A DSGE APPROACH TO THE ANALYSIS OF MONETARY POLICY AND BUSINESS CYCLES: EVIDENCE FROM SOME SELECTED COUNTRIES

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ABSTRACT
The study examines the role of monetary policy in influencing business cycles in Nigeria, Brazil, and China by estimating a small open sticky-price Dynamic Stochastic General Equilibrium (DSGE) model. The role of monetary policy is sub-divided into anticipated and unanticipated. Using quarterly data from 1986:1 to 2022:4, results show that monetary policy plays an active role in influencing business cycles in the selected countries. Furthermore, both anticipated and unanticipated monetary policies have impacts on macroeconomic variables' volatility.
KEYWORDS: Monetary Policy, Business Cycles. DSGE, Anticipated, Unanticipated
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1. INTRODUCTION

Understanding the nature of the relationship that exists between monetary policy and business cycles is one of the problems policy makers are making frantic efforts to achieve. That is, having the basic knowledge of the role monetary policy plays in the volatility of macroeconomic variables at different periods. A business cycle is defined as the fluctuation in the performance of macroeconomic variables majorly measured by output and inflation. It comprises four cyclical phases. These are recession, recovery, growth, and decline. Mitchell (1913) defines the business cycle as a timely occurrence of four phases. The phases are prosperity, crisis, depression, and revival. These phases are interwoven. A period of uncontrolled prosperity generates crisis. a persistent crisis causes depression which consequently produces a new dawn of revival. The world economy has experienced different shocks that generated business cycles over the years. Although those cycles shared some characteristics, however, they are not the same in terms of their causes, effects, and sections of the economy that were most affected. The recent covid-19 pandemic, otherwise known as the pandemic cycle, affected the global economy and left most economies in recession.

The past four decades revealed the experiences of the Nigerian economy as regards its exposure to a series of shocks and the instability of its macroeconomic environment. The effect of this instability is measured by the fluctuation of the aggregate level of output in the country. The first phase, which was between 1986 and 1992, marks the beginning of the Structural Adjustment Programme (SAP) in the country. The period recorded a significant increase or boom in the economic activities. This is evident in the improved performance of most economic indicators. During the period, inflation rose by an average of 27 percent, money supply rose by 2.24 percent, and total investment rose by 11.40 percent on average. Despite the upswing, there

were shreds of evidence that the economy was comatose due to the decrease in the level of production and the inability of the financial sector to assist in reviving the ailing economy. This experience impacted the economy negatively, thereby setting the pace for a declining economy with a burst of the earlier boom recorded.

Consequently, it was evident that the economy in the period 1992-2010, which is the second phase, exhibited economic stress as shown by the indicators. The period recorded the highest level of inflation which rose from an average of 39 percent at the beginning of the period to 73 percent in 1995. Furthermore, the unemployment rate, during this period, stood at an average rate of 18.54 percent. This experience was a result of the exposure of the economy to various shocks. Notable of these shocks are oil price shock, debt crisis, and fluctuation in the prices of agricultural products. The most recent is the Covid-19 pandemic that started in late 2019. All these shocks culminated in factors influencing macroeconomic fluctuations in Nigeria. This is evident in the performance of basic macroeconomic variables in the country between 2019 and 2022.

For instance, in 2019, the GDP growth rate was 2.20%. the value reduced to -1.79% in the middle of the global pandemic. This increased to 3.64% in 2021 and stood at 3.25% in 2022. The value was reduced to 2.54% in the third quarter of 2023 due to the failure of the economy to fully recover from the current economic crisis across the globe. In the same vein, inflation within the period increased from 11.40% in 2019 to 13.25% in 2020. It further increased to 16.95% in 2021. In 2022, the inflation rate in Nigeria increased to 18.85%. As of November 2023, the inflation rate was 28.9%, the highest since August 2005. Lastly, credit growth was also considered as one of the key variables affected by the global crisis. The annual credit growth increased from 6.4% in 2019 to 11.6% in 2020. As of 2021, the credit growth increased to 14.2% and stood at 17.4% in 2022 (WDI, online). However, the upward trend observed in credit growth did not translate to output growth within the period suggesting that the economy was badly affected by the crisis.

Furthermore, the Brazilian economy experienced four basic recessions between 1995 and 2009. This amounted to a 15-year economic downturn. Specifically, the periods are 1995, 1998-1999, 2002-2003, and 2008-2009. The major event preceding these periods is a rise in interest rates without a significant effect on the domestic fundamentals. The first year of the downturn coincided with the period of the Mexican crisis that affected mostly the emerging markets. Then, the monetary policy committee implemented a contractionary policy by raising interest rates to promote currency stabilization and circumvent capital outflows. The country had a similar experience during the Russian crisis of 1998. This triggered the rejection of the exchange rate peg in 1999. In addition, the Argentine crisis of 2002-2003 induced another recession in the Brazilian economy within the period. The recession was also attributed to the uncertainties associated with the election of a left-wing President. Finally, the global financial crisis of 2008-2009 that emanated from the United States mortgage market accounted for the 2008-2009 recession experienced in the economy.

Not minding the extent of the 2008-2009 crises, the economy developed a resistance to the shock, thereby mitigating the negative effect of the shock on the economy. This resistance was developed from strong fundamentals such as huge external reserves. However, the recent Covid-19 pandemic also affected the once-blooming Brazilian economy as no economy in the world was insulated against the shock. The effect of this pandemic was examined on the performance of selected macroeconomic variables between 2019 and 2023. First, the GDP growth rate of the country reduced from 1.22% in 2019 to -3.27% in 2020. In 2021, the GDP

growth rate increased to 4.98% and later fell to 2.9% in 2022. As of the third quarter in 2023, the value increased to 3%, signifying a boom and burst in output growth. Furthermore, inflation experienced the same trend within the period. The inflation rate reduced from 3.73% in 2019 to 3.21% in 2020. The value increased to 8.3% in 2021, 9.28% in 2022, and reduced to 4.73% in 2023. Lastly, the same trend was observed in the performance of money growth between 2019 and 2023. In 2019, the domestic growth rate stood at 8.13%. The value was reduced to 17.02% in 2020. It reduced further to 12.25% in 2021 and later increased to 13.27% in 2022. In 2023, as of November, the domestic growth rate reduced to 9.9%

In the case of China, the launching of the 1970s economic reform improves the performance of the country's economic growth. However, the economy exhibited macroeconomic fluctuation which cannot be overlooked. In 2003, the real GDP was 7 percentage points below its trend in quarter four, and in 2007, the same variable was 5 percentage points below its trend in quarter two. In addition, the economy experienced a stint of deflation between 1998 and 2003. However, there was an emergence of inflation in 2004. The inflation level in the country increased to over 10 percent in 2007. Given the experience of the Chinese economy, it could be said that the economy performed and was able to manage economic fluctuations when compared to other Latin American and developing countries. it was documented that between 1978 and 2008, the Chinese economy was confronted with five business cycles. The first experience was between 1978 and 1981, followed by the experience between 1982 and 1986. In 1987, the country experienced another wave of cycle and this lasted till 1990. The fourth episode was between 1990 and 1999, making it nine years of uncontrolled experience. The year 2000 marked the beginning of the fifth episode of the business cycle. The country's cycle was measured by the fluctuation of the growth rate of the GDP. Going by this definition, it could be said that the first three episodes of business cycles were very short as their durations were within five years. The narrative changed in 1990 as the duration became lengthier than the initial episodes. The fourth episode lasted for nine years while the fifth one was more than nine years.

The Chinese economy was greatly affected by the economic crisis of 2008. During this period, the volume of exports, imports foreign inflows, and GDP growth rate declined. Consequently, a larger portion of the active population became jobless. In responding to this scenario, the Chinese government implemented a two-edged policy by injecting a $586 Billion stimulus package and executing an expansionary monetary policy to increase the supply of money. These policies assisted in overcoming the effects of a fall in the global demand for the country's products. However, the performance of the economy has been foot-dragging in recent times, partly due to a decline in the growth rate of exports and a stagnant level of investment. The value of the real GDP fell from 10.4 percent to 7.8 percent between 2010 and 2012. This value decreased further to 7.3 percent in 2014. It was projected by the IMF that the Chinese economy will experience a slow growth rate of 6.8 percent and 6.3 percent in 2015 and 2016 respectively. The event took a new turn due to the Covid-19 pandemic that started in Wuhan, a city in China in December 2019. After the outbreak, the growth rate of the economy dropped drastically from 6 percent to 2.2 percent in 2020. The event badly affected economic drivers such as aggregate demand, investment, production, and external balance. The economy recovered in 2021 to an average of 8.4 percent growth rate from a very low base in 2020. Unfortunately, the re-occurrence of COVID-19 with a strict "Zero COVID" policy reduced the growth to 3 percent. In addition, the inflation rate irregularly responded to the pandemic. In 2019, the inflation rate was 2.9%. this reduced to 2.4% in 2020. It further went down to 0.8% in 2021 but increased to 1.88% in 2022. The last variable considered is domestic credit growth. The domestic credit

growth increased from 8.88 in 2019 to 10.01% in 2020. The value reduced to 9.07% in 2021 and further increased to 11.66% in 2022.

The use of monetary policy in stabilizing the macroeconomic environment has been acknowledged in the extant literature. (Woodford, 2003; Clarida et al., 1999; Saeed and Riaz, 2012; Alpanda, Granziera, and Zubairy, 2021; Xiano-Lin *et al*., 2021; Gorajski and Kuchta, 2024). Specifically, the strength of monetary policy in curtailing inflationary pressure is of great interest to economists (Clarida et al., 2000; Leeper, 1991; Weiss, 1980; Ghossoub, 2009; Liu *et al*. 2018). Clarida *et al*. (2000) and Saeed and Riaz (2012) argued that the implementation of passive monetary policy can lead to macroeconomic instability mainly due to self-fulfilling changes in future expectations of macroeconomic variables. Leeper (1991), Liu *et al*. (2018), Gimba *et al.* (2022), Mohimont (2022), and Oladipo and Akintola (2023) also argue that the failure of central bank actively using monetary policy to contain inflation could result in an inflation burst. With this literature in mind, monetary policy becomes an important instrument for analyzing economic stability. Therefore, our focus is to examine the role of monetary policy in macroeconomic instability in Nigeria, Brazil, and China. The choice of the three countries is determined by the economic ties among them. Nigeria is the second-largest trading partner with China in Africa and one of the main commercial partners with Brazil. While China and Brazil are members of the regional economic group BRICS, China is considered Brazil's largest trading partner. Given the economic ties among the three countries, it is necessary to examine the role monetary policy plays in influencing the business cycle among the countries.

The role of expectations in the analysis of the effect of monetary policy was stressed by Lucas (1972) and Sargent and Wallace (1975). According to them, the implementation of monetary policy plays an active role in expectation formation and that policy influences the economy through the expectation channel. The major reason adduced to this is that rational expectation is always brought to the fore when economic agents make their decisions (Mordi and Adebiyi, 2011; Agbonrofo and Ajibola, 2023; Yujia *et al.*, 2024). Therefore, the quantitative effect of policy impulses on the economy differs and the difference is based on whether the policy impulses are anticipated or unanticipated. Therefore, this study determines the impact of expected and unexpected monetary policy in influencing business cycles in the selected countries. To achieve this, we estimate a monetary policy behaviour that is captured by a Taylor-type interest rate rule using the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) models to examine the role of monetary policy in influencing macroeconomic instability over time. The New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models have become the standard framework for monetary policy analysis and economic forecasting (Christiano, Eichenbaum, and Evans, 2005; Smets and Wouters, 2003, 2007, Akinlo and Apanisile, 2019; Apanisile and Osinubi, 2020; Gorajski and Kuchta, 2024). Therefore, the objective of this study is to examine the effect of anticipated and unanticipated monetary policy on business cycles in Nigeria, China, and Brazil using a novel DSGE approach.

