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BANK OF GHANA'S FORECASTING AND POLICY ANALYSIS SYSTEM

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Preface[1]

In 2002, the Monetary Policy Committee (MPC) process got underway with a need to incorporate forecasting into the work of the Committee to inform future evolution of macroeconomic outcomes and guide the decision-making process under the forward-looking inflation targeting-lite regime. Starting with a simple Auto-Regressive (AR) model and Vector Error Correction Models (VECM), the forecasting process evolved, under the supervision of Maxwell Opoku-Afari (currently the First Deputy Governor), to a small policy-focused structural Econometric Model (E-MOD) in 2005. Subsequently, the E-MOD became the focal model, which provided a basis for policy discussions at the MPC meetings during the early stages of the inflation targeting (IT) regime.

In 2007, the Bank formally adopted the IT regime and continued to use the E-MOD for policy guidance. After several years of implementation, however, the Bank sought to strengthen the IT framework through capacity building in macroeconomic modelling to help sustain the process. This culminated in intensive training programmes in structural modelling for a select team of Bank staff at the International Monetary Fund (IMF) to enhance the inflation forecasting tools of the Bank, and sharpen the narrative on forecasts. The Bank of Ghana team, in a 6-week period, worked closely with the IMF Research Modelling team to develop the Bank's Quarterly Projection Model (QPM) within the Forecasting and Policy Analysis System (FPAS) – an integrated set of processes and tools used to prepare coherent macroeconomic forecasts to guide the work of the MPC. The key objective of the FPAS is to organize available economic information in a systemic manner to help interpret current economic conditions and draw inference for future economic developments and policy.

The QPM is a macroeconomic model used to assess economic conditions over the forecast horizon to determine the appropriate monetary policy stance consistent with the Bank's mandate of price stability, as well as evaluate the effect of changes in economic factors and policies on the economy. Tailored to fit Ghana's economy, the model provides a balance between data and economic theory by capturing relationships among key economic variables.

This report documents the Bank of Ghana's FPAS, centred on a structural macroeconomic model that captures key characteristics of the Ghanaian economy. The document is organized as follows: Chapter 1 provides the historical narrative of monetary policy formulation in Ghana. Chapter 2 describes the FPAS, that is, the practical institutional arrangements of the current IT monetary policy framework, followed by Chapter 3, which highlights the Bank's core Quarterly Projection Model (QPM), which is a semi-structural macroeconomic model balanced with the desired empirical properties of New Keynesian approach. Chapter 4 provides detailed description of the

[1] While the initial establishment of FPAS elements and the semi-structural quarterly projection model (QPM) described in the present paper were developed with IMF-based assistance, under the current TA project (commencing in 2019 and led by the IMF Institute for Capacity Development) the FPAS processes were reviewed and the QPM was extended. The enriched QPM is currently used for real-time policy analysis at the Bank of Ghana and will be documented in a future research paper.

properties of the original version of the Bank's core model (the version currently used in practice will be documented and published in a subsequent document), with graphical simulations to demonstrate how the key macroeconomic variables respond to specific shocks to ascertain the model's suitability for monetary policy analysis. In the next Chapter, we review extensions to the QPM, currently used for real-time policy analysis. The last chapter provides the summary and conclusion.

Non-Technical Summary

Over the past six decades, Bank of Ghana's monetary policy framework has gone through three main phases – from direct controls to monetary targeting, and currently, inflation targeting. The direct controls era, which was in place prior to 1992, involved the application of non-market instruments, such as interest rate controls, credit ceilings and directed lending (or sector lending). The primary objective for using this framework was to direct credit to priority sectors of the economy, mainly agriculture, manufacturing, mining, and export finance, in line with the country's development strategy at the time. While the system of direct controls facilitated credit flow to meet specific objectives in a largely rudimentary and non-competitive financial system, the implementation process instigated rent-seeking behaviours and led to inefficient resource allocation. This subsequently imposed significant costs on the financial system and weakened the country's macroeconomic fundamentals, with spells of high and volatile inflation, as well as low growth.

