squared	0.48	0.49	0.48
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.413	-0.037	0.107
		(0.320)	(0.155)	(0.393)
	Transport cost	0.049	0.020	0.064
		(0.042)	(0.020)	(0.052)
	Output	0.001	0.000	0.000
		(0.002)	(0.001)	(0.002)
	EXCH	-0.241	-0.684**	-0.462

		(0.712)	(0.345)	(0.875)
	EXER	0.178	0.326*	0.018
		(0.356)	(0.173)	(0.438)
	Constant	-0.262***	0.001	0.287***
		(0.071)	(0.034)	(0.087)
	Pseudo R-squared	0.06	0.06	0.04
B2				
	Monetary Policy	0.381	0.152	0.509*
		(0.290)	(0.203)	(0.285)
	Transport cost	-0.026	-0.000	-0.011
		(0.034)	(0.024)	(0.033)
	Output	0.000	0.000	-0.001
		(0.002)	(0.002)	(0.002)
	EXCH	-0.165	-0.352	-0.615
		(0.535)	(0.374)	(0.525)
	EXER	1.264***	0.842***	0.710***
		(0.261)	(0.183)	(0.256)
	Constant	-0.277***	-0.000	0.279***
		(0.064)	(0.045)	(0.063)
	Pseudo R-squared	0.08	0.09	0.09
B3				
	Monetary Policy	0.171	0.168	0.111
		(0.221)	(0.202)	(0.241)
	Transport cost	-0.069***	-0.085***	-0.129***
		(0.025)	(0.023)	(0.028)
	Output	-0.001	-0.002	-0.002
		(0.003)	(0.003)	(0.004)
	EXCH	0.664	0.440	0.705
		(0.432)	(0.396)	(0.472)
	EXER	1.875***	1.721***	2.095***
		(0.238)	(0.218)	(0.260)
	Constant	-0.393***	0.044	0.439***
		(0.073)	(0.067)	(0.079)
	Pseudo R-squared	0.22	0.21	0.29
B4				
	Monetary Policy	-0.807**	-0.490**	-0.515
		(0.397)	(0.241)	(0.431)
	Transport cost	0.010	-0.004	0.019
		(0.032)	(0.019)	(0.035)
	Output	0.005	0.002	-0.002
		(0.007)	(0.004)	(0.008)
	EXCH	0.340	0.093	-0.198
		(0.749)	(0.454)	(0.814)
	EXER	1.655***	1.145***	0.952***
		(0.255)	(0.154)	(0.277)
	Constant	-0.479***	-0.040	0.459***
		(0.119)	(0.072)	(0.129)
	Pseudo R-squared	0.39	0.31	0.22
Z4	Monetary Policy	-0.694***	-0.522**	-0.609*
		(0.093)	(0.217)	(0.352)

	Transport cost	0.159***	0.082*	0.031
		(0.018)	(0.0421)	(0.068)
	Output	0.002	0.007	-0.008
		(0.003)	(0.006)	(0.010)
	EXCH	1.341***	0.352	1.253
		(0.322)	(0.751)	(1.215)
	EXER	1.415***	1.436***	1.664***
		(0.069)	(0.161)	(0.261)
	Constant	-0.804	-0.396	3.911
		(0.769)	(1.791)	(2.900)
	Pseudo R-squared	0.63	0.58	0.51

Note: EXER represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.26: Robustness Results on Greater Accra Region

Scales	Variables	25^{th} Quantile	50^{th} Quantile	75^{th} Quantile
Raw/Initial data				
	Monetary Policy	0.810***	0.886***	1.119***
		(0.136)	(0.208)	(0.184)
	Transport cost	0.066**	0.029	-0.127***
		(0.026)	(0.040)	(0.035)
	Output	-0.005*	-0.007	0.002
		(0.003)	(0.005)	(0.004)
	EXCH	-0.579	-1.102*	-2.726***
		(0.417)	(0.640)	(0.567)
	EXGAR	0.133	0.183	0.404**
		(0.129)	(0.197)	(0.175)
	Constant	-1.602	0.712	1.356
		(1.241)	(1.903)	(1.686)
	Pseudo R-squared	0.34	0.35	0.46
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.326	-0.253	-0.240
		(0.325)	(0.202)	(0.269)
	Transport cost	0.030	0.067**	0.038
		(0.043)	(0.027)	(0.036)
	Output	0.001	0.000	0.000
		(0.002)	(0.001)	(0.001)
	EXCH	-1.682**	-1.451***	-2.032***
		(0.696)	(0.433)	(0.575)
	EXGAR	-1.235***	-1.397***	-1.599***
		(0.329)	(0.205)	(0.272)
	Constant	-0.266	-0.016	0.290***
		(0.073)	(0.045)	(0.060)
	Pseudo R-squared	0.14	0.14	0.16
B2				
	Monetary Policy	0.197	0.044	-0.475
		(0.345)	(0.225)	(0.320)
	Transport cost	0.040	0.043*	0.028
		(0.040)	(0.026)	(0.037)

	Output	0.002	0.002	0.000
		(0.002)	(0.002)	(0.002)
	EXCH	-1.258**	-1.015**	-0.992*
		(0.621)	(0.406)	(0.577)
	EXGAR	-0.923***	-0.678***	-0.768***
		(0.286)	(0.187)	(0.265)
	Constant	-0.357***	0.049	0.383***
		(0.076)	(0.050)	(0.070)
	Pseudo R-squared	0.07	0.05	0.07
B3				
	Monetary Policy	0.018	0.228	0.393
		(0.324)	(0.217)	(0.328)
	Transport cost	0.047	0.083***	0.028
		(0.038)	(0.025)	(0.038)
	Output	0.002	-0.002	-0.002
		(0.005)	(0.003)	(0.005)
	EXCH	-0.177	-0.128	-0.488
		(0.626)	(0.418)	(0.633)
	EXGAR	-1.069***	-1.191***	-1.122***
		(0.311)	(0.207)	(0.314)
	Constant	-0.501***	-0.068	0.429***
		(0.105)	(0.070)	(0.106)
	Pseudo R-squared	0.09	0.12	0.09
B4				
	Monetary Policy	1.822***	2.077***	3.292***
		(0.644)	(0.422)	(0.408)
	Transport cost	-0.181**	-0.086*	-0.054
		(0.073)	(0.048)	(0.046)
	Output	0.025*	0.017*	0.011
		(0.014)	(0.009)	(0.009)
	EXCH	-2.270	-2.896***	-2.446***
		(1.401)	(0.919)	(0.887)
	EXGAR	-0.487	-1.113***	-1.725***
		(0.497)	(0.326)	(0.315)
	Constant	-1.032***	0.189	1.103***
		(0.233)	(0.153)	(0.148)
	Pseudo R-squared	0.13	0.20	0.32
Z4	Monetary Policy	0.766***	0.749***	0.801***
		(0.052)	(0.083)	(0.064)
	Transport cost	0.070***	0.087***	0.067***
		(0.012)	(0.019)	(0.015)
	Output	-0.002	-0.003	-0.003
		(0.002)	(0.003)	(0.002)
	EXCH	-1.345***	-1.467***	-1.772***
		(0.202)	(0.322)	(0.247)
	EXGAR	0.741***	0.628***	0.517***
		(0.047)	(0.075)	(0.057)
	Constant	-4.603***	-2.307***	-0.638
		(0.505)	(0.802)	(0.617)
	Pseudo R-squared	0.77	0.78	0.82