After the brief introduction, section two synchronized the existing theories, empirical studies, and the gaps in the literature. Section three explains the methodology and section four presents the results and discussion of findings. Section 5 presents the conclusion and recommendation.

2. LITERATURE REVIEW

This section examines the discussion on the definitions, causes, measurements, the identification of business cycles, and the implementation of monetary policy. This is done with the view to understanding the role of monetary policy in influencing business cycles. To

achieve this, this section is sub-divided into conceptual literature, theoretical literature, empirical literature, and gaps in the literature and value addition.

2.1 Conceptual Literature

The business cycle explains the fluctuations in the aggregate level of output and employment of a country overtime. The cycle has four different phases that an economy could eventually experience. They are expansion, peak, recession, and trough. The modern definition of business cycle dates back to the work of Mitchell (1923) titled business cycles and employment. He defined the business cycle as a series of crises that followed periods of prosperity. The causes of these crises include weather, uncertainty, innovation, savings, and over-production. As an extension to the definition of the concept of business cycles, Burns and Mitchell (1946) defined business cycles as phenomena that are recurrent in time. They are cyclical although they do not follow a given frequency, that is, they are not periodic. The sequencing of business cycles includes expansion, which is followed by recession, recession by contraction, contraction by revival, and revival by a fresh expansion. Given this characterization, the authors focused on identifying turning points which are referred to as peaks or troughs. Their choice of characterization was data-driven as against theoretical underpinning and this forms the basis for its criticism. Hicks (1933) defines the business cycle as a state of disequilibrium from the ideal state of dynamic equilibrium and it is caused by changes in structural elements that directly affect prices, rate of interest, and the value of money. Alternatively, Keynes (1936) defines business cycles as periods of low growth and high unemployment that are caused by changes in aggregate demand.

Furthermore, monetary policy is defined as a set of policies aimed at ensuring that an economy's value, supply, and cost of money are all commensurate with the expected level of activity. According to the Central Bank of Nigeria (2006), monetary policy refers to the specific actions taken by the Central Bank to regulate the value, supply, and cost of money in the economy to achieve the government's macroeconomic objectives. The employment of monetary policy instruments may be traced back to Adam Smith's period and has since been championed by monetarists like Milton Friedman. Since the role and importance of monetary policy in influencing macroeconomic objectives have been well documented (Shittu *et al*., 2023; Obioma and Sarah, 2023), it might be stated that monetary authorities have the task of utilizing monetary policy's potency to expand their domestic economies, taking into account economic indicators such as economic growth, price stability, the balance of payment equilibrium, and unemployment reduction. The success of monetary policy is found in its ability to adjust the money in circulation during periods of inflation and always reduce the money in circulation within weeks of its introduction.

The monetary tool can be either expansionary or contractionary. When a monetary authority utilizes its tools to boost the economy by increasing the total amount or quantity of money in an economy more quickly than usual, this is known as expansionary. If otherwise, it is referred to as contractionary policy. The choice of monetary policy tool to be adopted is determined by the objective(s) of the government at a given period.

2.2 Theoretical Literature

This section examines existing theories of business cycles that have been propounded overtime.

2.2.1 Keynes Business Cycle Theory

Keynes's contribution to the causes of business cycles was documented in his Business Cycle Theory, presented in the 'General Theory of Employment, Interest and Money'. According to him, fluctuations in the aggregate level of income are caused by changes in the level of

aggregate demand. He defined aggregate demand to mean the demand for consumption and investment goods. He explained further that since the desire to make a profit and the expectation of business owners about the economy determines the level of investment, then, total fluctuations in the economy are primarily a function of changes in investment. However, the theory did not elucidate the characteristics of a business cycle.

2.2.2 Schumpeter's Innovation Theory Of Business Cycle

Following Keynes's business cycle theory is Schumpeter's Innovation theory of the business cycle. He attributed the introduction of a major innovation to the major cause of the business cycle. According to him, as an innovative entrepreneur gathers factor inputs from different industries, the demand for inputs increases both the prices and money income. This will consequently enhance more investments. Furthermore, an increase in the level of production, which is a result of innovation, will increase the circular flow in the economy, thereby raising supply above demand. In this case, there is a disequilibrium that expands economic activities. Schumpeter refers to this expansion as a primary wave which is followed by a secondary wave in the expansion process. Both waves (primary and secondary) explain the effect of innovation on the business rivals. The success of innovation in one sector of the economy induces innovation in the related sectors, thereby increasing money income and prices further. As this exercise increases the stream of income in the industry, the whole economy expands.

2.2.3 Samuelson's Theory of Business Cycle

Samuelson expresses the role of a multiplier in the investment-income nexus. According to him, the rate at which investment will increase income depends on the value of the investment multiplier. In addition, an increase in income could also increase the level of investment. This is achieved through the acceleration effect. In the acceleration effect, improved income increases the level of output. For firms to meet the new demands more capital is required and this leads to extra investment. Therefore, there is a mutual relationship between investment and income. Investment aids income; income consequently increases demand, thereby causing income and employment to fluctuate cyclically.

2.2.4 Real Business Cycle Theory

This theory arrogated no role to changes in expectation or monetary shocks in influencing business cycles. The theory assumes that real shock to an economy is the cause of business cycles and that the real shock is caused by changes in technology. According to the theory, an increase in technical progress shifts the production function upward thereby leading to an increase in consumption, investment, and output. This level of progress consequently increases the stock of capital which further increases output, consumption, and investment. This process is continuous due to changes in technology in the long-run. The theory therefore attributed business cycles to a negative real shock that decreases the available resources and reduces production. This, in turn, decreases the level of output. Examples of negative real shocks include a decline in technology, unexpected rise in input price, scanty rainfall, etc.

2.2.5 New Keynesian Theory

The most recent theory in the analysis of the business cycle is the new Keynesian theory, which combines the real business cycle and long-run price rigidities to explain the causes of fluctuation in the short run. The New Keynesian Economists explain that sources of shocks could either be from the supply side or the demand side. However, the shocks could be amplified by market frictions and imperfections. Therefore, the major concern of this theory is the response of an economy to these shocks in the face of market imperfections and frictions. This implies the theory focuses on the response of an economy to a shock. It is worthy of note

that a branch of the new Keynesian economists focuses on the role of market imperfections. This group concludes that coordination failure is the determinant of the business cycle because there are no incentives to jointly choose a better strategy. However, a second strand argued that price and wage flexibility are the causes of the business cycle.

2.3 Empirical Literature

After the revival of interest in business cycle research following the work of Kydland and Prescott (1982), an enormous amount of research has been carried out in the literature to examine the sources of business cycles and the role monetary policy plays in influencing business cycles. Floden (2000) examined a model of the business cycle in the USA with the money supply set by the central bank to reduce the volatility of inflation and output in the country. To achieve this, the study estimated a DSGE model of macroeconomic fluctuations with endogenized money supply. The model captured the ability of the central bank to control inflation and output and it is expected to respond to changes in both the real and nominal variables behavior. In addition, it could be deduced that the central bank's desire to stabilize output at the expense of inflation changes the money supply process and the nominal variables' behavior significantly while the real variables remain unchanged.

To examine the role of monetary policy in influencing the performance of macroeconomic variables as demonstrated by Floden (2000), Kollmann (2002) estimated a Taylor-rule interest rate with welfare maximizing capacity using a small open business cycle model with sticky price setting. The study assumed various shocks such as domestic productivity, world interest rate, world inflation, and uncovered interest rate parity in the study. The study used a sticky-prices open economy dynamic stochastic general equilibrium (DSGE) model that calibrated to data for Japan, Germany, and the U.K. Results showed that the estimated interest rate policy rule strictly reduces inflation and significantly induces the volatility of real and nominal exchange rates. In addition, the effect of an increase in external is cushioned in the country by investing in foreign assets. The study concluded that the policy rule affects the variances and the means of macro-variables, and this impact significantly influences welfare.

Kim (2003) examined the essential properties of the business cycle in the face of both exogenous and endogenous policy rules using a calibrated DSGE with nominal rigidities as demonstrated by Kollmann (2002). It could be deduced that changes in the performance of the business cycle when using a model with exogenous and endogenous monetary policy rules are equal to those generated when using a model with nominal rigidities. The findings suggested tat incorporating endogenous monetary policy rules is as important as developing a new transmission mechanism of monetary policy disturbance when researching the monetary business cycle. However, the result of Kim (2003) is different from that of Kollmann (2002) despite employing the same methodology.

The Taylor-type interest rate estimated by Rabanal (2004) for the US made provision for time and state dependence. The study provided evidence for significant changes in the Taylor rule coefficient over time. It also concluded that a two-state switching-regime model is appropriate for explaining the performance of the Federal Reserve over the business cycle period. In the period of expansion, an inflation-targeting rule is employed with a high-interest rate smoothing while output growth is targeted during the recession. During this period, there was an active conduct of monetary policy to achieve the state objective. Ths implies that this type of policy is analyzed within the framework of a small-scale model of the New Keynesian.

Alege (2008) adapted Nson and Cogley's (1994) and Schorfheide's (2000) models with the introduction of the export sector to investigate sources of business cycles in Nigeria. The study

employed DSGE and it was estimated using the Bayesian approach. The study further incorporated money supply, technology, and export supply shock into the model and examined their impacts on macroeconomic variables. The introduction of the export sector was done to capture the terms of trade channel of transmission. Results showed that the Nigerian business cycle is driven by both real and nominal shocks.

Souza-Sobrinho (2010) developed a DSGE model for the Brazilian economy to explain the amount of output volatility generated by interest rate fluctuations in the country. The model is characterized by a capital constraint and an independent labor supply. The results recorded a volatile interest rate that is counter-cyclical and positively related to net exports. This is similar to what is obtainable in other emerging economies. In addition, the parsimonious model predicted that interest rate fluctuations accounted for a third of total fluctuations in output thereby generating business cycle regularities that are consistent with the Brazilian data.

Curdia and Finocchiaro (2012) analyzed the effect of monetary policy regimes on business cycles in a small open economy. It also investigated whether policy breaks affected the estimation procedure. By estimating a DSGE model that accounted for regime change from exchange rate to inflation targeting in Swedish data, the results showed that monetary policy responded strongly to both policies at different periods. Furthermore, the external sector is important in the economy and the choice of exchange rate regime affects the international transmission mechanism. The study further conducted a counterfactual experiment between the two policies and found out that it would have enhanced increased output and employment, depreciated currency, caused high inflation and produced a volatile economy.

Saeed and Riaz (2012) examined the conduct of monetary policy and its impact on macroeconomic volatility in Pakistan between the 1990s and 2000s using a forward-looking monetary policy rule. Quarterly data between 1991:1 and 2010:4 were analyzed using a GMM technique. This study This study was conducted in the same year as Curdia and Finocchiaro (2012). However, the study employed different methodologies to achieve the same objective. The study employed baseline variables such as output gap, treasury bill rate, and inflation rate, and also introduced other variables such as money supply, GDP, and REPO rates. Results showed that since 2002 when Pakistan had a new Governor of the State Bank of Pakistan, the objective of monetary policy changed to countering the business cycle and this led to lesser pursuit of anti-inflation policies. The study concluded that the increase in the level of inflation observed in the country from 2008 was a result of the policies implemented.