In response to the macroeconomic imbalances, Ghana embarked on an Economic Recovery Programme (ERP) in April 1983. The ERP package introduced several economic and financial liberalisation policies, alongside institutional structural reforms to regain macroeconomic stability. Implementation of the liberalised policies brought about a paradigm shift from direct interventions and controls toward market-based instruments for implementing monetary policy. Accordingly, the Bank adopted monetary targeting as the framework in 1992, with market-based instruments to formulate monetary policies. The new regime assumed that inflation was predominantly a monetary phenomenon. This assumption was premised on the existence of a stable relationship between money supply and inflation, and the absolute control of money supply.

The monetary targeting framework relied heavily on the quantity theory of money and presupposed that money was the only channel through which monetary policy actions could affect the real economy. The Bank's experiences showed that the use of such a single indicator in the decision-making process led to sub-optimal monetary policy decisions, because the on-going reforms in the financial sector had instigated an unstable money-inflation relationship – a key tenet of the monetary targeting framework. In the late 1990s and early 2000s, evidence of divergence between money supply and inflation emerged – like other economies in both advanced and developing world – confirming the fact that monetary targeting had become less effective. In addition, the Bank's monetary accommodation during the period had built strong inflation inertia and inflation expectations within the economy, which necessitated further reforms in monetary policy formulation post-2000.

The first step in the reform process was to strengthen the Bank's policy framework and re-anchor inflation expectations. In this regard, the Bank of Ghana Act, 2002 (Act 612), as amended, was enacted. The Act reset the Bank's primary mandate to price stability, granted the Bank operational independence in the choice of instruments to formulate monetary policy, and established the

Monetary Policy Committee (MPC) charged with the responsibility to formulate monetary policy. With the passage of Act 612 and the subsequent inauguration of the MPC in November 2002, the Bank developed the institutional structures that ultimately led to adoption of the Inflation Targeting (IT) framework in May 2007. Under the IT regime, monetary policy is designed to influence the inflation forecast, replacing money supply as the intermediate target, to keep inflation within the medium-term path consistent with the adopted definition of price stability.

As an IT central bank, the Bank, in collaboration with the Ministry of Finance, set the medium-term inflation target at 8 percent with a symmetrical tolerance band of 2 percent. The choice of a tolerance band around the inflation target was to accommodate unanticipated shocks, which could cause transitory price pressures and dislodge inflation expectations. The Bank also settled on a four-quarter horizon to achieve the medium-term target, typically at the end of the financial year. Broadly, the IT framework entails the assessment of a wide array of indicators and subsequent adjustment of the key policy tool – the Monetary Policy Rate (MPR) – to signal the monetary policy stance consistent with delivering price stability.

As stated in the Act, monetary policy formulation at Bank was vested in the MPC, which is a seven (7)-member body, and chaired by the Governor. At the bi-monthly meetings, the MPC deliberates on a comprehensive macroeconomic and financial sector datasets and rigorous analyses to decide on the monetary policy stance deemed appropriate to deliver price stability. In addition, inflation forecasts are conducted alongside scenarios of upside and downside risk factors to provide the basis for forward-looking monetary policy formulation.

The Bank's core macroeconomic model used for the inflation forecasting process is a version of the Semi-Structural New Keynesian (SSNK) model. It is also referred to as the 'Gap' model or the Quarterly Projection Model (QPM) and widely used as an effective tool for forecasting and policy analysis in many IT central banks. The core model comprises four blocks – the aggregate demand block, a Phillips curve, an exchange rate block, and a monetary policy reaction function. Together, these blocks characterize the dynamic interactions or behaviours of four key macroeconomic variables, namely output, inflation, exchange rate, and short-term nominal interest rate. The external sector is exogenous to the core model and, hence, foreign variables are taken as given.

The Ghana QPM, like most central bank models, approximates two main monetary policy transmission channels; the interest rate channel and the exchange rate channel with expectations playing a major role[2]. The interest rate channel works through the financial intermediaries, through aggregate demand to prices, while the exchange rate channel works through net exports, through aggregate demand and then to prices. After several years of using the QPM for forecasting inflation, the Bank saw the need to re-calibrate and extend the model. This was done through the

[2] On some occasions, the expectations channel is considered separately.

disaggregation of the Phillips curve (headline inflation) into food and non-food inflation equations to improve policy analysis and communication.