Note: EXGAR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.27: Robustness Results on Northern Region

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.134	-0.318	-0.660***
		(0.122)	(0.249)	(0.219)
	Transport cost	-0.012	-0.025	0.021
		(0.020)	(0.041)	(0.036)
	Output	-0.004*	-0.003	-0.004
		(0.0022)	(0.005)	(0.004)
	EXCH	0.868**	0.720	0.639
		(0.340)	(0.696)	(0.611)
	EXNR	1.160***	1.415***	1.865***
		(0.097)	(0.199)	(0.175)
	Constant	-0.854	1.032	3.293*
		(0.952)	(1.949)	(1.711)
	Pseudo R-squared	0.46	0.49	0.56
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.136	0.024	-0.031
		(0.301)	(0.206)	(0.307)
	Transport cost	0.052	-0.031	0.028
		(0.040)	(0.027)	(0.041)
	Output	-0.001	-0.001	-0.002
		(0.001)	(0.001)	(0.002)
	EXCH	0.581	0.347	1.241*
		(0.672)	(0.459)	(0.686)
	EXNR	0.259	0.833***	0.572
		(0.358)	(0.245)	(0.365)
	Constant	-0.336***	-0.031	0.315***
		(0.067)	(0.046)	(0.068)
	Pseudo R-squared	0.03	0.04	0.04
B2				
	Monetary Policy	-0.431	-0.253	0.112
		(0.301)	(0.253)	(0.324)
	Transport cost	0.013	-0.032	-0.069*
		(0.035)	(0.029)	(0.037)
	Output	-0.000	-0.002	-0.0036
		(0.002)	(0.002)	(0.0022)
	EXCH	1.416**	0.814*	0.829
		(0.565)	(0.474)	(0.608)
	EXNR	0.902***	0.862***	1.142***
		(0.275)	(0.230)	(0.295)
	Constant	-0.351***	0.011	0.324***
		(0.066)	(0.056)	(0.071)
	Pseudo R-squared	0.07	0.09	0.09

B3				
	Monetary Policy	-0.034	-0.242	-0.732**
		(0.317)	(0.262)	(0.327)
	Transport cost	-0.044	-0.040	-0.026
		(0.035)	(0.029)	(0.036)
	Output	-0.014***	-0.007*	-0.006
		(0.005)	(0.004)	(0.005)
	EXCH	1.131*	0.656	0.699
		(0.614)	(0.507)	(0.633)
	EXNR	0.359	0.432	0.696**
		(0.317)	(0.262)	(0.327)
	Constant	-0.598***	0.004	0.486***
		(0.103)	(0.085)	(0.106)
	Pseudo R-squared	0.04	0.03	0.06
B4				
	Monetary Policy	1.210*	0.935**	0.483
		(0.668)	(0.449)	(0.722)
	Transport cost	0.160***	0.113***	0.147**
		(0.055)	(0.037)	(0.060)
	Output	-0.011	-0.002	-0.001
		(0.012)	(0.010)	(0.013)
	EXCH	-0.790	-0.150	-0.507
		(1.297)	(0.872)	(1.403)
	EXNR	0.368	0.390	0.680
		(0.430)	(0.289)	(0.465)
	Constant	-0.943***	-0.045	1.138***
		(0.207)	(0.139)	(0.224)
	Pseudo R-squared	0.16	0.21	0.19
Z4	Monetary Policy	-0.918***	-0.683***	-0.513***
		(0.090)	(0.120)	(0.172)
	Transport cost	0.089***	0.057**	-0.048
		(0.017)	(0.023)	(0.033)
	Output	-0.011***	-0.012***	-0.016***
		(0.003)	(0.003)	(0.005)
	EXCH	2.333***	1.959***	1.672***
		(0.315)	(0.417)	(0.600)
	EXNR	1.746***	1.694***	1.830***
		(0.068)	(0.090)	(0.129)
	Constant	3.243***	2.274**	2.742*
		(0.748)	(0.991)	(1.426)
	Pseudo R-squared	0.75	0.74	0.74

Note: EXNR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.28: Robustness Results on Volta Region

Scales	Variables	25^{th} Quantile	50^{th} Quantile	75^{th} Quantile
Raw/Initial data				
	Monetary Policy	-0.002	-0.325	-0.335

		(0.186)	(0.215)	(0.289)
	Transport cost	0.029	0.015	-0.028
		(0.031)	(0.036)	(0.049)
	Output	0.001	-0.002	-0.004
		(0.004)	(0.004)	(0.005)
	EXCH	0.620	1.019*	0.551
		(0.528)	(0.611)	(0.820)
	EXVR	0.956***	1.428***	1.653***
		(0.162)	(0.187)	(0.251)
	Constant	-3.321**	-0.820	1.224
		(1.486)	(1.719)	(2.308)
	Pseudo R-squared	0.46	0.45	0.41
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.126	-0.124	-0.136
		(0.440)	(0.219)	(0.358)
	Transport cost	0.056	0.050*	-0.002
		(0.058)	(0.029)	(0.047)
	Output	0.001	0.000	-0.000
		(0.002)	(0.001)	(0.002)
	EXCH	-0.815	-1.295***	-1.791**
		(0.952)	(0.475)	(0.776)
	EXVR	-0.459	-0.649***	-0.929**
		(0.496)	(0.247)	(0.404)
	Constant	-0.343***	-0.006	0.301***
		(0.097)	(0.048)	(0.079)
	Pseudo R-squared	0.04	0.06	0.06
B2				
	Monetary Policy	0.472	0.353	0.157
		(0.358)	(0.252)	(0.441)
	Transport cost	-0.008	0.010	-0.015
		(0.042)	(0.029)	(0.051)
	Output	0.001	-0.000	0.001
		(0.002)	(0.002)	(0.003)
	EXCH	-2.033***	-2.262***	-2.046***
		(0.635)	(0.447)	(0.783)
	EXVR	-0.723**	-0.937***	-0.995***
		(0.299)	(0.210)	(0.369)
	Constant	-0.438***	0.037	0.357***
		(0.078)	(0.055)	(0.097)
	Pseudo R-squared	0.10	0.07	0.07
B3				
	Monetary Policy	1.107***	1.076***	0.859***
		(0.232)	(0.278)	(0.313)
	Transport cost	0.102***	0.114***	0.087**
		(0.027)	(0.032)	(0.036)
	Output	-0.003	-0.006	-0.006
		(0.004)	(0.004)	(0.005)
	EXCH	-2.843***	-2.040***	-1.977***
		(0.466)	(0.558)	(0.629)
	EXVR	-0.339	-0.456	-1.102***