Ma and Zhang (2016) studied the interactions among financial, business, and monetary policy cycles by incorporating the financial cycle into the model. Results showed that the financial cycle is a major determinant of the business cycle and that it is the major driver of macroeconomic fluctuation during financial instability. Furthermore, the study compared the performance of the augmented and the conventional Taylor rule and found that the augmented Taylor rule performed better in stabilizing the economy. This finding supported the arguments for the effectiveness of monetary policy in stabilizing the financial system. The study recommended that the objective of monetary policy should include financial stability.

Ghalayin (2018) examined the role of monetary and real shocks in generating economic activity fluctuations in Lebanon between 1998Q1 and 2015Q4 using Granger Causality and OLS. It also studied the capacity utilization and inflation rate nexus within the period under investigation. Findings revealed the existence of a strong relationship between capacity utilization and inflation rate and also the effectiveness of monetary factors in the short-run period.

In an attempt to investigate he asymmetric effects of monetary policy on the business cycles, Hang and Xue (2020) analyzed panel data from 40 countries from 2005 to 2016 using panel smoothed quintile regression. It was discovered that monetary policy promotes the business cycle and that its effect is larger in emerging countries under expansion than in a recession. In the same year, Hall and McDermott (2020) estimated a New Keynesian model of a small open economy before and after the Global Financial Crisis of 2007. The estimated model is characterized by sticky prices and monopolistic competition. As indicated by the research, the difference between the two periods is the less sensitivity to interest rates. This calls for a stronger monetary policy action for stabilizing the economy. In addition, the reduction in the insensitivity of interest rates during the post-crisis period has reduced output and prices.

Bruns and Piffer (2021) investigated the effects of monetary policy on the business cycle using Smooth Transition Vector Autoregressive tat allows identification and sign restrictions as against calibration of parameters. The study offered a different approach to the recursive identification with the selectively calibrated parameters. Findings confirmed the financial accelerator theory and concluded that macroeconomic variables responded to monetary policy shocks in a recession rather than expansion. However, Hollander and Christensen (2022) examined whether the choice of monetary policy framework has a significant implication for monetary aggregates and interest rate policy in influencing business cycles in the USA. The study employed a Dynamic Stochastic General Equilibrium model and showed that the interaction among endogenous monetary regime, money supply, and demand captured the actual behavior of the economy. Results showed that the stricter interest rate targeting regime rendered the performance of the central bank ineffective.

Gandjon and Fouda (2023) analyzed the feasibility of an African monetary union using the condition of business cycle synchronization. To achieve this objective, the study examined the synchronization of growth cycles among the five regional economic groups that wanted to merge to form an African monetary union, using a continuous wavelength approach. The results confirmed heterogeneous synchronization across time and horizons among the Regional Economic Communities. However, the results revealed that business cycle synchronization has not reached a sufficient level that will allow the African economies to benefit from a common monetary policy.

It was generally believed that central bank announcements convey monetary policy actions and the bank's assessment of the economic outlook. To verify the validity of this statement, Hou *et al.* (2024) analyzed the monetary and information shocks from the Federal Reserve and the European Central Bank using daily data from 42 countries between February 2, 1990, to December 12, 2016. Data was analyzed using panel data regression with fixed effects. Results showed that both information and monetary policy shocks from both central banks contribute to the comovements of interest rates in many countries. It was also discovered that business cycle comovements, foreign exchange dynamics, and financial openness are the transmission channels for transmitting monetary policy shocks and information shocks during the period under investigation.

2.4 Gaps in Literature and Value Addition

The literature review has showcased shreds of evidence about the monetary policy-business cycle nexus. However, studies have not examined the effect of expectations in the economy on the business cycle. To achieve this, the study proxies expectation in the economy with monetary policy expectation and examines its influence on the business cycle. In this study, we disaggregated monetary policy expectations into anticipated and unanticipated monetary

policies and examined their effects on the selected macroeconomic variables. Also, the study employs DSGE to model the expectation because the model is forward-looking in nature.

3. METHODOLOGY

The study employs the New Keynesian theory as its framework. The framework is an offshoot of the standard real business cycle that is characterized by money neutrality. This is as a result of flexibility in wages and prices. The difference between the Real Business Cycle and the New Keynesian theory is that the latter introduced Keynesian attributes such as imperfect competition and sticky prices. It also accommodated the role of monetary policy as an important determinant of macroeconomic fluctuations. The underlining assumption of the model is imperfect competition in the goods market. This is made possible by the fact that each firm sells branded products thereby setting their prices. Furthermore, the process of price adjustment is not smooth. This is based on the assumption that few numbers among firms can readjust their prices overtime. It consists of individuals who consume goods and services, make labor supply decisions, and invest in stocks; production units that demand labor services for production, and monetary authority whose decisions control monetary policy. The settings of the framework follow the work of Akinlo and Apanisile (2019), Apanisile and Osinubi (2020), and Apanisile (2021).

3.1 Household

The model assumes a set of homogenous households with each household desiring to maximize:

$$max_{C_{t,}\, N_t, \frac{M_t}{P_t}} E_0 \sum_{t=0}^{\infty} \beta^t \; U \left(C_{t,}\, N_t, \frac{M_t}{P_t} \right) \qquad (i)$$

E_0 is the expectation operator condition on time 0 information, β denotes the discount factor, and $\frac{M_t}{P_t}$ represents the value of cash at hand. This is subject to the budget constraint:

$$P_t C_t + \; Q_t B_t \; + \; M_t \leq + M_{t-1} \, B_{t-1} + \; W_t N_t + J_t \qquad (ii)$$

Where $C_t \; (i)$ denotes the amount of commodity *i* bought by individuals in period t, for $i \in [0,1]$ for t = 0, 1, 2, …., $P_t \; (i)$ represents the amount to be paid for commodity *i*, N_t is the number of hours worked, W_t represents the nominal wage, B_t is the value of a bond bought at a price Q_t, B_{t-1} represents the lag value of B_t, M_t is cash at hand, and J_t represents the lump sum aspect of income. $\in$ measures the degree of responsiveness to the substitution between the heterogenous commodities. The FOC condition of equations *(i)* and *(ii)* is obtained using the Kuhn-Tucker approach. Re-arranging the FOC, it becomes:

$$1 = \beta(1 + i_t) E_t \left\{ \frac{U_{c(t+1)}}{U_{c(t)}} \frac{P_t}{P_{t+1}} \right\} \qquad (iii)$$

$$- \frac{U_{N(t)}}{U_{C(t)}} = \frac{W_t}{P_t} \qquad (iv)$$

$$\frac{U_{M(t)}}{U_{C(t)}} = \frac{i_t}{1+i_t} \qquad (v)$$

The re-arranged FOC equations explain the forward-looking allocation decision of rational households. These are presented in equations *(iii), (iv), and (v).*

A period utility assumption is presented as:

$$\mathrm{u}(C_t, N_t, M_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} + \frac{\left(\frac{M_t}{P_t}\right)^{1-v}}{1-v} \qquad (vi)$$

The equations for additional satisfaction derived from consumption, labor, and money are:

$$U_{Ct} = C_t^{-\sigma}$$
$$U_{Nt} = -N_t^{\varphi}$$
$$U_{Mt} = \left(\frac{M_t}{P_t}\right)^{-v}$$

Substituting the above equations into *(iii)* – *(v)* gives:

1=

$$\beta Q_t^{-1} E_t \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+1}} \right\} \qquad (vii)$$

$$C_t^{\sigma} N_t^{\varphi} = \frac{W_t}{P_t} \qquad (viii)$$

$$\frac{M_t}{P_t} = C_t^{\frac{\sigma}{v}} \left(\frac{1+i_t}{i_t}\right)^{\frac{1}{v}} \qquad (ix)$$

By log- log-linearizing and representing the log of variables with small letters, equations *(vii)* – *(ix)* become:

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(i_t - \rho - E_t \pi_{t+1}) \qquad (x)$$

$$w_t - p_t = \sigma c_t + \varphi n_t \qquad (xi)$$

$$m_t - p_t = c_t - \eta i_t \qquad (xii)$$

3.2 Firms

The model contains a set of identical firms represented by $i \in [0,1]$. Although the firms employ the same technology, they produce heterogeneous goods. The production function is presented as:

$$Y_{it} = A_t N_{it}^{1-\alpha} \qquad (xiii)$$

Y_{it} represents the level of output produced by firm i during period t, A_t is the homogenous technology employed by all firms, and N_{it} is the labor input employed by firms. The key feature of the New Keynesian model is the rigidity of price level. Firms have the freedom to set their prices, however, the opportunity to do so is rare. Therefore, the firms' likelihood of not being able to reset their prices is represented as θ. This represents the proportion of firms that are unable to reset their prices in the current period. Other $1 - \theta$ firms consequently choose a new price in the market. The firms operate with the same elastic demand schedule that contains price elasticity ϵ with price level P_t and consumption index C_t. Changes in the aggregate price setting are defined as:

$$\pi_t{}^{1-\epsilon} = \theta + (1-\theta)\left(\frac{P_t{}^*}{P_{t-1}}\right)^{1-\epsilon} \qquad (xiv)$$

From the equation, $\pi_t \equiv \frac{P_t}{P_{t-1}}$ explains the total inflation rate and P_t^* is price-optimizing firms in period t. All firms are expected to choose the same prize due to the problem of identification. Therefore, the condition for a steady state with zero inflation is $\pi = 1$. Based on the aggregate price index of zero inflation, steady state equals:

$$\backslash\, \pi_t = (1-\theta)(P_t^* - P_{t-1}) \qquad (xv)$$

Equation (15) shows that inflation in the current period is caused by firms whose prices are different from the economy's average price. Therefore, understanding the dynamics of inflation requires the analysis of factors that determine price-setting decisions. To achieve this, firms that re-optimize with price P_t^* that maximize profit must be considered. The optimization problem is solved as follows:

$$max P_t^* \sum_{k=0}^{\infty} \theta^k E_t \left[Q_{t,t+k} \left(P_t^* Y_{t+k/t} - \varphi_{t+k}(Y_{t+k/t}) \right) \right] \qquad (xvi)$$

Subject to the sequence of demand constraints

$$Y_{t+k/t} = \left(\frac{P_t^*}{P_{t+k}} \right)^{-\epsilon} C_{t+k} \qquad (xvii)$$

The first-order condition of the problem takes the form:

$$\sum_{k=0}^{\infty} \theta^k E_t \left(Q_{t.t+k} Y_{t+k/t} \left[P_t^* - M\omega_{t+k/t} \right] \right) = 0 \qquad (xviii)$$

for k = 0,1,2,…….. where $Q_{t,t+k}$ represents the density function for nominal payoffs. The cost function is defined as $\varphi_t(.)$ and output in period t+k for a firm that resets its price $Y_{t+k/t}$. The likelihood of being stuck with the current price is θ^k and the frictionless markups are given as M. The equilibrium price P_t^* is

$$p_t^* = \mu + (1 - \theta\beta) E_t \sum_{k=0}^{\infty} \theta^k \beta^k [m r_{t+k|t}^r + p_{t+k}] \qquad (xix)$$

Equilibrium condition in the goods and market states that:

$$Y_{it} = C_{it} \qquad (xx)$$

The total output level is given as:

$$Y_t = \left(\int_0^1 Y_{it}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon-1}{\epsilon}} \qquad (xxi)$$