Chapter 1: Background

Monetary policy formulation is designed to use various policy instruments at the disposal of the central bank to deliver specific objectives such as price stability, economic growth, and employment. Traditionally, central banks focus on price stability because high inflation undermines the role of money as a store of value and impedes investment and growth. The literature on monetary policy frameworks have evolved over the years to ensure low and stable inflation, a necessary condition for sustainable growth.

Over the past sixty years, Bank of Ghana's monetary policy frameworks have transitioned through the direct controls regime, to monetary targeting regime and, presently to inflation targeting framework.

1.1 Evolution of Monetary Policy Formulation in Ghana

1.1.1 The Direct Control Phase

Prior to 1992, the Bank of Ghana's monetary policy framework focused on direct controls, which involved non-market instruments to control inflation and promote growth. The policy tools included interest rate controls, credit ceilings, and directed lending (or sector lending). These tools sought to redirect credit from the non-productive sectors to productive sectors of the economy, mainly agriculture, manufacturing, mining and exports. In addition, other tools, such as reserve requirements, were imposed on commercial banks to dampen the potential inflationary effects of excess reserves in the banking system arising from excessive monetary accommodation.

As a policy strategy, the direct control system assumed some level of money supply growth needed to impact inflation and economic growth. The predetermined money supply then provided an aggregate target for domestic credit for commercial banks, which was capped to guarantee fair distribution of credit across the various sectors. To ensure compliance, BOG tightly monitored banks' credit extension within the allowable ceilings, with severe penalties levied on non-complying banks.

While the system of direct controls channelled credit towards specific objectives in a largely rudimentary and non-competitive financial system, its implementation led to resource misallocation, which imposed significant costs on the financial system, coupled with sharp growth in money supply and inflation. The economy came under severe stress from both external and domestic shocks and coupled with the sub-optimal monetary policies, resulted in macroeconomic imbalances, volatile and high inflation amid low growth. To address these, Ghana embarked on an Economic Recovery Programme (ERP) in April 1983. Under the programme, the Government implemented far-reaching economic and financial liberalization policies, as well as structural reforms. These policies set in motion the gradual de-regulation of the economy, alongside the introduction of market-based instruments for monetary policy formulation.

1.1.2 Monetary Targeting Era

The financial sector reforms under the ERP replaced the direct control measures with market-based (indirect) instruments. Almost a decade after implementation of the ERP, BOG adopted monetary targeting as a policy framework in 1992. The assumption underpinning the new framework was that excess money in the economy instigated inflation. Therefore, under this framework, money supply became the nominal anchor for monetary policy[3] and policy formulation was premised on the strong assumption of the existence of a stable relationship between money supply and inflation, and that the central bank has full control of money supply. This therefore entails the determination of targets for key monetary aggregates and the selection of policy instruments to deploy.

The monetary targeting framework was based on an IMF monetary programming model[4], which assumed reserve money as the 'operating target variable', monetary aggregates as the 'intermediate target variable' and inflation or growth as the 'ultimate policy target'. The mechanics of the targeting process was based on the strong view that inflation was predominantly a monetary phenomenon. Thus, the ability to restrain the operating target is expected to constrain the intermediate target and impact the ultimate policy in the needed direction. The BOG used instruments such as the bank rate, reserve requirements, open market operations and moral suasion under the monetary targeting regime of monetary policy formulation. For monetary management purposes, the Bank used open market tools as well as repurchase agreements (repo) and reverse repos.

Technically, the monetary targeting process involved four main steps:

Step 1: Determination of the money supply target

This was done using the quantity theory of money relation:

$$M2 * V = P * Y \tag{1.1}$$

Where, $M2$ is the intermediate target variable, V is the velocity of circulation of money, P is the general price level and Y is the gross output of the economy.

Step 2: Determination of the Reserve Money (RM) target

The main identity used here is the relationship between reserve money and money supply via the money multiplier:

$$M2 = m * RM \tag{1.2}$$

[3] A nominal anchor for monetary policy is a single variable or device which the central bank uses to pin down expectations of private agents about the nominal price level or its path, or about what the central bank might do with respect to achieving that path.

[4] A more complete discussion of this model and the IMF financial programming methodology is provided in Khan et al. (1990)

Where, m is the money multiplier and RM represents the operating target, reserve money. With an estimate of M2 from (1) and an estimate of m, the RM target is determined.