		(0.242)	(0.290)	(0.327)
	Constant	-0.582***	-0.115	0.507***
		(0.080)	(0.096)	(0.108)
	Pseudo R-squared	0.22	0.19	0.22
B4				
	Monetary Policy	1.728***	2.234***	2.185***
		(0.379)	(0.563)	(0.509)
	Transport cost	0.296***	0.373***	0.290***
		(0.031)	(0.047)	(0.042)
	Output	-0.002	0.013*	0.011*
		(0.005)	(0.007)	(0.006)
	EXCH	-0.382	0.867	-0.528
		(0.518)	(0.769)	(0.696)
	EXVR	-0.856***	-0.735**	-0.506
		(0.244)	(0.363)	(0.328)
	Constant	-1.178***	-0.087	1.008***
		(0.127)	(0.189)	(0.171)
	Pseudo R-squared	0.38	0.30	0.34
Z4	Monetary Policy	-0.587***	-0.631***	-0.640***
		(0.087)	(0.093)	(0.075)
	Transport cost	-0.034**	-0.066***	-0.113***
		(0.016)	(0.017)	(0.014)
	Output	-0.008***	-0.014***	-0.019***
		(0.002)	(0.003)	(0.002)
	EXCH	2.020***	2.484***	2.872***
		(0.306)	(0.326)	(0.263)
	EXVR	1.808***	1.786***	1.744***
		(0.071)	(0.076)	(0.061)
	Constant	-0.329	3.099***	5.754***
		(0.713)	(0.761)	(0.613)
	Pseudo R-squared	0.82	0.82	0.84

Note: EXVR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.29: Robustness Results on Western Region

Scales	**Variables**	**25th Quantile**	**50th Quantile**	**75th Quantile**
Raw/Initial data				
	Monetary Policy	-0.281*	-0.074	-0.066
		(0.154)	(0.153)	(0.214)
	Transport cost	0.095***	0.000	0.022
		(0.026)	(0.025)	(0.036)
	Output	0.002	0.004	0.008**
		(0.003)	(0.003)	(0.004)
	EXCH	0.788*	-0.029	-0.941
		(0.429)	(0.426)	(0.596)
	EXWR	0.995***	1.053***	0.940***
		(0.126)	(0.125)	(0.175)
	Constant	0.485	1.160	3.843**

		(1.210)	(1.202)	(1.682)
	Pseudo R-squared	0.50	0.50	0.42
Decomposed series (Wavelet)				
B1	Monetary Policy	0.386	-0.080	-0.025
		(0.336)	(0.141)	(0.222)
	Transport cost	0.001	0.023	0.017
		(0.044)	(0.019)	(0.029)
	Output	0.000	0.000	-0.000
		(0.002)	(0.001)	(0.001)
	EXCH	-1.020	-0.739**	-0.767
		(0.735)	(0.308)	(0.483)
	EXWR	1.051**	0.551***	0.428
		(0.412)	(0.172)	(0.271)
	Constant	-0.295***	0.024	0.216***
		(0.074)	(0.031)	(0.049)
	Pseudo R-squared	0.09	0.10	0.08
B2				
	Monetary Policy	-0.372	-0.356	0.096
		(0.454)	(0.237)	(0.314)
	Transport cost	0.142***	0.066**	0.146***
		(0.051)	(0.027)	(0.035)
	Output	0.006*	0.004**	0.003
		(0.003)	(0.002)	(0.002)
	EXCH	-0.512	-0.723*	-0.957*
		(0.831)	(0.433)	(0.575)
	EXWR	-0.104	0.097	0.072
		(0.401)	(0.209)	(0.277)
	Constant	-0.343***	0.039	0.427***
		(0.010)	(0.052)	(0.069)
	Pseudo R-squared	0.11	0.11	0.12
B3				
	Monetary Policy	0.382	0.359	0.213
		(0.337)	(0.251)	(0.296)
	Transport cost	0.158***	0.148***	0.151***
		(0.037)	(0.028)	(0.033)
	Output	0.004	0.001	0.000
		(0.005)	(0.004)	(0.004)
	EXCH	-0.315	-0.571	-0.712
		(0.655)	(0.489)	(0.575)
	EXWR	-0.431	-0.274	-0.156
		(0.339)	(0.253)	(0.298)
	Constant	-0.536***	0.071	0.438***
		(0.111)	(0.083)	(0.097)
	Pseudo R-squared	0.15	0.13	0.12
B4				
	Monetary Policy	0.243	0.853***	0.628
		(0.358)	(0.297)	(0.435)
	Transport cost	0.241***	0.250***	0.244***
		(0.030)	(0.025)	(0.036)
	Output	-0.015**	-0.013**	-0.013

		(0.007)	(0.005)	(0.008)
	EXCH	2.594***	2.048***	1.605*
		(0.717)	(0.594)	(0.872)
	EXWR	0.395*	0.184	0.132
		(0.227)	(0.188)	(0.276)
	Constant	-0.597***	-0.146	0.578***
		(0.112)	(0.093)	(0.136)
	Pseudo R-squared	0.35	0.29	0.29
Z4	Monetary Policy	-0.120***	-0.232**	-0.280**
		(0.036)	(0.100)	(0.136)
	Transport cost	-0.008	0.013	-0.001
		(0.007)	(0.020)	(0.027)
	Output	0.010***	0.016***	0.021***
		(0.001)	(0.003)	(0.004)
	EXCH	-0.161	-0.486	-1.193**
		(0.123)	(0.346)	(0.471)
	EXWR	1.050***	1.134***	1.185***
		(0.027)	(0.077)	(0.105)
	Constant	-0.377	-0.271	0.909
		(0.299)	(0.841)	(1.143)
	Pseudo R-squared	0.79	0.76	0.71

Note: EXWR represents the weighted average of the inflation rates of the regions excluding the Eastern region. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

2: RESULTS ON ROBUSTNESS CHECKS – SOUTH AFRICA

Table 4.30: Robustness Results on Eastern Cape Province

Scales	**Variables**	**25th Quantile**	**50th Quantile**	**75th Quantile**
Raw/Initial data				
	Monetary Policy	0.003	0.008	-0.125**
		(0.040)	(0.052)	(0.061)
	Transport cost	-0.001	0.012	0.001
		(0.010)	(0.013)	(0.015)
	Output	-0.035***	-0.065***	-0.044**
		(0.013)	(0.017)	(0.019)
	EXCH	0.019	-0.002	-0.067**
		(0.018)	(0.023)	(0.027)
	EXEC	1.010***	1.052***	1.146***
		(0.040)	(0.051)	(0.060)
	Constant	3.552**	6.847***	6.283***
		(1.488)	(1.913)	(2.240)
	Pseudo R-squared	0.70	0.72	0.75
Decomposed series (Wavelet)				
B1	Monetary Policy	0.059	0.166	0.077
		(0.188)	(0.168)	(0.143)
	Transport cost	0.022	0.029**	0.024**