Substitute for *(xx)* in *(xxi)*, equation *(xxi)* then becomes:

$$Y_t = C_t$$

Taking a log of both sides, we have:

$$y_t = c_t \qquad (xxii)$$

The aggregate market clearing condition is stated in equation *(xx).* In addition, market-clearing conditions in the labor market equal:

$$N_t = \int_0^1 N_{it}\, di \qquad (xxiii)$$

Re-arrange (13) by making N_{it} the subject. Equation (13) becomes

$$N_{it} = \left(\frac{Y_{it}}{A_t}\right)^{\frac{1}{1-\alpha}}. \qquad (xxiv)$$

Substitute (22) and (24) into (23) and log-linearize the result. Equation (22) becomes:

$$y_t = a_t + (1-\alpha)n_t \qquad (xxv)$$

3.3 Monetary Authority

The short-term interest rate is employed as the monetary policy instrument by the monetary authorities. A decrease in interest rate (both current and expected) increases aggregate demand for consumption goods. This results in the extra cost incurred by firms and consequently increases in price. This leads to inflation. The reverse is the case when the interest rate is high. Then, Taylor's rule dictates the setting of short-term interest rates. Following the Taylor's rule, interest rate setting is given as:

$$i_t = \alpha_r i_{t-1} + (1-\alpha_r)(1+\alpha_\pi)\pi_t + \beta_x(\hat{y}) + v_t \qquad (xxvi)$$

Where

$i_t = short\ term\ interest\ rate$
$i_{t-1} = lag\ of\ short\ term\ interest\ rate$
$\pi_t = inflation\ rate$
$y_t = output\ gap$
$v_t = is\ the\ monetary\ shock$

3.4 Log-linearized model

This helps in transforming a system of non-linear equations into a linear form and they are defined in terms of their deviation around their steady state. This reduces complexity in the computation of the variables and allows simultaneous computation of the system of equations. Equations *(xxvii) – (xxix)* are the log linearized system of the above equations.

$$output_t = \alpha_1 output_{t+1} + \alpha_2\, exc_t + \alpha_3\, inf_t + \alpha_4\, ant_t + \alpha_5 una_t + \alpha_6 trad_t + \alpha_7\, interest_t + \alpha_8 cred_t + x_t \qquad xxvii$$

$$inf_t = \beta_1 inf_{t+1} + \beta_2 output_t + \beta_3 exc_t + \beta_4\, ant_t + \beta_5 una_t + \beta_6 trad_t + \beta_7\, interest_t + \beta_8 cred_t + k_t \qquad (xxviii)$$

$$interest_t = \varphi_1 interest_{t-1} + \varphi_2 inf_t + \varphi_3 output_t + v_t \qquad (xxix)$$

Equation (27) defines the determinant of the current level of output as its expected future value and its ex-ante real interest rate which is defined as the difference between nominal interest rate and expected inflation. Other determinants of the output gap in equation *(xxvii)* include exchange rate, inflation, anticipated and unanticipated monetary policies, terms of trade, and credit growth. The equation is a log-linearized Euler equation that links the household marginal rate of substitution to the real interest rate. This equation is called expectation IS. The New Keynesian Philip curve is presented in equation *(xxviii).* It is the log-linearized equation of the optimal behavior of firms that choose between facing the explicit cost of nominal price adjustment (Rotemberg, 1982) or setting nominal prices (Calvo, 1983). According to the equation, determinants of inflation are the expected future value of inflation, output gap, anticipated and unanticipated monetary policies, terms of trade, interest rate, and credit growth. A monetary policy framework with interest rate as the policy instrument is presented in equation *(xxix),* as proposed by Taylor (1993). The Central Bank either increases or decreases interest rates to adjust movements in inflation and output. Variables in the three equations include output gap, inflation, and short-term interest rate.

The proposed framework shows that monetary impulses pass through the interest rate channel to the economy. A contractionary policy raises interest rates, both nominal and real, in the face of sluggish movement of nominal prices. This is a result of price-setting rigidity. This policy encourages households to reduce their spending according to the IS curve. A reduction in output destabilizes inflation through the Philip curve. The price level then resets gradually after the shock. More importantly, a forward-looking term included in both equations *(xxvii)* and *(xxviii)* explains the difference in the qualitative effects of the policies. This difference depends on the nature of the policy which could be anticipated or unanticipated.

3.5 Data

Quarterly data is employed in estimating the parameters of the model. Data on output gap, nominal interest rate, domestic inflation, nominal exchange rate, credit to private sector, anticipated and unanticipated monetary policies, and terms of trade are sourced for Brazil, Nigeria, and China between 1986 Q1 and 2014 Q4. The natural log of the ratio of trend output to real output was taken in computing the output gap. The Hodrick-Prescott filter was used to separate trend real output from the output data. The derivation of anticipated and unanticipated monetary policies involves estimating the monetary reaction function. From the estimation, the predictive component is separated from the residual. While the predictive represents anticipated policy, the residual represents unanticipated policy. All sources of noise were removed through filtering of the data. Such noise includes outliers, trends, and non-stationarity. The whole idea is to achieve stability of the model.

4. RESULTS AND DISCUSSION OF FINDINGS

DSGE models are estimated using different estimation techniques. Such techniques include likelihood-base, minimum distance, generalized method of moments, and Bayesian approach. However, this study employs the Bayesian technique. This is because of its ability to overcome problems of identification, lack of precision, and it makes room for easy comparison among models Adjemian (2013). The use of the Bayesian technique requires the calibration of some or all the parameters. This enables the technique to overcome all the problems associated with all other techniques.

In accessing the extent to which the data fit the model, steady-state parameters are calibrated in the estimation process. This implies parameters that are germane in the achievement of a

steady state must be calibrated. The technique also makes provision for the introduction of theoretical knowledge and likelihood function into the model. Both items generate the required posterior distribution required for estimating the model.

4.1 Estimation Technique

The posterior density, as defined by the Bayes' theorem, is given as: $p\left(\theta\middle|Y_{1,}^{T}, M_i\right) = \frac{L\left(\theta\middle|Y_1^T, M_i\right)p(\theta|M_1)}{p(Y_1^T|M_i)}$, $for\ i = 1,2\ and\ 3$

Where the model parameters and the observed data are presented as $\theta\ and\ Y_1^T$ respectively. The probability function is given as L. Prior density and the individual density of the marginal data on M_i are $p(\theta|M_1)$ and $p(Y_1^T|M_1)$. $L(\theta|Y_1^T, M_i)$ is constructed and evaluated using the Kalman filter. The posterior kernel $L(\theta|Y_1^T, M_i)p(\theta|M_1)$ for each model is simulated using the random-walk Metropolis-Hastings (MH) algorithm. His is also known as the Markov chain Monte Carlo (MCMC) simulation method used in the recent literature of DSGE model estimate by Bayesian technique. Given that most recent studies in the Nigerian literature estimated DSGE by Dynare, a popular Matlab package, this study also employs Dynare 4.3.3 to estimate the models.

4.2 Calibration

Estimating DSGE with the Bayesian technique requires calibrating the parameters of interest. This process is referred to as setting the priors in DSGE. There are several ways of setting priors in the extant literature. This includes personal beliefs about basic economic theories, the researcher's confidence about the position of the structural parameters in a model, observation, facts about the economy, and the empirical literature. Therefore, priors for Philips and IS curves for Brazil were selected from the study of Carvalho, Catsro, and Costa (2013) and Areosa and Coelho (2013). The selected priors for the parameters and the standard error of shocks are presented in Table 1.

Table 1: Selected Priors for Brazil

Parameter	Description	Density	Mean	Std Deviation
α_3	Inflation parameter in IS equation	beta	0.300	0.050
α_4	Anticipated policy parameter in IS equation	beta	0.670	0.050
α_5	Unanticipated policy parameter in IS equation	beta	0.320	0.050
α_7	Interest rate parameter in IS equation	beta	0.200	0.049
α_8	Bank loan parameter in IS equation	beta	0.300	0.050
β_1	Intercept	beta	0.990	0.051
β_2	Output gap parameter in Philips Curve equation	beta	0.125	0.050
β_4	Anticipated policy parameter in Philips Curve equation	beta	0.300	0.050
β_5	Unanticipated policy parameter in Philips Curve equation	beta	0.250	0.050
β_7	Interest rate parameter in Philips Curve equation	beta	0.260	0.050

β_8	Bank loan parameter in Philips Curve equation	beta	0.310	0.050
φ_1	Measures policy persistence	gamma	0.220	0.050
φ_2	Inflation parameter in Taylor rule equation	gamma	0.240	0.051
φ_3	Output gap parameter in Taylor rule equation	gamma	0.300	0.050
eps_v	Unanticipated policy shock	invg	0.063	0.0267
eps_k	Bank credit shock	invg	0.035	0.0301
eps_x	Demand shock	invg	0.488	0.0426
eps_u	Supply shock	invg	0.060	0.0098
eps_a	Anticipated policy shock	invg	0.500	0.0455

For China, the work of Liu and Zhang (2010) and Li and Liu (2013) guided the selection of priors for the Philips and IS curve estimates. Table 2 shows the priors selected for the parameters and their standard errors of shocks.

Table 2: Selected Priors for China

Parameter	Description	Density	Mean	Std Deviation
α_3	Inflation parameter in IS equation	beta	0.300	0.050
α_4	Anticipated policy parameter in IS equation	beta	0.670	0.050
α_5	Unanticipated policy parameter in IS equation	beta	0.320	0.050
α_7	Interest rate parameter in IS equation	beta	0.200	0.049
α_8	Bank loan parameter in IS equation	beta	0.300	0.050
β_1	Intercept	beta	0.990	0.051
β_2	Output gap parameter in Philips Curve equation	beta	0.125	0.050
β_4	Anticipated policy parameter in Philips Curve equation	beta	0.300	0.050
β_5	Unanticipated policy parameter in Philips Curve equation	beta	0.250	0.050
β_7	Interest rate parameter in Philips Curve equation	beta	0.260	0.050
β_8	Bank loan parameter in Philips Curve equation	beta	0.310	0.050
φ_1	Measures policy persistence	gamma	0.220	0.050
φ_2	Inflation parameter in Taylor rule equation	gamma	0.240	0.051
φ_3	Output gap parameter in Taylor rule equation	gamma	0.300	0.050
eps_v	Unanticipated policy shock	invg	0.063	0.0267
eps_k	Bank credit shock	invg	0.035	0.0301
eps_x	Demand shock	invg	0.488	0.0426

eps_u	Supply shock	invg	0.060	0.0098
eps_a	Anticipated policy shock	invg	0.500	0.0455

For Nigeria, Adebiyi and Mordi (2010) and Mordi et. al. (2013) were considered in selecting the priors for the models of Philips and IS curves. The selected priors for the parameters and standard error of shocks are presented in Table 3.