Step 3: Targeting RM Operating Framework: Bank of Ghana's Balance Sheet

$$NDA_{BOG} + NFA_{BOG} = RM \tag{1.3}$$

The Net Foreign Assets (NFA) target of the Bank of Ghana is defined by the overall balance of payments position, while the Net Domestic Assets (NDA) are managed to achieve the operating target, RM.

Step 4: Managing the NDA

Open Market Operations (OMO) is the main tool in regulating NDA of the banking system. Therefore, BOG released or redeemed money market instruments as and when to control the money stock.

Broadly, the pace of growth in monetary aggregates slowed and inflation outcomes were better under the regime of market-based monetary management than under the controlled regime. Though operationally, the monetary targeting framework was better able to monitor and target the intermediate variables, a key criticism of the framework was that it lacked the sophistication that allowed policy makers to determine the dynamics involved in the interaction of variables. Agenor and Montiel[5] (1996) argued that the IMF financial programming model is a short-run model for adjustment and stabilization and did not represent a comprehensive macro-econometric model that could analyse the dynamics of an economy and assess the impact of policy changes.

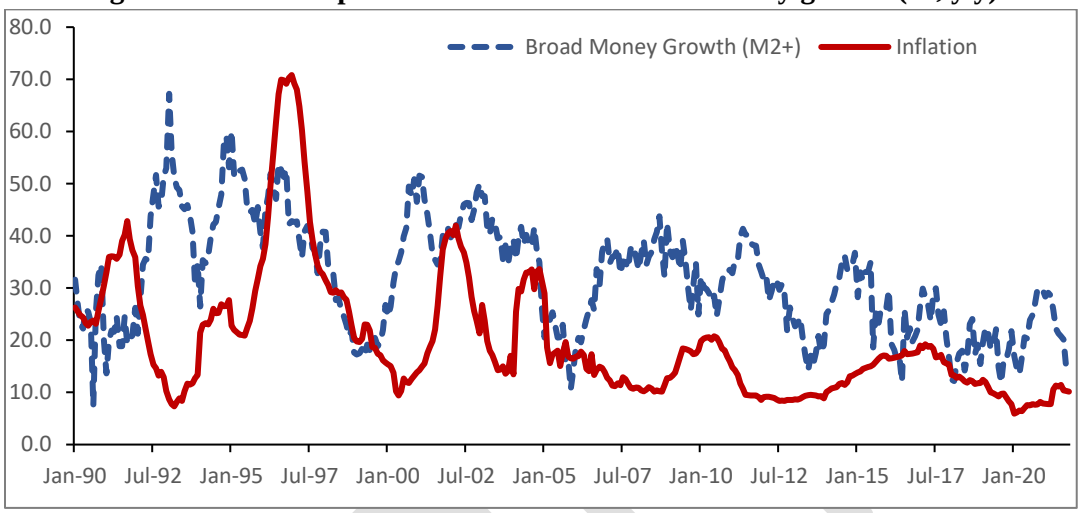
The monetary targeting framework, which relied heavily on the quantity theory of money also presupposed the existence of only one channel – monetary aggregates – through which monetary policy actions impacted inflation. The use of such a single indicator in the decision-making process led to sub-optimal monetary policy decisions. Other arguments on why monetary targeting lost its efficacy bothered on the parametric shift in the money-inflation relation[6] and loss of information content in monetary aggregates due to the reforms and development of the financial sector. As seen in Figure 1, high money supply growth coincided with low inflation and vice-versa for most parts of the 1990's. However, the trend changed in the 2000s, represented by a weak link between money supply and inflation, which also indicated an unstable velocity of money (V) and money multiplier (m). This presupposed some loss of information content from money growth. Under such circumstances, the nominal anchor became ineffective and money supply no longer held sufficient information for price developments. In practical terms, evidence of the divergence

[5]

[6] By the late 1980s, evidence of weak relationship between money and inflation in the short run had been established across several countries. Thus, central bank policy makers began to look for a new framework to help contain inflation, which had surged up on the back of the oil price shocks of the late 1970s and early 1980s, accompanied by weak growth, in what has become known as 'stagflation'. As captured in the words of the former Governor of the Bank of Canada, Bouey, "we did not abandon M1, M1 abandoned us".

between money supply and inflation emerged, weakening the monetary policy transmission mechanism, and confirming the fact that monetary targeting had become less useful in controlling inflation (see Figure 1). These developments brought to the fore the need to adjust the monetary policy formulating process for the second time in a decade.