		(0.016)	(0.014)	(0.012)
	Output	0.088	0.043	0.042
		(0.056)	(0.050)	(0.043)
	EXCH	0.152**	0.128**	0.052
		(0.071)	(0.063)	(0.054)
	EXEC	0.906***	0.881***	1.027***
		(0.162)	(0.145)	(0.123)
	Constant	-0.098***	0.012	0.100***
		(0.018)	(0.016)	(0.014)
	Pseudo R-squared	0.27	0.26	0.32
B2	Monetary Policy	0.437**	0.491**	0.457**
		(0.186)	(0.198)	(0.215)
	Transport cost	-0.009	-0.013	-0.021**
		(0.008)	(0.009)	(0.010)
	Output	0.052	0.027	0.004
		(0.032)	(0.035)	(0.038)
	EXCH	-0.077*	-0.031	0.010
		(0.040)	(0.043)	(0.046)
	EXEC	1.121***	1.184***	1.165***
		(0.090)	(0.096)	(0.104)
	Constant	-0.091***	0.005	0.091***
		(0.014)	(0.014)	(0.016)
	Pseudo R-squared	0.48	0.47	0.48
B3	Monetary Policy	0.243***	0.374***	0.206*
		(0.092)	(0.054)	(0.108)
	Transport cost	-0.055***	-0.046***	-0.046***
		(0.010)	(0.006)	(0.012)
	Output	-0.004	-0.003	-0.019
		(0.019)	(0.011)	(0.022)
	EXCH	-0.088***	-0.103***	-0.109***
		(0.028)	(0.017)	(0.033)
	EXEC	1.342***	1.297***	1.293***
		(0.065)	(0.038)	(0.077)
	Constant	-0.078***	0.001	0.060***
		(0.016)	(0.009)	(0.019)
	Pseudo R-squared	0.66	0.68	0.69
B4	Monetary Policy	0.233***	0.250*	0.576***
		(0.072)	(0.133)	(0.095)
	Transport cost	-0.033***	-0.036**	-0.064***
		(0.008)	(0.016)	(0.011)
	Output	-0.133***	-0.124***	-0.109***
		(0.009)	(0.016)	(0.012)
	EXCH	-0.086***	-0.143***	-0.203***
		(0.028)	(0.052)	(0.037)
	EXEC	1.301***	1.411***	1.283***
		(0.047)	(0.087)	(0.062)
	Constant	-0.176***	-0.027	0.172***
		(0.016)	(0.030)	(0.022)

	Pseudo R-squared	0.76	0.76	0.79
Z4	Monetary Policy	0.016	0.029	-0.189***
		(0.027)	(0.051)	(0.065)
	Transport cost	0.010	0.017	0.019
		(0.010)	(0.019)	(0.024)
	Output	-0.061***	-0.064***	-0.032
		(0.011)	(0.022)	(0.027)
	EXCH	0.021*	-0.001	-0.011
		(0.011)	(0.022)	(0.028)
	EXEC	1.031***	0.991***	1.188***
		(0.027)	(0.053)	(0.067)
	Constant	6.075***	6.874***	4.591
		(1.287)	(2.470)	(3.131)
	Pseudo R-squared	0.80	0.79	0.82

Note: EXEC represents the weighted average of the inflation rates of the provinces excluding Eastern Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.31: Robustness Results on Free State Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.023	-0.044	-0.019
		(0.032)	(0.046)	(0.051)
	Transport cost	-0.003	-0.011	-0.008
		(0.008)	(0.011)	(0.012)
	Output	-0.014	-0.010	0.003
		(0.010)	(0.015)	(0.016)
	EXCH	-0.020	-0.012	-0.013
		(0.015)	(0.021)	(0.023)
	EXFS	0.983***	1.017***	0.980***
		(0.031)	(0.044)	(0.049)
	Constant	2.009*	1.868	0.862
		(1.200)	(1.690)	(1.890)
	Pseudo R-squared	0.77	0.75	0.79
Decomposed series (Wavelet)				
B1	Monetary Policy	0.112	0.142	0.104
		(0.160)	(0.115)	(0.153)
	Transport cost	-0.007	0.005	-0.005
		(0.014)	(0.010)	(0.013)
	Output	-0.052	-0.038	-0.026
		(0.048)	(0.034)	(0.046)
	EXCH	0.031	0.060	0.067
		(0.061)	(0.044)	(0.058)
	EXFS	0.829***	0.713***	0.749***
		(0.133)	(0.096)	(0.128)
	Constant	-0.071***	-0.003	0.069***
		(0.016)	(0.011)	(0.015)
	Pseudo R-squared	0.27	0.26	0.25

B2	Monetary Policy	-0.080	-0.049	-0.026
		(0.204)	(0.153)	(0.219)
	Transport cost	0.023**	0.018**	0.024**
		(0.009)	(0.007)	(0.010)
	Output	-0.033	-0.035	-0.028
		(0.036)	(0.027)	(0.039)
	EXCH	0.057	0.057*	0.072
		(0.044)	(0.033)	(0.047)
	EXFS	0.849***	0.917***	0.806***
		(0.095)	(0.071)	(0.102)
	Constant	-0.062***	-0.007	0.077***
		(0.015)	(0.011)	(0.016)
	Pseudo R-squared	0.52	0.50	0.49
B3	Monetary Policy	-0.180***	-0.119	-0.102
		(0.068)	(0.075)	(0.114)
	Transport cost	-0.016**	-0.012	-0.018
		(0.007)	(0.008)	(0.012)
	Output	0.011	-0.008	-0.009
		(0.014)	(0.015)	(0.023)
	EXCH	-0.042**	-0.020	0.006
		(0.021)	(0.023)	(0.035)
	EXFS	1.087***	1.079***	1.046***
		(0.047)	(0.051)	(0.078)
	Constant	-0.087***	-0.010	0.083***
		(0.012)	(0.013)	(0.020)
	Pseudo R-squared	0.70	0.68	0.67
B4	Monetary Policy	-0.061	0.084	0.101
		(0.094)	(0.087)	(0.103)
	Transport cost	-0.036***	-0.024**	-0.026**
		(0.011)	(0.010)	(0.012)
	Output	-0.038***	-0.035***	-0.047***
		(0.012)	(0.011)	(0.013)
	EXCH	-0.074**	-0.091***	-0.149***
		(0.037)	(0.034)	(0.040)
	EXFS	1.236***	1.105***	1.021***
		(0.058)	(0.054)	(0.064)
	Constant	-0.130***	-0.034*	0.140***
		(0.021)	(0.0198)	(0.023
	Pseudo R-squared	0.71	0.73	0.73
Z4	Monetary Policy	-0.051***	0.015	0.015
		(0.019)	(0.035)	(0.044)
	Transport cost	0.008	-0.003	-0.015
		(0.007)	(0.013)	(0.016)
	Output	-0.016**	-0.016	-0.009
		(0.008)	(0.015)	(0.018)
	EXCH	-0.050***	-0.033**	-0.017
		(0.008)	(0.015)	(0.019)

	EXFS	1.007***	0.925***	0.902***
		(0.019)	(0.035)	(0.044)
	Constant	2.717***	2.733	2.283
		(0.912)	(1.668)	(2.120)
	Pseudo R-squared	0.84	0.83	0.87

Note: EXFS represents the weighted average of the inflation rates of the provinces excluding Free State province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.32: Robustness Results on Gauteng Province