Table 3: Selected Priors for Nigeria

Parameter	Description	Density	Mean	Std Deviation
α_3	Inflation parameter in IS curve	beta	0.300	0.050
α_4	Anticipated policy parameter in IS curve	beta	0.670	0.050
α_5	Unanticipated policy parameter in IS curve	beta	0.320	0.050
α_7	Interest rate parameter in IS curve	beta	0.200	0.049
α_8	Bank loans parameter in IS curve	beta	0.300	0.050
β_1	Intercept	beta	0.990	0.051
β_2	Measures output persistence	beta	0.125	0.050
β_4	Anticipated policy parameter in Philips Curve equation	beta	0.300	0.050
β_5	Unanticipated policy parameter in Philips Curve equation	beta	0.250	0.050
β_7	Interest rate parameter in Philips Curve equation	beta	0.260	0.050
β_8	Bank loan parameter in Philips Curve equation	beta	0.310	0.050
φ_1	Measures policy persistence	gamma	0.220	0.050
φ_2	Inflation parameter in Taylor rule equation	gamma	0.240	0.051
φ_3	Output gap parameter in Taylor rule equation	gamma	0.300	0.050
eps_v	Unanticipated policy shock	invg	0.063	0.0267
eps_k	Bank credit shock	invg	0.035	0.0301
eps_x	Demand shock	invg	0.488	0.0426
eps_u	Supply shock	invg	0.060	0.0098
eps_a	Anticipated policy shock	invg	0.500	0.0455

After calibration, it is important to simulate the derived models. The essence of simulation is to confirm the satisfaction of the steady state conditions and obtain values for the endogenous variables at the steady state. This is done for all the countries. results confirmed the existence of stedy state with the steady state values of endogenous values generated. The results of the responses of the endogenous variables to orthogonal shocks were also obtained from the simulation results.

4.3 Discussion of Results

Brazil

The first result generated from the analysis is the posterior density that combines the suitable priors and the likelihood. Also, the posteriors were generated using a random walk MH algorithm with 10,000 draws. The Log data density of -302.667285 was generated from 19 out of the 112 data points. This spanned from 1990Q$ to 2013Q4. Table 4 presents the results which include the distribution, prior mean, posterior mean, standard deviation, and the confidence interval for all the parameters and standard deviation of shocks.

Table 4: Priors and Posterior of the Estimated Parameters

Parameters	**Prior Mean**	**Posterior Mean**	**90% HPD Interval**		**Posterior Standard Deviation**
alpha_pi	0.300	0.3007	0.2919	0.3086	0.0050
alpha_a	0.670	0.6699	0.6620	0.6781	0.0050
alpha_u	0.320	0.3201	0.3118	0.3286	0.0050
alpha_i	0.200	0.2011	0.1926	0.2094	0.0050
alpha_c	0.300	0.2989	0.2905	0.3067	0.0050
beta	0.990	0.9959	0.9928	0.9988	0.0050
beta_y	0.125	0.1236	0.1155	0.1314	0.0050
beta_a	0.300	0.2996	0.2917	0.3077	0.0050
beta_u	0.250	0.2499	0.2420	0.2582	0.0050
beta_i	0.260	0.2581	0.2489	0.2671	0.0050
beta_c	0.310	0.3118	0.3035	0.3203	0.0050
theta_i	0.220	0.2211	0.2129	0.2295	0.0050
theta_pi	0.240	0.2398	0.2321	0.2472	0.0050
theta_y	0.300	0.3020	0.2943	0.3105	0.0050
eps_v	0.063	0.4740	0.3092	0.6427	0.267
eps_x	0.488	0.4100	0.1975	0.6032	0.426
eps_u	0.060	0.0449	0.0150	0.0851	0.098
eps_a	0.500	0.3343	0.1186	0.5476	0.455

Brazilin data provides informative results as shown in Table 4. This is because both posterior and prior means are tightly close. In addition, output gap equation results showed that the posterior mean (0.3007) of the inflation expectation parameter ($alpha\_pi$) is greater than the prior mean (0.300). Likewise, the posterior mean of both the anticipated (0.6699) and unanticipated (0.3201) monetary policy impacts are greater than their prior means ($alpha\_a =$ 0.6700) and ($alpha\_u$=0.3200) respectively. Lastly, on the output gap, the estimated posterior of measures of commercial bank credit impact ($alpha\_c$ = 0.3003) is greater than its prior (0.3000). it could be said from the results that the values of the estimated parameters are data-driven, indicating a high degree of Brazilian persistence in the household's consumption. Overall, the results showed that estimated values draw information from the data because the posterior is different from the priors.

The estimates of the New Keynesian Philips curve for Brazil explain the inflationary behavior of the country. The inflationary behaviour depends on $beta\_y$, $beta\_a, beta\_u$, and $beta\_i$ which means measures of the output gap, anticipated monetary policy, unanticipated monetary policy and impact of interest rate on inflation. Information about how frequently a firm changes its price, which is otherwise known as the likelihood of not changing price in a given period is represented by the calvo price stickiness. The $beta\_a$ (0.2996) shows the proportion of firms that do not reset their prices in a quarter. However, $beta\_u$ (0.2499) shows that in every

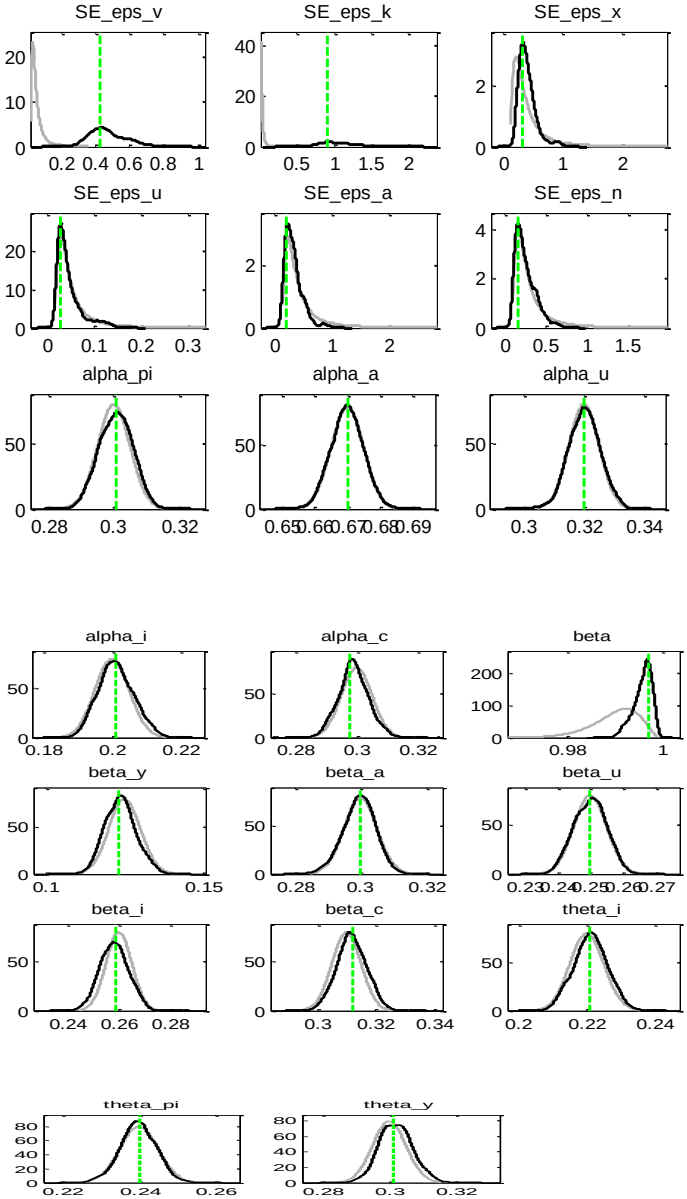
second quarter, some firms reoptimize their prices. The implication is that on average, price contracts in every second quarter. It is expected that the $beta\_y$ (0.1236) must be greater than zero if the monetary policy would influence inflation. This condition is satisfied with $beta\_y$ greater than zero. Monetary policy, therefore, becomes an important tool for controlling inflation through the output channel.

The estimates of the Brazilian policy reaction function revealed the policy design of the country during the period under investigation. Following the Taylor rule benchmark, the monetary policy ($theta\_i = 0.2211$) is active and controls the level of output ($theta\_y$ = 0.3020). this shows that the implementation of monetary policy in the country follows the Taylor type and that the central bank trade-off price stability for output stabilization in the long run.

Furthermore, the posterior of the estimates of the lag of interest rate parameter ($theta_i = 0.2211$) is different from its prior (0.2200). this implies a smooth path for the short-term interest rate. The result shows that monetary policy design in Brazil is effective and that its objectives are price stability and economic growth. Looking at the standard deviation estimates, the most volatile shock is the output gap shock (0.4740) and the least volatile is the unanticipated monetary (0.0449).

The study concludes that to a reasonable extent, the results are data-driven. This assertion is confirmed by the prior and posterior distribution presented in Figure 1. The grey and black lines represent prior and posterior distributions respectively. The vertical green line in the diagram is the posterior mode generated from the optimization simulation. The diagram confirms the probability of the estimated results as the optimization mode is similar to the posterior mode with few exceptions. Also, it could be deduced from the diagram that the plotted posterior distribution is close to normality. This is an indication that the model explains factors that determine the performance of the Brazilian economy and pass the goodness of fit test. The overall results support the findings of Ghoussob (2009), Ghalagini (2008), and Hall and McDermott (2020). However, the result is against the theoretical arguments of the real business cycles school that postulated that monetary policy is ineffective in influencing business cycles.

Figure 2: Priors and Posterior Shapes for Brazil



Source: Authors' Computation (2024)

Monte Carlo Markov Chain (MCMC) Diagnostics Test.

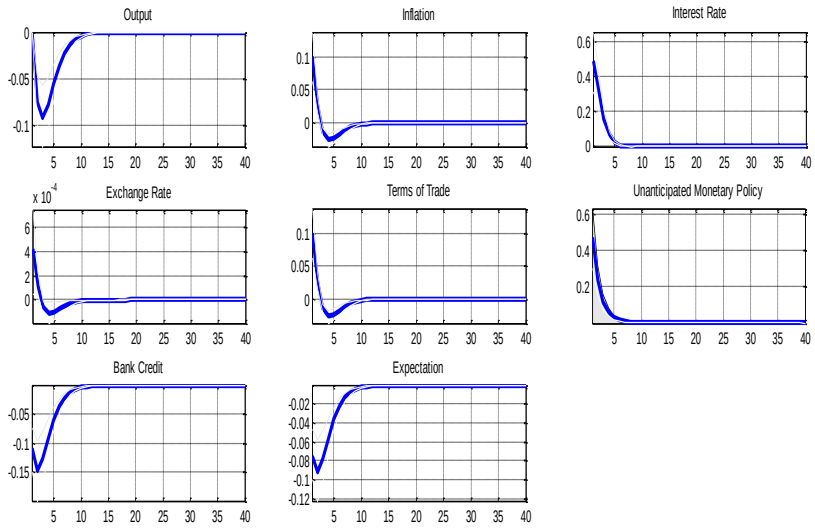
The study employs both the univariate and multivariate MCMC diagnostic tests to evaluate the sensibility of the Metropolis-Hastings simulations. The condition is that the simulation must be similar within and across chains. There must be little variability and then convergence. Results from the diagram showed that the conditions are satisfied. Also, the results of the multivariate Monte Carlo Markov Chain (MCMC) diagnostics test are summarized in three graphs. They are mean (interval), variance (m2), and third moment (m3). It is expected that

both lines for the three graphs must converge. The results supported the convergence and the stability condition. Results of these tests are available on request.

Bayesian Impulse Response Analysis

Figures 3.1-3.4 present the graphical illustration of the variables response to the respective shocks examined in the study.