Figure 1: Historical profile of inflation and broad money growth (%, y/y)



Note: *M2+ refers to broad money supply, including foreign currency deposits*
Source: Bank of Ghana

1.1.3 Transition to Inflation Targeting

Country experiences have shown that successful implementation of the IT framework was predicated on a strong degree of central bank independence and absence of fiscal dominance. However, the desire to review the monetary policy strategy coincided with a severe economic crisis in Ghana, on the back of weak economic policies, including fiscal dominance, where persistent fiscal deficits were mainly financed by monetary accommodation. The economy was characterised by high and volatile inflation, sharp exchange rate depreciation, and low growth. Thus, for BOG, the urgent need to break the inflation inertia became the prime focus for monetary policy in the post-2000 era. In this regard, the Government enacted a new Bank of Ghana law, which refocused the objective of BOG to price stability.

The enactment of the Bank of Ghana Act, 2002 (Act 612), as amended by Act 918 in 2016, unambiguously set price stability as the core mandate of the Bank. The Act also granted the Bank operational independence to deploy the appropriate tools to contain inflation. Section 3 (1) of the Act states inter alia that: *"The primary objective of the Bank is to maintain stability in the general level of prices".* Without prejudice to the objective of price stability, section 3(2) of the Act also enjoined the Bank to promote economic growth and ensure financial stability, independent of instructions from the Government or any other authority.

The Act therefore enhanced the degree of independence of the Bank in the conduct of monetary policy and established a Monetary Policy Committee (MPC). The Committee was inaugurated on 9th September, 2002 and tasked with the responsibilities to formulate monetary policies of the Bank and provide statistical data and advice necessary for the formulation of monetary policy. Without the supportive structures, the MPC adopted a framework labelled Inflation Targeting Lite regime (IT-Lite), which mimicked the IT framework where the economy was reviewed, and the interest rate positioned to influence inflation towards the yearly targets. While operating under the IT-Lite regime, BOG took adequate steps to build the necessary institutional frameworks, structures, and processes required to transition to a full-fledged IT central bank.

1.1.3.1 Preconditions

With the operational independence guaranteed under the Bank's Act, BOG needed to introduce a transparent monetary policy regime with a clear anchor to stabilize and shape inflation expectations. The transition process was marked by new structures, procedures, and processes, which culminated in the Forecasting and Policy Analysis System (FPAS) that would support the formal adoption of the Inflation Targeting Framework. The FPAS required the Bank to address issues such as,

- Which price level to target?
- What information set to use as a basis for monetary policy formulation?
- What statistical data and analysis will be required to enhance understanding of the inflation process?
- Which econometric requirements will provide a clear analysis of the transmission mechanisms prevailing in the economy?
- What time horizon to adopt during which an inflation objective will be met given the lags in the impact of monetary policy actions.

1.1.3.2 Selection of the Price Index

The Bank focused on headline inflation as the target of its policy, given the several advantages to adopting a consumer price index (CPI) target as opposed to some other price indices. The CPI is usually produced and announced by the statistical agency on a timely basis, is generally not revised (except due to potential seasonal adjustment reasons), and is usually transparent, easily available, and understood by the public. This was not an easy decision to settle on, since the central bank was faced with the trade-off between credibility and communication effectiveness and usefulness of the stable inflation measure. A quick review of the literature show that most converging economies use unadjusted consumer prices and, indeed, the choice of target price index in IT countries has mainly favoured the headline CPI (see Tables 1-3).