Scales	**Variables**	**25th Quantile**	**50th Quantile**	**75th Quantile**
Raw/Initial data				
	Monetary Policy	-0.014	0.016	-0.036
		(0.031)	(0.035)	(0.038)
	Transport cost	0.013*	0.007	0.001
		(0.007)	(0.009)	(0.009)
	Output	0.009	0.022*	0.021*
		(0.010)	(0.012)	(0.012)
	EXCH	0.037***	0.048***	0.030*
		(0.014)	(0.016)	(0.017)
	EXGP	1.305***	1.396***	1.435***
		(0.042)	(0.048)	(0.052)
	Constant	-0.615	-2.389*	-1.684
		(1.125)	(1.303)	(1.412)
	Pseudo R-squared	0.78	0.79	0.83
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.094	0.087	0.063
		(0.123)	(0.099)	(0.134)
	Transport cost	0.042***	0.024***	0.033***
		(0.010)	(0.008)	(0.011)
	Output	0.021	0.015	0.020
		(0.036)	(0.029)	(0.040)
	EXCH	0.100**	0.066*	0.085*
		(0.046)	(0.037)	(0.050)
	EXGP	0.921***	1.120***	1.101***
		(0.143)	(0.115)	(0.155)
	Constant	-0.067***	-0.003	0.056***
		(0.012)	(0.010)	(0.013)
	Pseudo R-squared	0.38	0.40	0.39
B2	Monetary Policy	0.021	-0.055	-0.235*
		(0.143)	(0.120)	(0.140)
	Transport cost	0.036***	0.033***	0.026***
		(0.006)	(0.005)	(0.006)
	Output	0.025	0.024	0.006
		(0.025)	(0.021)	(0.024)
	EXCH	0.145***	0.134***	0.114***
		(0.030)	(0.025)	(0.029)
	EXGP	1.068***	1.073***	1.131***
		(0.089)	(0.074)	(0.087)

	Constant	-0.057***	-0.003	0.053***
		(0.010)	(0.009)	(0.010)
	Pseudo R-squared	0.64	0.63	0.64
B3	Monetary Policy	0.030	-0.062	-0.096
		(0.063)	(0.057)	(0.065)
	Transport cost	0.035***	0.036***	0.032***
		(0.006)	(0.006)	(0.007)
	Output	0.021*	0.026**	0.027**
		(0.013)	(0.012)	(0.013)
	EXCH	0.092***	0.094***	0.084***
		(0.019)	(0.017)	(0.020)
	EXGP	1.292***	1.243***	1.211***
		(0.059)	(0.054)	(0.061)
	Constant	-0.067***	0.001	0.054***
		(0.011)	(0.010)	(0.011)
	Pseudo R-squared	0.75	0.75	0.75
B4	Monetary Policy	-0.180***	-0.175***	-0.188**
		(0.061)	(0.056)	(0.084)
	Transport cost	0.050***	0.044***	0.029***
		(0.007)	(0.006)	(0.009)
	Output	0.051***	0.064***	0.088***
		(0.007)	(0.007)	(0.010)
	EXCH	0.135***	0.146***	0.134***
		(0.023)	(0.021)	(0.031)
	EXGP	1.276***	1.289***	1.382***
		(0.051)	(0.047)	(0.071)
	Constant	-0.088***	-0.022*	0.115***
		(0.013)	(0.012)	(0.019)
	Pseudo R-squared	0.80	0.80	0.81
Z4	Monetary Policy	0.049**	-0.011	-0.035
		(0.021)	(0.033)	(0.024)
	Transport cost	-0.030***	-0.003	0.022**
		(0.008)	(0.012)	(0.009)
	Output	0.003	0.003	-0.003
		(0.009)	(0.014)	(0.010)
	EXCH	0.018**	0.004	-0.019*
		(0.009)	(0.014)	(0.010)
	EXGP	1.314***	1.370***	1.348***
		(0.029)	(0.047)	(0.034)
	Constant	-0.034	0.323	1.422
		(0.987)	(1.574)	(1.140)
	Pseudo R-squared	0.85	0.85	0.90

Note: EXGP represents the weighted average of the inflation rates of the provinces excluding Gauteng province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.33: Robustness Results on KwaZulu-Natal Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.123***	-0.122**	-0.005
		(0.030)	(0.047)	(0.056)
	Transport cost	0.039***	0.032***	0.026*
		(0.007)	(0.011)	(0.014)
	Output	-0.043***	-0.074***	-0.072***
		(0.010)	(0.015)	(0.018)
	EXCH	-0.004	-0.013	-0.041
		(0.013)	(0.021)	(0.025)
	EXKZN	1.284***	1.264***	1.246***
		(0.031)	(0.050)	(0.059)
	Constant	4.002***	7.685***	7.461***
		(1.093)	(1.736)	(2.074)
	Pseudo R-squared	0.78	0.78	0.80
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.120	-0.056	-0.124
		(0.167)	(0.130)	(0.139)
	Transport cost	0.042***	0.050***	0.037***
		(0.014)	(0.011)	(0.012)
	Output	-0.086*	-0.015	-0.034
		(0.050)	(0.039)	(0.041)
	EXCH	0.047	0.044	0.029
		(0.063)	(0.049)	(0.053)
	EXKZN	0.667***	0.722***	0.559***
		(0.143)	(0.111)	(0.119)
	Constant	-0.084***	0.010	0.095***
		(0.016)	(0.013)	(0.014)
	Pseudo R-squared	0.27	0.31	0.32
B2	Monetary Policy	0.158	0.358**	0.204
		(0.168)	(0.142)	(0.200)
	Transport cost	0.010	0.009	0.006
		(0.008)	(0.006)	(0.009)
	Output	-0.031	-0.000	0.001
		(0.029)	(0.025)	(0.035)
	EXCH	-0.068*	-0.051	-0.060
		(0.037)	(0.031)	(0.044)
	EXKZN	1.078***	1.064***	1.097***
		(0.084)	(0.071)	(0.100)
	Constant	-0.074***	0.002	0.073***
		(0.012)	(0.010)	(0.015)
	Pseudo R-squared	0.52	0.515	0.53
B3	Monetary Policy	0.104	0.112	0.142
		(0.109)	(0.074)	(0.095)
	Transport cost	-0.002	-0.021***	-0.008
		(0.012)	(0.008)	(0.010)

	Output	-0.006	-0.019	-0.005
		(0.022)	(0.015)	(0.019)
	EXCH	-0.021	-0.040*	0.016
		(0.033)	(0.023)	(0.029)
	EXKZN	1.066***	1.142***	1.041***
		(0.080)	(0.054)	(0.069)
	Constant	-0.089***	-0.002	0.089***
		(0.019)	(0.013)	(0.016)
	Pseudo R-squared	0.60	0.61	0.62
B4	Monetary Policy	0.228***	0.369***	0.490***
		(0.079)	(0.118)	(0.095)
	Transport cost	0.008	-0.004	-0.040***
		(0.009)	(0.014)	(0.011)
	Output	-0.124***	-0.133***	-0.125***
		(0.010)	(0.015)	(0.012)
	EXCH	-0.079**	-0.106**	-0.225***
		(0.031)	(0.047)	(0.038)
	EXKZN	1.150***	1.093***	1.309***
		(0.054)	(0.081)	(0.065)
	Constant	-0.132***	-0.029	0.169***
		(0.018)	(0.027)	(0.022)
	Pseudo R-squared	0.75	0.75	0.79
Z4	Monetary Policy	-0.233***	-0.214***	-0.135***
		(0.021)	(0.035)	(0.030)
	Transport cost	0.041***	0.087***	0.104***
		(0.008)	(0.013)	(0.011)
	Output	-0.060***	-0.075***	-0.067***
		(0.009)	(0.014)	(0.012)
	EXCH	0.019**	0.018	0.004
		(0.009)	(0.015)	(0.013)
	EXKZN	1.44***	1.386***	1.303***
		(0.023)	(0.038)	(0.033)
	Constant	5.522***	7.217***	6.599***
		(1.007)	(1.656)	(1.415)
	Pseudo R-squared	0.89	0.88	0.91