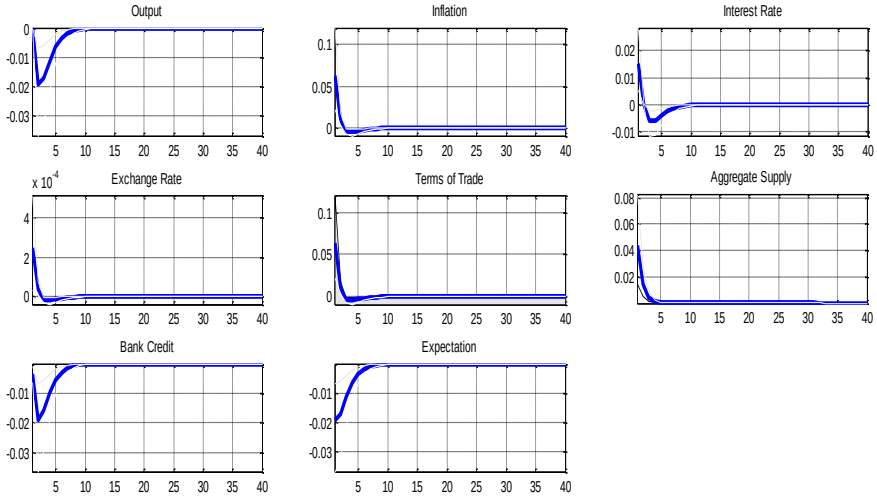
Figure 3.1: 1% Response to Unanticipated Monetary Policy Shock



Source: Authors' Computation (2024)

The effects of unanticipated monetary policy are positive on interest rate and nominal exchange rate, however, negative on credit and expectation channels. In response to unanticipated shocks, the interest rate was reduced from 0.41 percent in quarter 1 to 0.004 percent in quarter 6. Also, the nominal exchange rate was pressurized by positive unanticipated shock. Its value reduced from 0.004 in quarter one and became insignificant in periods four and eight. Credit to the private sector also responded negatively to this shock in the first quarter, however, it later experienced an upward trend in the last quarter. lastly, expectations also showed an upward trend in responding to unanticipated shock. This shows the procyclicality nature of monetary policy as it expresses the procedure for achieving its objectives with few trade-offs between output and exchange rate. Variables return to a steady state in the long run.

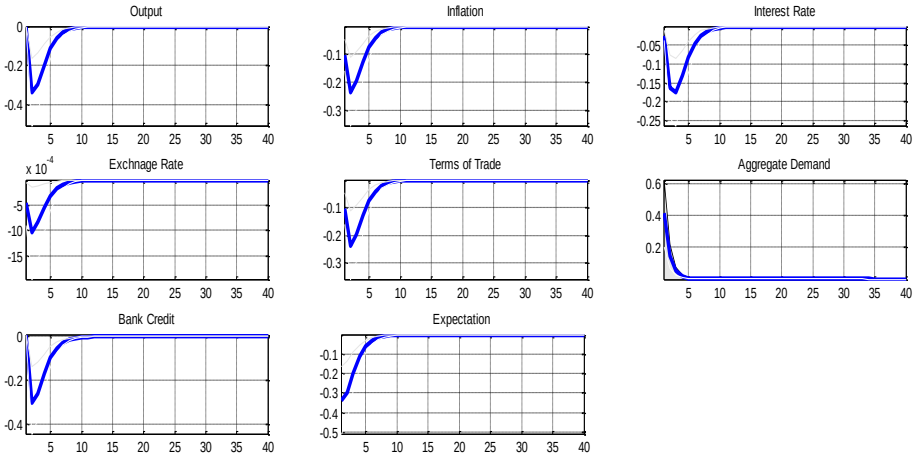
Figure 3.2: 1% Response to Aggregate Supply Shock



Source: Authors'Computation (2024)

Macroeconomic variables' responses to the supply shocks differ. Credit to the private sector and expectation responded negatively both in the long run and short run periods. However, interest rates and exchange rates responded positively in the short run and negatively in the long run. A positive supply shock to the variables reduced their performance in the short run and later fizzled out in the long run except for output, bank credit, and expectation which experienced an upward trend. The results showed that supply and demand shocks are different in their relative impacts. While supply shocks are active in the short run, the reverse is the case for the demand shock. The supply shock increases the performance of credit to the private sector between the first and the fourth quarters. Interest rates turned negative in the fourth quarter with a fall from 0.002 and 0.001 percent. The effect of supply shocks on the exchange rate is insignificant throughout the periods. All variables return to equilibrium.

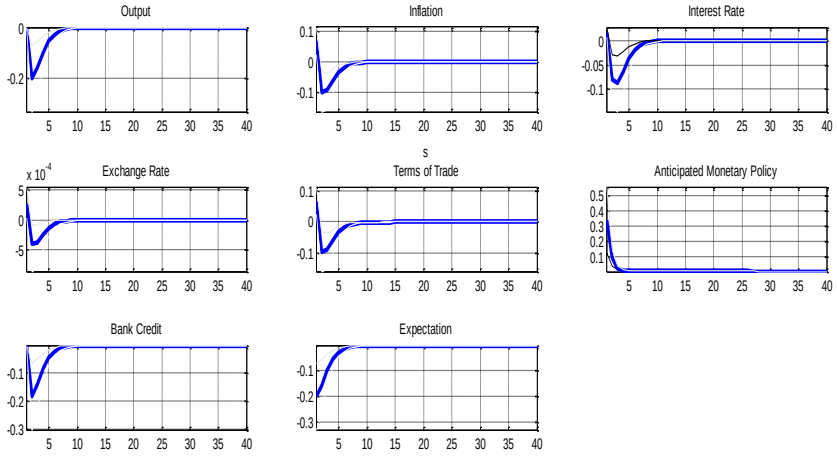
Figure 3.3: 1% Response to Aggregate Demand Shock



Source: Authors'Computation (2024)

The effect of aggregate demand shock on interest rate, exchange rate, credit to the private sector, and expectations are similar. All the variables responded negatively to the shock. Other variables did not respond to the effects of this shock in the short run but their responses are negative in the long run. Variables converge to their steady states in the long run.

Figure 3.4: 1% Response to Anticipated Monetary Shock



Source: Authors'Computation (2024)

As expected, all the variables responded negatively to anticipated monetary policy shocks. The rational expectation theory is confirmed by this result as all the variables fizzle out after a negative response in the long run. Variables converge to their steady states in the long run.

CHINA

The posterior density for the Chinese economy is generated from the suitable priors and the likelihood of an algorithm of 10,000 draws. 19 of the available 112 data points were used. This spanned between 1990Q4 and 2013Q4. The generated log data density through prior and posterior mean, prior standard deviation, and the confidence interval is -205.912172. results are presented in Table 5.

Table 5: Priors and Posterior of the Estimated Parameters

Parameters	Prior Mean	Posterior Mean	90% HPD Interval		Posterior Standard Deviation
alpha_pi	0.300	0.3002	0.2921	0.3084	0.0050
alpha_a	0.670	0.6702	0.6617	0.6785	0.0050
alpha_u	0.320	0.3196	0.3118	0.3282	0.0050
alpha_i	0.200	0.1997	0.1916	0.2083	0.0050
alpha_c	0.300	0.3005	0.2920	0.3089	0.0050
beta	0.990	0.9952	0.9919	0.9988	0.0050
beta_y	0.125	0.1237	0.1151	0.1310	0.0050
beta_a	0.300	0.2998	0.2924	0.3079	0.0050
beta_u	0.250	0.2498	0.2422	0.2586	0.0050
beta_i	0.260	0.2588	0.2507	0.2671	0.0050
beta_c	0.310	0.3098	0.3010	0.3178	0.0050

theta_i	0.220	0.2206	0.2124	0.2288	0.0050
theta_pi	0.240	0.2401	0.2321	0.2474	0.0050
theta_y	0.300	0.3010	0.2931	0.3090	0.0050
eps_v	0.063	0.4957	0.3146	0.6903	0.267
eps_x	0.488	0.4494	0.1059	0.8966	0.426
eps_u	0.060	1.2983	0.8128	1.8145	0.098
eps_a	0.500	2.5866	1.6694	4.2865	0.455

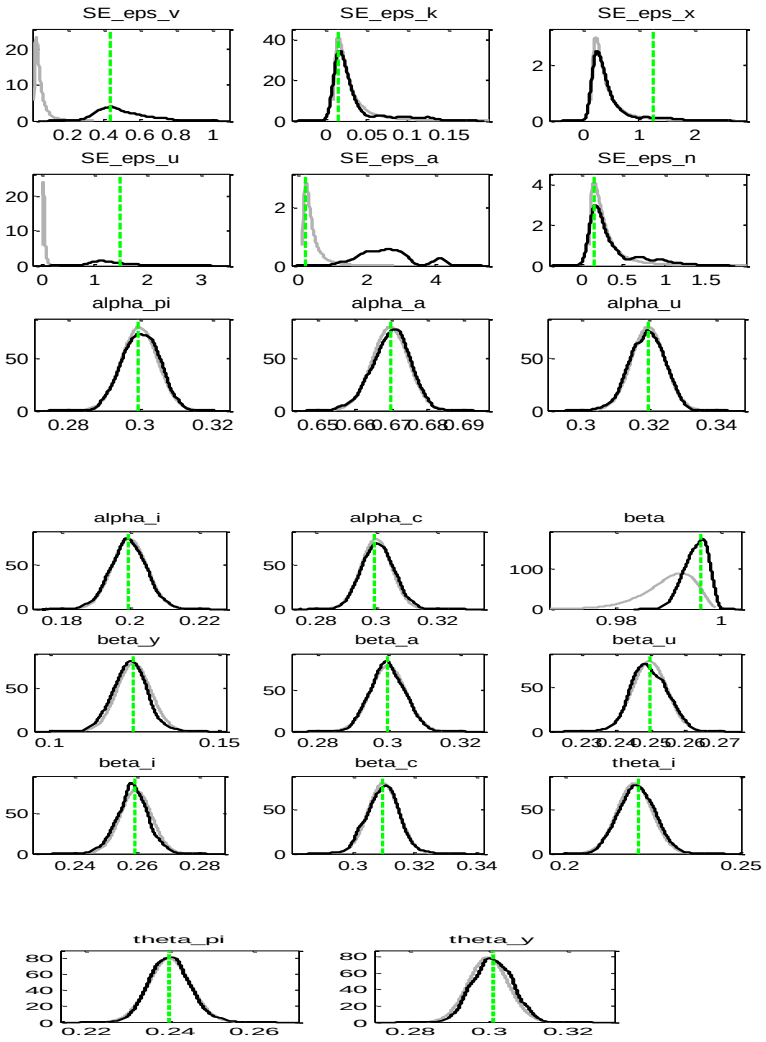
The data is informative as the posterior means of all the variables in the output gap equation are greater than their selected prior means. For instance, inflation expectation ($alpha\_pi = 0.3002$) is greater than its prior mean (0.300). Lastly, on the output gap, the estimated posterior of measures of commercial bank credit impact ($alpha\_c$ = 0.3005) is greater than its prior (0.300). this shows that the values of the parameters are data-driven and that the Chinese household's consumption is persistent.

The New Keynesian Phillip curve results explain the inflationary behavior of the Chinese economy. This is revealed by the coefficients of $beta\_y$, $beta\_a$, $beta\_u$, $beta\_i$ which implies output gap, anticipated monetary policy, unanticipated monetary policy, and interest rate impact. The value of the estimate of Calvo price stickiness ($beta\_a$ = 0.2998) revealed that 29 percent of the firms do not re-optimize in a given quarter. Also, $beta\_u$ (0.2498) for anticipated showed that on average, price contracts around the second quarter. The effectiveness of monetary policy in controlling inflation is defined by $beta\_y$ (0.1237) which must be greater than zero. This condition is satisfied given the value of the parameter. Therefore, the bank of China has an effective tool in the output gap to control inflation.