Based on further technical work done during the transition period, another important study was conducted to evaluate the various measures of core inflation in Ghana, which would reflect underlying inflationary pressures in the economy. The study employed both statistical and

econometric methodologies to assess the robustness of the various core measures of inflation. The statistical approach had, as its basis, the argument that a good measure of core inflation should track trend inflation in two respects. Thus, over a reasonable period, the average rate of core inflation should match the average rate of inflation, with minimal deviations; and that a core measure must move closely with the trend inflation, which requires that the standard deviation of these two variables must be low. The econometric analysis was done at three levels and included testing for the degree of unbiasedness between the headline and the core measures of inflation, testing for the direction of causality between all the core measures of inflation and the headline inflation to establish a unidirectional causality, and testing for the level of cointegration between the core and headline inflation. The results from the statistical and econometric analyses were conclusive and supported the core measure of inflation that excludes energy and utilities from the consumer basket. The Bank therefore adopted the core inflation, defined to exclude energy and utilities prices, as the main measure that would be a useful guide for monetary policy. Other core measures of inflation are also analysed as part of the general inflation analysis.

1.1.3.3 Information Set for Policy Formulation

The Bank assembled a large array of detailed data on the economy in all the major macroeconomic sectors, including the budget, monetary and financial, inflation, external sector, as well as the real sector. The lack of data on the real sector was a concern to the MPC in the absence of quarterly GDP series and delays in the annual GDP releases during the early 2000s. The Bank therefore designed methods to gain insights into real sector performance in a timely manner before the release of formal GDP numbers. This started with the survey of business confidence and involved the administration of a questionnaire to a cross-section of businesses on conditions and expectations regarding employment, output, sales, costs, exchange rates and the general economic conditions. Next, the consumer confidence survey attempts to gauge consumer confidence on economic performance and expectations on prices. Confidence indices are constructed out of these surveys to gauge sentiments on real sector performance. The final method is the computation of a Composite Index of Economic Activity (CIEA)[7].

Another critical element in the analysis leading to the MPC's decision-making is a review of the inflationary developments. The inflation analysis often captures current inflation trends and the main driving factors. A forward-looking view of inflation is also considered through forecasts. The forecasts are generated through a suite of models, including a semi-structural forward looking rational expectations macroeconomic model for key relations and variables, short-term models such as the Auto Regressive (AR) process and calibration of the CPI path, and the Error Correction forecasting framework. The forecasts and a derived central path from these models are incorporated in a Fan Chart analysis and presented as part of the information content available to

7 The CIEA captures high frequency economic indicators such as industrial electricity consumption, exports, imports, sales of selected manufacturing companies, passenger arrivals at the airport, construction, private sector credit, and domestic VAT collections.

the MPC to inform its judgment. In all cases, expert judgement on factors affecting relevant economic variables plays a critical role in the monetary policy decision.

1.1.3.4 Framework, Operations and Accountability, and Communication Issues

According to Mishkin (2000), IT is a "monetary policy strategy that encompasses five main elements", namely,

- The public announcement of a medium-term numerical target for inflation.
- Institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated.
- Information inclusive strategy in which most variables, and not just monetary aggregates, are analysed prior to the policy decision.
- Increased transparency of the monetary policy strategy through communication; and
- Increased accountability of the central bank towards the attainment of the inflation target.

The Bank settled on 18-24 month horizon for its forecasts. Tables 1-3 below compares Ghana with other inflation targeting countries in terms of the framework, operational, and accountability and transparency issues. The survey showed that Ghana's institutional structures, in terms of framework, operations and transparency, were close to what pertained elsewhere. It is important to also note that some slight differences were observed across countries as regards certain components, which somehow present challenges on the BOG to continue fine-tuning its framework to suit the country's specific circumstances.

1.1.3.5 Addressing Fiscal Dominance

The success of the IT regime, as extensively discussed in the literature, depended on the fulfilment of certain preconditions, including central bank independence and the absence of fiscal dominance. In 2002, the BOG Act guaranteed the independence of the central bank and made provision to 'tie the hands of the government'. Section 30 of the Act defined the framework for granting temporary advances to government. Subsection 1 of Section 30 states that the Bank may make advances and loans to the Government on overdraft or in any other form that the Board may determine; or make direct purchase from the Government of treasury bills or securities representing obligations of the Government.