Note: EXKZN represents the weighted average of the inflation rates of the provinces excluding KwaZulu-Natal province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.34: Robustness Results on Limpopo Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.097	-0.115**	-0.005
		(0.069)	(0.058)	(0.078)
	Transport cost	0.015	0.001	0.008
		(0.017)	(0.014)	(0.019)
	Output	0.021	0.036*	0.032
		(0.022)	(0.019)	(0.025)

	EXCH	-0.050	-0.056**	0.060*
		(0.031)	(0.026)	(0.035)
	EXLMP	1.258***	1.393***	1.316***
		(0.068)	(0.057)	(0.076)
	Constant	-2.539	-4.047*	-4.644
		(2.561)	(2.162)	(2.887)
	Pseudo R-squared	0.67	0.71	0.74
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.025	-0.122	-0.283
		(0.270)	(0.245)	(0.269)
	Transport cost	0.030	0.013	-0.007
		(0.023)	(0.021)	(0.023)
	Output	0.140*	0.105	0.055
		(0.081)	(0.073)	(0.080)
	EXCH	0.156	0.155*	0.058
		(0.102)	(0.092)	(0.101)
	EXLMP	1.045***	0.846***	1.092***
		(0.227)	(0.206)	(0.226)
	Constant	-0.133***	-0.004	0.162***
		(0.026)	(0.024)	(0.026)
	Pseudo R-squared	0.20	0.20	0.21
B2	Monetary Policy	-0.511	-0.168	-0.445
		(0.408)	(0.313)	(0.386)
	Transport cost	-0.045**	-0.024*	-0.045**
		(0.019)	(0.014)	(0.018)
	Output	0.030	-0.001	-0.011
		(0.072)	(0.055)	(0.068)
	EXCH	-0.122	-0.095	-0.192**
		(0.089)	(0.068)	(0.084)
	EXLMP	1.453***	1.129***	1.280***
		(0.190)	(0.146)	(0.180)
	Constant	-0.164***	-0.000	0.150***
		(0.030)	(0.023)	(0.028)
	Pseudo R-squared	0.33	0.31	0.33
B3	Monetary Policy	0.082	0.155	-0.091
		(0.144)	(0.139)	(0.145)
	Transport cost	-0.021	-0.031**	-0.034**
		(0.015)	(0.015)	(0.015)
	Output	0.005	-0.011	-0.047
		(0.030)	(0.028)	(0.030)
	EXCH	0.016	-0.003	-0.004
		(0.044)	(0.042)	(0.044)
	EXLMP	0.992***	1.029***	1.156***
		(0.099)	(0.095)	(0.099)
	Constant	-0.142***	-0.000	0.151***
		(0.025)	(0.024)	(0.025)
	Pseudo R-squared	0.48	0.46	0.50

B4	Monetary Policy	0.079	0.317*	0.597***
		(0.215)	(0.162)	(0.196)
	Transport cost	-0.012	-0.019	-0.007
		(0.025)	(0.018)	(0.022)
	Output	-0.051*	-0.046**	-0.077***
		(0.026)	(0.020)	(0.024)
	EXCH	-0.075	-0.135**	-0.177**
		(0.083)	(0.063)	(0.076)
	EXLMP	1.239***	1.088***	1.189***
		(0.135)	(0.102)	(0.123)
	Constant	-0.229***	-0.006	0.264***
		(0.048)	(0.036)	(0.044)
	Pseudo R-squared	0.57	0.61	0.66
Z4	Monetary Policy	-0.235***	-0.133***	-0.038
		(0.045)	(0.046)	(0.031)
	Transport cost	0.021	0.049***	0.076***
		(0.017)	(0.017)	(0.011)
	Output	0.060***	0.061***	0.064***
		(0.019)	(0.019)	(0.013)
	EXCH	0.018	0.086***	0.121***
		(0.019)	(0.020)	(0.013)
	EXLMP	1.535***	1.430***	1.352***
		(0.046)	(0.047)	(0.032)
	Constant	-7.652***	-8.322***	-9.065***
		(2.182)	(2.210)	(1.488)
	Pseudo R-squared	0.84	0.85	0.89

Note: EXLMP represents the weighted average of the inflation rates of the provinces excluding Limpopo province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.35: Robustness Results on Mpumalanga Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.036	0.019	0.058
		(0.040)	(0.039)	(0.048)
	Transport cost	-0.031***	-0.014	-0.008
		(0.010)	(0.009)	(0.012)
	Output	-0.041***	-0.046***	-0.038**
		(0.013)	(0.012)	(0.015)
	EXCH	-0.155***	-0.153***	-0.138***
		(0.018)	(0.017)	(0.022)
	EXMPU	1.123***	1.076***	1.066***
		(0.036)	(0.035)	(0.044)
	Constant	5.220***	5.797***	4.877***
		(1.483)	(1.439)	(1.788)
	Pseudo R-squared	0.81	0.83	0.85
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.044	0.032	-0.047

		(0.133)	(0.117)	(0.110)
	Transport cost	-0.007	-0.016	-0.020**
		(0.011)	(0.010)	(0.009)
	Output	-0.017	-0.033	-0.009
		(0.040)	(0.035)	(0.033)
	EXCH	-0.167***	-0.163***	-0.232***
		(0.050)	(0.045)	(0.042)
	EXMPU	0.950***	0.876***	0.932***
		(0.103)	(0.091)	(0.085)
	Constant	-0.065***	0.003	0.060***
		(0.013)	(0.011)	(0.011)
	Pseudo R-squared	0.34	0.335	0.33
B2	Monetary Policy	0.221	0.242	0.329*
		(0.221)	(0.196)	(0.186)
	Transport cost	-0.060***	-0.052***	-0.029***
		(0.010)	(0.009)	(0.008)
	Output	0.018	-0.048	-0.028
		(0.039)	(0.034)	(0.032)
	EXCH	-0.120**	-0.203***	-0.134***
		(0.048)	(0.042)	(0.040)
	EXMPU	1.332***	1.307***	1.212***
		(0.095)	(0.083)	(0.079)
	Constant	-0.094***	-0.002	0.090***
		(0.016)	(0.014)	(0.014)
	Pseudo R-squared	0.50	0.48	0.53
B3	Monetary Policy	-0.254**	-0.314***	-0.327***
		(0.123)	(0.088)	(0.101)
	Transport cost	-0.040***	-0.039***	-0.021**
		(0.013)	(0.009)	(0.011)
	Output	-0.029	0.014	-0.036*
		(0.025)	(0.018)	(0.021)
	EXCH	-0.196***	-0.142***	-0.181***
		(0.038)	(0.027)	(0.031)
	EXMPU	1.237***	1.199***	1.217***
		(0.078)	(0.056)	(0.064)
	Constant	-0.104***	-0.003	0.120***
		(0.021)	(0.015)	(0.017)
	Pseudo R-squared	0.60	0.61	0.63
B4	Monetary Policy	-0.394***	-0.334***	-0.479***
		(0.075)	(0.059)	(0.109)
	Transport cost	-0.032***	-0.039***	-0.038***
		(0.009)	(0.007)	(0.013)
	Output	-0.047***	-0.044***	-0.060***
		(0.009)	(0.007)	(0.013)
	EXCH	-0.069**	-0.113***	-0.110**
		(0.029)	(0.023)	(0.042)
	EXMPU	1.224***	1.206***	1.234***
		(0.044)	(0.034)	(0.063)