The monetary policy design of China is described by the estimates of its reaction function. With the Taylor rule as the benchmark, the monetary policy is active ($theta\_i$ = 0.2206), and target output stabilization ($theta\_y$ = 0.3010). This implies the monetary policy design follows the Taylor rule. This is an indication that output stabilization is the focus of the monetary policy in the long run and the primary objective of price stability in the short run. The smoothing path of interest rate is observed by the estimate of the lag of interest rate. The rate of the parameter ($theta\_i$ = 0.2206) is more than it's prior (0.220). Furthermore, the persistency result of the estimated standard deviation showed that the most volatile shock is the anticipated monetary shock (2.5866) and the least volatile is the inflationary shock (0.4494).

The prior and the posterior distribution which captures the probability of the estimated parameters are also generated. Results showed that the prior (grey) and posterior (black) are fairly close as shown in Figure 4. Also, it does not deviate substantially from normality. This implies the data is informative and fits the Chinese economy.

Figure 4: Priors and Posterior Shapes for China



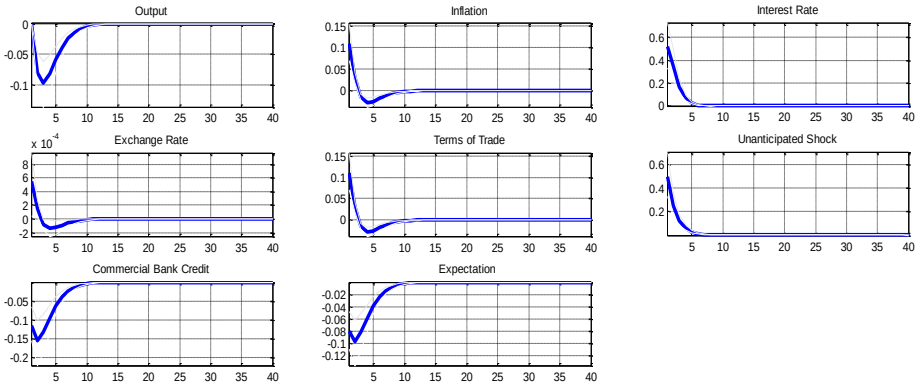
Authors' Computation (2023)

The diagnostic test, Monte Carlo Markov Chain (MCMC) was generated for China. The results, through the diagram generated, confirmed the stability and convergence of all the parameters' moments.

Bayesian Impulse Response Analysis

In this section, responses of macroeconomic variables to individual shocks are generated and presented using a graphical illustration. This is presented in Figures 5.1-5.4.

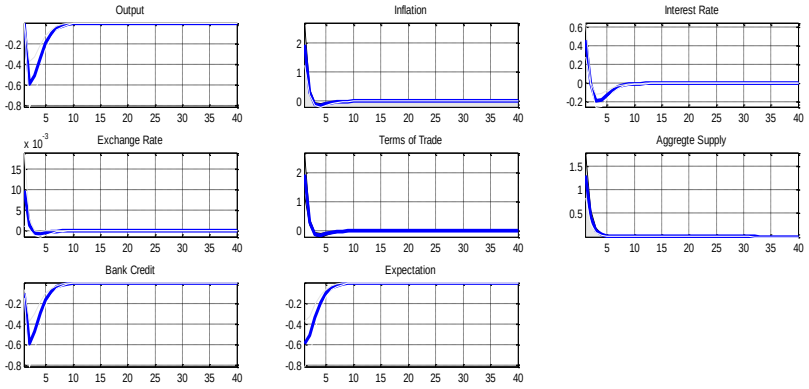
Figure 5.1: 1% Response to Unanticipated Monetary Shock



Source: Authors'Computation (2024)

The response of variables to unanticipated monetary policy is mixed. While interest rate and nominal exchange rate reacted positively, credit to the private sector and expectation responded negatively. The results also confirmed the procyclicality of monetary policy and the effectiveness of monetary policy in achieving the objectives. These objectives are with nominal trade-offs in terms of output decline and exchange rate appreciation. Variables converge to their steady state in the long run.

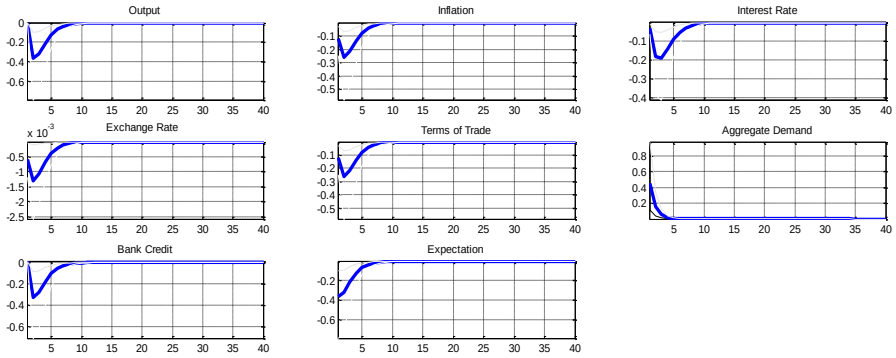
Figure 5.2: 1% Response to Aggregate Supply Shock



Source: Authors'Computation (2024)

Macroeconomic variable responses to supply shocks are also mixed for China. The results are similar to the Brazilian case. While credit and expectation exhibit negative responses, interest rates, and exchange rates responded positively in the short run and then became insignificant. Variables return to their steady state after responding to the shock in the long run.

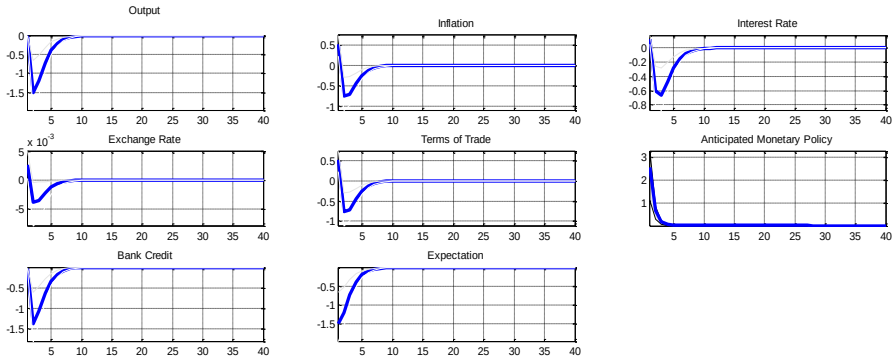
Figure 5.3: 1% Response to Aggregate Demand Shock



Source: Authors'Computation (2024)

The effect of aggregate demand shock on macroeconomic variables is negative. This implies macroeconomic variables fell significantly as they were affected by the shock both in the long run and short run periods. Also, all variables return to their steady state in the long run.

Figure 5.4: 1% Response to Anticipated Monetary Shock



Source: Authors'Computation (2024)

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The posterior density is obtained from the combination of suitable priors and the likelihood using the Bayesian technique. The process generated a random walk MH algorithm using 10,000 draws and 94 of the 112 data points. This spanned between 1990Q4 and 2013Q4. The Log data density generated is -215.036470. results are shown in Table 6. The selected prior means, the generated posterior mean, the standard error of shocks, and the confidence interval are also presented in Table 6.

Table 6: Priors and Posterior of the Estimated Parameters

Parameter	Density	Prior Mean	Posterior Mean	Standard Deviation	Confidence Interval at 90%
α_3	beta	0.300	0.3022	0.050	0.2937 0.3105
α_4	beta	0.670	0.6702	0.050	0.6616 0.6782
α_5	beta	0.320	0.3203	0.050	0.3118 0.3286
α_7	beta	0.200	0.1952	0.049	0.1873 0.2026
α_8	beta	0.300	0.3003	0.050	0.2925 0.3078
β_1	beta	0.990	0.9877	0.051	0.9788 0.9971
β_2	beta	0.125	0.1260	0.050	0.1174 0.1349
β_4	beta	0.300	0.2993	0.050	0.2916 0.3077

β_5	beta	0.250	0.2497	0.050	0.2415	0.2584
β_7	beta	0.260	0.2600	0.050	0.2524	0.2679
β_8	beta	0.310	0.3113	0.050	0.3033	0.3201
φ_1	gamma	0.220	0.2297	0.050	0.2215	0.2382
φ_2	gamma	0.240	0.2439	0.051	0.2358	0.2521
φ_3	gamma	0.300	0.3112	0.050	0.3026	0.3205
eps_v	invg	0.063	0.3438	0.267	0.2983	0.3854
eps_k	invg	0.035	0.4173	0.301	0.3662	0.4684
eps_x	invg	0.488	0.5907	0.426	0.5182	0.6645
eps_u	invg	0.060	0.0382	0.098	0.0137	0.0648
eps_a	invg	0.500	0.2039	0.455	0.1105	0.2903

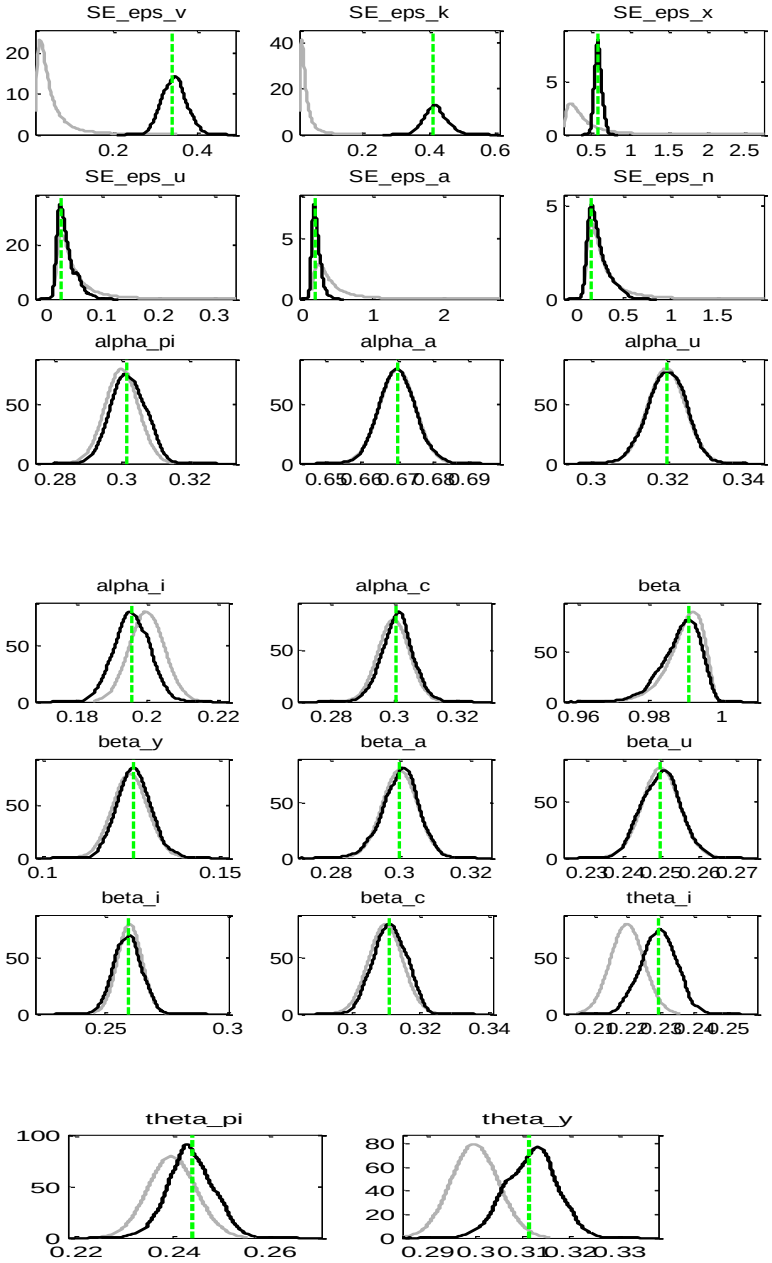
Like other models of the Brazilian and Chinese economies, output gap estimates showed that the results are data-driven. This implies it is informative as the generated posterior means are different from the selected priors. Estimate of inflation expectation parameter ($\alpha_3 = 0.3020$) is more than its prior (0.300). Also, the estimates of anticipated monetary ($\alpha_4 = 0.6702$) and unanticipated monetary policy ($\alpha_5 = 0.3203$) are more than their priors (0.6700 and 0.3200). Lastly, on the output gap, the estimated posterior of measures of commercial bank credit impact (α_8 = 0.3003) is greater than its prior (0.3000). This shows that important information is drawn from the data. The result is supported by the work of Adebiyi and Mordi (2010) and Mordi et. al.(2013)