Sub-section 2 further limits the total of the loans, advances, purchase of treasury bills and securities together with money borrowed by the Government from other banking institutions and the public at the close of a financial year not to exceed 10 percent of the total revenue of the fiscal year in which the advances were made. For certainty on the extent of government borrowing from the central bank, this was amended under Act 918 to 5 percent of the total revenue of the previous fiscal year. The Act also provides that any advance made shall be repaid within three months after the grant of the advance, and where that advance remains unpaid after the due date, the power of the Bank to make further advances in a subsequent financial year shall not be exercised unless the amounts due in respect of outstanding advances have been repaid. Where repayment of the

advances and overdrafts is unduly delayed, the Bank may transfer the debt to the public through the sale of treasury bills. These measures ensured that the Bank was shielded from direct governmental influence in the conduct of monetary policy. It is widely considered that when central banks are independent of political pressures, they effectively pursue policies that focus on their immediate objectives better.

These financing restraints received a further boost in 2016 when a zero central bank financing Memorandum of Understanding (MOU) was signed between the Bank and the Ministry of Finance. In addition, the Fiscal Responsibility Act, 2018 (Act 982) capped the fiscal deficit to 5 percent of GDP per year[8].

Table 1: Survey of Framework Issues - Ghana Compared to other economies

		Canada	New Zealand	UK	South Africa	Ghana
1	**Instrument Independence**	Yes	Yes	Yes	Yes	**Yes**
2	**Primary Objective**	Price Stability	Price Stability	Price Stability	Price Stability	**Price Stability**
3	**Target Set By:**	Joint: Gov't & Central Bank	Joint: Gov't & Central Bank	Gov't	Gov't	**Joint: Gov't & Central Bank**
4	**Commitment Period and Target Horizon**	Multi-Year Target (18-24 months); **Reviewed Periodically**	Indefinite 18-24 months	Indefinite 2 years	2 years	**No Commitment; 18-24 months**
5	**Price Index**	CPI. Various core measures of inflation estimated and monitored by Central Bank	CPI (excludes interest charges and section prices)	All items retail price index, excl. mortgage int. charges	CPI excluding interest rates on mortgage bonds	**CPI. Movements in 5 Other core measures monitored; CPI excl. energy & utilities settled on as representative core measure**
6	**Point or Range Target**	2% midpoint target with a range of 1-3 percent	2% midpoint target with a range of 1 - 3 percent	Point Target of 2% Deviation in excess of 1% require explanation	Range: 3-6 percent	**8% midpoint target with a symmetric band of 2%**

Source: Bank of Ghana

[8] At the height of the COVID-19 pandemic, the Fiscal Responsibility Act was suspended.

Table 2: Survey of Operational Issues - Ghana Compared to other economies

		Canada	New Zealand	UK	South Africa	Ghana
1	**Operating Target**	Overnight Int. Rate (short-term rate)	Overnight Cash Rate (short-term rate)	Repo Rate (short-term rate)	Repo Rate (short-term rate)	**Prime Rate** (short-term rate)
2	**Inflation Forecasting**	Terms-of-Trade Economic Model, Various Financial and Statistical Indicators	New Zealand Structural Inflation Model (NZSIM); Survey on inflation Expectations	Quarterly Projection Model and Supporting Models, Economic and Financial Market indicators, survey on inflation expectations	Quarterly projection Model and other supporting models	**Quarterly Projection model, VECM, AR Forecasting Model, Inflation expectations, Other Statistical indications**
3	**Size of Committee**	11	7	9	7	**7**

Source: Bank of Ghana

Table 3: Survey of Accountability and Transparency Issues - Ghana Compared to other economies

		Canada	New Zealand	UK	South Africa	Ghana
1	**Main Communication Vehicle**	Press Release and a Monetary Policy Report	Speech by Governor and Inflation Report	Press Release and Inflation Report	Press Conference and Monetary Policy Report	**Press Release through a Press Conference and release of economic reports 2 weeks after the MPC meeting**
2	**Policy Making Body**	Governing Council	Governor	Monetary Policy Committee	Monetary Policy Committee	**Monetary Policy Committee**
3	**Frequency of Meeting**	8 times a year	7 times a year	8 times a year	Bi-monthly	**Bi-monthly**
4	**Decision Process**	Consensus	Consensus	Voting: The Governor can break a tie	Voting: The Governor can break a tie	**Decision making by voting, Governor has no vote; Consensus is achieved**
5	**Publication of Minutes**	No	yes	Yes: After 2 weeks	No	**No**