	Constant	-0.098***	-0.020	0.101***
		(0.017)	(0.013)	(0.025)
	Pseudo R-squared	0.78	0.79	0.79
Z4	Monetary Policy	0.044***	-0.032	0.058**
		(0.014)	(0.029)	(0.025)
	Transport cost	0.035***	0.035***	-0.006
		(0.005)	(0.011)	(0.009)
	Output	-0.067***	-0.063***	-0.018*
		(0.006)	(0.012)	(0.010)
	EXCH	-0.159***	-0.163***	-0.145***
		(0.006)	(0.012)	(0.011)
	EXMPU	1.021***	1.093***	1.039***
		(0.013)	(0.028)	(0.023)
	Constant	7.747***	7.581***	2.875**
		(0.683)	(1.405)	(1.187)
	Pseudo R-squared	0.91	0.90	0.93

Note: EXMPU represents the weighted average of the inflation rates of the provinces excluding Mpumalanga province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.36: Robustness Results on Northern Cape Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.269***	-0.194***	-0.129
		(0.044)	(0.061)	(0.104)
	Transport cost	0.002	-0.005	-0.018
		(0.011)	(0.015)	(0.025)
	Output	-0.013	-0.016	0.022
		(0.014)	(0.019)	(0.033)
	EXCH	-0.152***	-0.137***	-0.153***
		(0.020)	(0.027)	(0.047)
	EXNC	1.104***	1.095***	1.178***
		(0.041)	(0.057)	(0.097)
	Constant	3.465**	3.627	-0.459
		(1.640)	(2.250)	(3.858)
	Pseudo R-squared	0.69	0.69	0.70
Decomposed series (Wavelet)				
B1	Monetary Policy	0.088	0.140	0.051
		(0.159)	(0.138)	(0.222)
	Transport cost	-0.010	-0.019	-0.005
		(0.014)	(0.012)	(0.020)
	Output	-0.093*	-0.096**	-0.071
		(0.047)	(0.041)	(0.066)
	EXCH	-0.055	-0.116**	-0.066
		(0.061)	(0.053)	(0.085)
	EXNC	0.873***	1.045***	0.981***
		(0.132)	(0.115)	(0.185)
	Constant	-0.100***	-0.019	0.091***

		(0.015)	(0.013)	(0.022)
	Pseudo R-squared	0.26	0.24	0.22
B2	Monetary Policy	0.328	-0.007	0.247
		(0.439)	(0.217)	(0.248)
	Transport cost	0.002	0.002	0.000
		(0.020)	(0.010)	(0.011)
	Output	-0.001	-0.032	-0.050
		(0.077)	(0.038)	(0.043)
	EXCH	0.042	-0.003	0.023
		(0.095)	(0.047)	(0.054)
	EXNC	0.998***	1.052***	1.087***
		(0.198)	(0.098)	(0.112)
	Constant	-0.083**	0.009	0.107***
		(0.032)	(0.016)	(0.018)
	Pseudo R-squared	0.33	0.35	0.37
B3	Monetary Policy	0.333***	0.423***	0.342**
		(0.111)	(0.087)	(0.150)
	Transport cost	-0.022*	-0.027***	-0.053***
		(0.012)	(0.009)	(0.016)
	Output	-0.028	-0.005	-0.051*
		(0.023)	(0.018)	(0.031)
	EXCH	-0.153***	-0.174***	-0.171***
		(0.034)	(0.027)	(0.046)
	EXNC	1.240***	1.274***	1.416***
		(0.073)	(0.058)	(0.099)
	Constant	-0.111***	-0.014	0.112***
		(0.019)	(0.015)	(0.026)
	Pseudo R-squared	0.61	0.61	0.595
B4	Monetary Policy	0.341*	0.379***	0.496***
		(0.188)	(0.118)	(0.101)
	Transport cost	-0.068***	-0.072***	-0.077***
		(0.022)	(0.014)	(0.012)
	Output	-0.044*	-0.038**	-0.053***
		(0.023)	(0.015)	(0.012)
	EXCH	-0.037	-0.074	-0.154***
		(0.074)	(0.046)	(0.039)
	EXNC	1.226***	1.192***	1.165***
		(0.112)	(0.071)	(0.060)
	Constant	-0.141***	0.015	0.186***
		(0.043)	(0.027)	(0.023)
	Pseudo R-squared	0.62	0.67	0.735
Z4	Monetary Policy	-0.219***	-0.265***	-0.358***
		(0.046)	(0.055)	(0.030)
	Transport cost	0.089***	0.044**	0.019*
		(0.017)	(0.020)	(0.011)
	Output	-0.078***	-0.067***	-0.063***

		(0.019)	(0.023)	(0.012)
	EXCH	-0.191***	-0.205***	-0.230***
		(0.020)	(0.023)	(0.013)
	EXNC	1.091***	1.103***	1.163***
		(0.045)	(0.053)	(0.029)
	Constant	10.053***	9.875***	10.467***
		(2.223)	(2.648)	(1.431)
	Pseudo R-squared	0.78	0.80	0.87

Note: EXNC represents the weighted average of the inflation rates of the provinces excluding Northern Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.37: Robustness Results on North West Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	-0.082	-0.090**	-0.005
		(0.066)	(0.041)	(0.058)
	Transport cost	-0.026*	-0.015	0.005
		(0.016)	(0.010)	(0.014)
	Output	0.005	0.001	-0.006
		(0.021)	(0.013)	(0.019)
	EXCH	-0.075**	-0.099***	-0.114***
		(0.030)	(0.018)	(0.026)
	EXNW	1.390***	1.354***	1.244***
		(0.064)	(0.039)	(0.056)
	Constant	-1.329	-0.203	0.883
		(2.428)	(1.498)	(2.141)
	Pseudo R-squared	0.73	0.78	0.81
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.239	-0.146	0.012
		(0.177)	(0.150)	(0.173)
	Transport cost	0.013	0.029**	0.037**
		(0.015)	(0.013)	(0.015)
	Output	-0.077	-0.126***	-0.114**
		(0.053)	(0.045)	(0.052)
	EXCH	-0.130*	-0.046	0.006
		(0.067)	(0.057)	(0.065)
	EXNW	1.146***	0.961***	0.940***
		(0.150)	(0.127)	(0.146)
	Constant	-0.107***	-0.006	0.105***
		(0.017)	(0.015)	(0.017)
	Pseudo R-squared	0.29	0.29	0.30
B2	Monetary Policy	0.083	0.214	0.184
		(0.298)	(0.226)	(0.258)
	Transport cost	-0.012	-0.022**	-0.009
		(0.013)	(0.010)	(0.012)
	Output	0.008	0.001	-0.014
		(0.052)	(0.040)	(0.045)