The New Keynesian Phillip curve explains the inflationary behavior of the Nigerian economy. The performance of the economy depends onβ_2, β_4, β_5, and β_7 which are output gap, anticipated monetary policy, unanticipated monetary policy, and interest rate impact. β_4 (0.2993) and β_5(0.2497) show that the firms re-optimize their prices every second quarter and that prices contract around quarter two on average. These findings agreed with the work of Adebiyi and Mordi (2010), Mordi *et al.* (2013), and Garcia (2010). For the effectiveness of monetary policy in controlling inflation, it is expected that the coefficient of the output gap (β_2 = 0.1260) and exchange rate (β_6= 0.15) must be greater than zero. Going by the result, the conditions are satisfied. This implies monetary policy is active in controlling inflation in Nigeria through output and exchange rate.

The monetary policy design in Nigeria is captured by the estimates of reaction policy function. Using Taylor rule as the benchmark, the design in Nigeria follows an active policy (φ_1 = 0.2297) and showed that output gap concern (φ_3= 0.3112). This implies the implementation of monetary policy follows the Taylor rule and that price stability and output growth are the objectives of the central bank in the short and long-run periods. The smoothing path of interest rate is confirmed through the estimates of the lag of interest rate (φ_1 = 0.2297). The estimate is more than its prior (0.2200). The value is less than that of Adebiyi and Mordi (2010) and Mordi *et al*. (2013) (0.623 and 0.43). It also showed that monetary policy is effective in Nigeria. The persistency in the estimates of standard deviation showed that output gap shock (0.5907) is the most volatile while credit to the private sector (0.035) is the least volatile.

The graphical illustration of the prior (grey) and posterior (black) distributions is presented in Figure 6. From the diagram, the optimization mode is generally similar to the posterior mode with few exceptions. This confirmed the normality of the distribution and implies that the model is a replica of the Nigerian economy.

Figure 6: Prior and Posterior Distribution for Nigeria



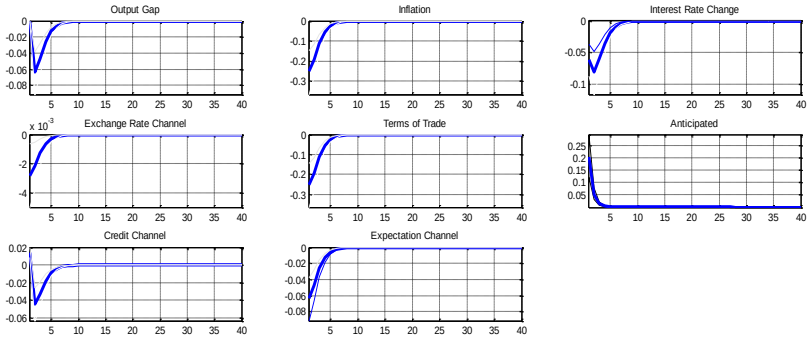
Source: Authors' Computation (2023)

To check the diagnostic test of the estimated parameters, Monte Carlo Markov Chain (MCMC) was conducted and the results confirmed the stability and convergence properties of the model.

Bayesian Impulse Response Analysis

The propagation of the shocks to the economy is examined. Results are presented in graphs from Figure 7.1 to 7.4.

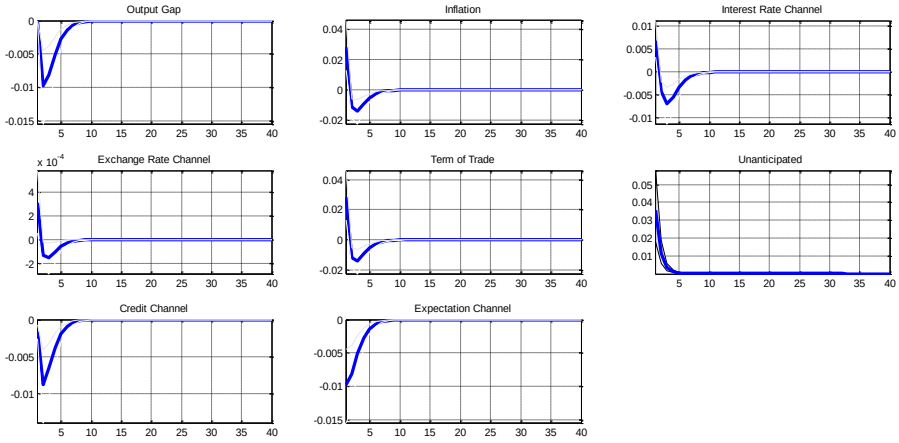
Figure 7.1: Response to 1% Anticipated Monetary Policy Shock



Source: Authors'Computation (2024)

The response of all variables to anticipated monetary policy shock is an inverse relationship. This implies as the shock increases, the performance of the variables dwindles throughout the period. This confirmed the rational expectation theory of the anticipated policy not achieving the stated objectives because the policies are already expected. Variables converge to their equilibrium in the long run.

Figure 7.2: Response to 1% Unanticipated Monetary Policy Shock

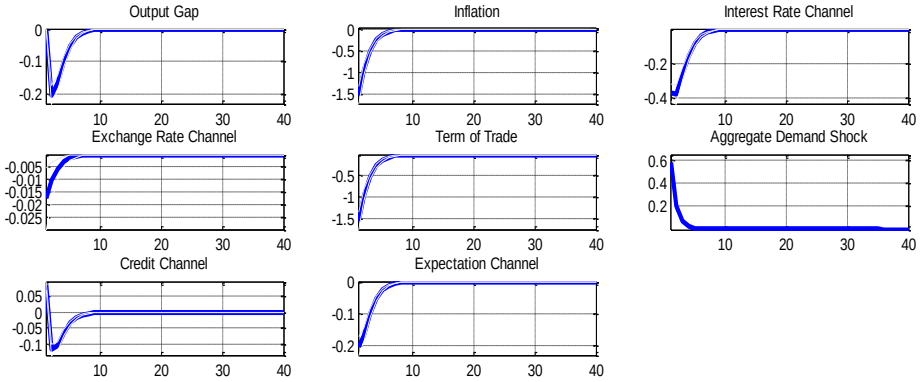


Source: Authors'Computation (2024)

The responses of variables to unanticipated monetary policy are mixed. While interest rates responded positively to unanticipated shocks, others responded negatively. The responses to this shock showed the pro-cyclical nature of monetary policy in Nigeria and that the policy is effective in achieving the stated objectives. However, there are cases of trade-offs between

output and exchange rate. The stability of the model is confirmed by the convergence of the variables to a steady state in the long run.

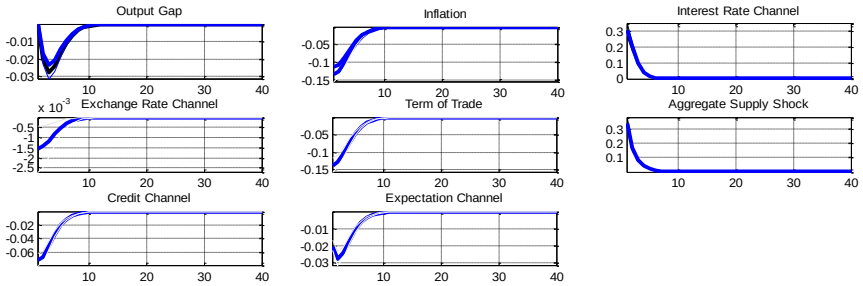
Figure 7.3: Response to 1% Aggregate Demand Shock



Source: Authors'Computation (2024)

In the same vein, variables' responses to aggregate demand shock are the same. Aggregate demand shock reduced the performance of all the variables throughout the periods except the exchange rate whose response fizzled out in the long run. The convergence of the variables to the steady state in the long run exists.

Figure 7.4: Response to 1% Aggregate Supply Shock



Source: Authors Computation (2024)

The responses of variables to aggregate supply shock are nixed. This is evident as the credit to the private sector and expectations responded negatively. Interest rate and exchange rate responses are alternating in the long run and short run respectively. This is an indication of the short-term effects of aggregate supply shocks. Variables return to equilibrium in the long run.

4.4 Robustness Check

The essence of a robustness check is to examine the sensibility of the result in the face of additional evidence. This was done in two ways. The study introduced other samples apart from the baseline sample, in this case, the study chose another sample between 2004Q4 and 2013Q4. In addition, some of the observable variables were replaced. For instance, the interest rate was

replaced with treasury bills and official exchange rate for the real effective exchange rate. After all these manipulations, the results did not change significantly.[1]

5. CONCLUSIONS AND RECOMMENDATIONS

Examining the role of monetary policy in influencing business cycles in Nigeria, Brazil, and China by estimating a sticky-price Dynamic Stochastic General Equilibrium (DSGE) model is the focus of this study. The study investigates the impact of unanticipated and anticipated monetary policy on the business cycle, as monetary policy action can either be anticipated or unanticipated using quarterly data between 1986Q1 and 2022Q4. This exercise is important in defining the importance of monetary policy as a determinant of the business cycle in the economies under investigation. In addition, the study explored the consistency of the monetary policy implemented through the models, in explaining the basic characteristics of the economies towards achieving output and price stability. Results show that both anticipated and unanticipated monetary policies have an impact on macroeconomic variables' volatility; suggesting that expectations play an active role in the fluctuation of macroeconomic variables. Throughout the analysis, the model demonstrated that data are informative and that the implementation of the monetary policy follows the Taylor rule. Also, useful information is produced by data in the explanation of output and prices in the selected countries. The study concluded that monetary policy plays an active role in influencing business cycles in the selected countries. The study therefore, recommended that the implementation of monetary policy by the central banks of the selected countries should be unanticipated as it is the unanticipated that will reduce the fluctuations in the performance of macroeconomic variables. Also, the central banks of the selected countries should continue the use of an inflation-targeting framework that follows the Taylor-rule type of monetary policy where the interest rate is the policy instrument against the traditional monetary aggregate.

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[1] The results of the robustness check are available from us upon request.

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