	EXCH	-0.172***	-0.162***	-0.136**
		(0.064)	(0.049)	(0.056)
	EXNW	1.182***	1.323***	1.137***
		(0.138)	(0.105)	(0.120)
	Constant	-0.107***	0.000	0.092***
		(0.022)	(0.016)	(0.019)
	Pseudo R-squared	0.40	0.39	0.43
B3	Monetary Policy	-0.215**	-0.214***	-0.136
		(0.106)	(0.071)	(0.108)
	Transport cost	0.030***	0.040***	0.026**
		(0.011)	(0.007)	(0.011)
	Output	-0.029	-0.040	-0.027
		(0.022)	(0.014)	(0.022)
	EXCH	-0.136***	-0.154***	-0.198***
		(0.033)	(0.022)	(0.033)
	EXNW	1.032***	1.050***	1.057***
		(0.072)	(0.047)	(0.072)
	Constant	-0.067***	-0.010	0.102***
		(0.018)	(0.012)	(0.018)
	Pseudo R-squared	0.59	0.62	0.625
B4	Monetary Policy	0.069	0.197	0.020
		(0.157)	(0.145)	(0.172)
	Transport cost	0.044**	0.038**	0.053***
		(0.018)	(0.016)	(0.020)
	Output	-0.060***	-0.036**	0.005
		(0.019)	(0.018)	(0.021)
	EXCH	-0.293***	-0.341***	-0.209***
		(0.061)	(0.057)	(0.067)
	EXNW	1.214***	1.080***	1.048***
		(0.097)	(0.090)	(0.106)
	Constant	-0.209***	-0.003	0.240***
		(0.036)	(0.033)	(0.039)
	Pseudo R-squared	0.585	0.64	0.66
Z4	Monetary Policy	-0.094***	-0.154***	-0.136***
		(0.029)	(0.029)	(0.025)
	Transport cost	-0.048***	-0.007	0.005
		(0.011)	(0.011)	(0.009)
	Output	0.057***	0.038***	0.037***
		(0.012)	(0.012)	(0.010)
	EXCH	-0.081***	-0.070***	-0.029***
		(0.012)	(0.012)	(0.011)
	EXNW	1.488***	1.494***	1.469***
		(0.029)	(0.030)	(0.025)
	Constant	-6.906***	-4.621***	-4.772***
		(1.384)	(1.412)	(1.192)
	Pseudo R-squared	0.88	0.89	0.92

Note: EXNW represents the weighted average of the inflation rates of the provinces excluding North West province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Table 4.38: Robustness Results on Western Cape Province

Scales	Variables	25th Quantile	50th Quantile	75th Quantile
Raw/Initial data				
	Monetary Policy	0.177***	0.275***	0.275***
		(0.054)	(0.043)	(0.046)
	Transport cost	-0.037***	-0.016	-0.010
		(0.013)	(0.011)	(0.012)
	Output	0.066***	0.033**	0.019
		(0.018)	(0.014)	(0.015)
	EXCH	0.107***	0.112***	0.136***
		(0.025)	(0.020)	(0.021)
	EXWC	1.072***	0.991***	0.956***
		(0.059)	(0.047)	(0.051)
	Constant	-8.354***	-5.061***	-3.511**
		(2.060)	(1.627)	(1.774)
	Pseudo R-squared	0.68	0.72	0.79
Decomposed series (Wavelet)				
B1	Monetary Policy	-0.064	-0.089	-0.023
		(0.115)	(0.089)	(0.093)
	Transport cost	-0.001	0.004	0.002
		(0.010)	(0.008)	(0.008)
	Output	0.039	0.049*	0.017
		(0.034)	(0.027)	(0.028)
	EXCH	-0.045	-0.029	0.026
		(0.044)	(0.034)	(0.035)
	EXWC	1.049***	1.129***	0.992***
		(0.109)	(0.084)	(0.088)
	Constant	-0.062***	0.004	0.064***
		(0.011)	(0.009)	(0.009)
	Pseudo R-squared	0.36	0.40	0.43
B2	Monetary Policy	-0.195	-0.055	-0.075
		(0.155)	(0.154)	(0.178)
	Transport cost	0.018**	0.021***	0.019**
		(0.007)	(0.007)	(0.008)
	Output	0.011	0.020	0.047
		(0.027)	(0.027)	(0.031)
	EXCH	0.062*	0.077**	0.044
		(0.033)	(0.033)	(0.038)
	EXWC	0.991***	0.966***	0.926***
		(0.080)	(0.080)	(0.092)
	Constant	-0.073***	0.003	0.068***
		(0.011)	(0.011)	(0.013)
	Pseudo R-squared	0.54	0.54	0.55
B3	Monetary Policy	0.156	-0.023	0.005
		(0.134)	(0.095)	(0.077)
	Transport cost	0.009	0.012	0.001
		(0.014)	(0.010)	(0.008)

	Output	0.056**	0.058***	0.026*
		(0.027)	(0.019)	(0.016)
	EXCH	0.113***	0.151***	0.102***
		(0.040)	(0.029)	(0.023)
	EXWC	1.172***	1.012***	1.246***
		(0.105)	(0.074)	(0.060)
	Constant	-0.122***	0.020	0.112***
		(0.023)	(0.016)	(0.013)
	Pseudo R-squared	0.61	0.63	0.67
B4	Monetary Policy	-0.165	-0.028	0.122
		(0.158)	(0.091)	(0.132)
	Transport cost	0.001	-0.022**	-0.022
		(0.018)	(0.011)	(0.015)
	Output	0.105***	0.109***	0.108***
		(0.020)	(0.011)	(0.016)
	EXCH	0.232***	0.176***	0.123**
		(0.061)	(0.035)	(0.051)
	EXWC	1.020***	1.037***	0.967***
		(0.108)	(0.063)	(0.090)
	Constant	-0.146***	0.004	0.173***
		(0.036)	(0.021)	(0.030)
	Pseudo R-squared	0.62	0.64	0.65
Z4	Monetary Policy	0.268***	0.311***	0.356***
		(0.028)	(0.041)	(0.024)
	Transport cost	-0.082***	-0.067***	-0.067***
		(0.011)	(0.016)	(0.009)
	Output	0.061***	0.055***	0.048***
		(0.012)	(0.018)	(0.010)
	EXCH	0.060***	0.125***	0.144***
		(0.013)	(0.018)	(0.011)
	EXWC	1.050***	0.965***	0.879***
		(0.032)	(0.047)	(0.027)
	Constant	-7.621***	-7.383***	-6.469***
		(1.416)	(2.070)	(1.199)
	Pseudo R-squared	0.81	0.83	0.89

Note: EXWC represents the weighted average of the inflation rates of the provinces excluding Western Cape province. ***,** and * represent statistical significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.