Source: Bank of Ghana

Chapter 2: The Forecasting and Policy Analysis System (FPAS)

2.1 Overview

The FPAS refers to the systematic organisation of available economic information to interpret current economic conditions and draw inference for future economic developments and policy, which will ultimately support central bank decision-making. The period from 2002 to 2006 served as the preparatory stage for the Bank to institute structures to efficiently organize the monetary policy formulation process. Thereafter, in May 2007, the Bank formally adopted the Inflation Targeting (IT) framework for monetary policy formulation by the MPC. Broadly, the IT framework entails an assessment of a wide array of indicators and adjustment of the key policy tool – the Monetary Policy Rate (MPR) – to signal the monetary policy stance to deliver the price stability objective of monetary policy.

2.2 MPC Membership

As stated under section 27 of the Amended Act, monetary policy formulation in Ghana is vested in the MPC, which is a seven (7) member body comprising:

- The Governor
- The First and Second Deputy Governors
- Head of the Department responsible for economic research of the Bank
- Head of the Department responsible for treasury operations of the Bank, and
- Two other persons with knowledge and experience relevant to the functions of the MPC members who are not employees of the Bank and appointed by the Board[9].

The two (2) external MPC members, as per the BOG Amendment Act 918, can hold office for a period of five years and are eligible for re-appointment for another term only. The appointment of external members seeks to complement the knowledge and expertise of monetary policy formulation within the Bank of Ghana.

2.3 MPC Decision-Making Processes

The Governor of the Bank chairs the bi-monthly MPC meetings, which are held to decide the positioning of the monetary policy rate deemed appropriate to deliver price stability. The meetings are generally conducted over three days[10]. During the MPC meetings, Bank staff provide technical support and present a wide range of macroeconomic and banking sector indicators, as well as the baseline and alternative forecasts to the Committee. The information is extensively discussed by Committee members, who often highlight the upside and downside risks to the inflation and growth outlook. The Committee, after assessing recent economic conditions and taking a forward-looking view of the evolution of key macroeconomic indicators, decides on the position of the

[9] Under Act 2002 (Act 612), the external members were appointed by the Minister of Finance.

[10] Duration of the meetings has varied overtime, ranging between 2-5 days. In emergency situations, the MPC is held within a day – as happened on 7th February, 2014.

policy rate, with each member assigning reasons for the stated or preferred direction of the policy rate. Each interest rate decision provides a signal on the stance of monetary policy. The final decision is taken through a process of consensus building, unlike other IT central banks where the decision is by majority vote. In general, the monetary policy rate is hiked, lowered, or maintained, given the balance of risks to the inflation and growth outlook. Each MPC meeting concludes with a press conference, which highlights deliberations during the meetings and announces the latest positioning of the policy rate. The Bank of Ghana's MPC held its first meeting in November 2002.

As an IT central bank, the Bank of Ghana, in collaboration with the Ministry of Finance, selected a medium-term inflation target of 8 percent with a tolerance band of ±2 percent to allow for flexibility in stabilizing deviations of inflation from the target. The Bank also settled on 18-24 months to achieve the medium-term target, typically at the end of the financial year. The choice of the tolerance band is to signal the unavoidable consequences of unanticipated shocks, which a small-open economy such as Ghana faces in the policy decision making process to anchor inflation expectations.

Broadly, the set of information presented to the MPC includes detailed assessment of the following:

- Global economic outlook and exchange rate developments
- Balance of payments developments
- Real sector developments
- Monetary developments
- Fiscal developments
- Financial stability reports, and
- Inflation analysis and outlook.

These reports equip the MPC members with clear understanding on the state of the economy and its likely trajectory over the medium-term. The analysis seeks to assess aggregate demand and supply conditions, which is the key focus for monetary policy formulation.

2.4 Making FPAS Operational

2.4.1 Pre-MPC Procedures

The MPC uses comprehensive macroeconomic and financial sector datasets during the meetings. To address data gaps, especially in the real sector of the economy, the Bank introduced an economic indicator, the Composite Index of Economic Activity (CIEA) in 2004, to complement the regular business and consumer confidence surveys, as well as the credit conditions surveys in the banking sector. The Bank's CIEA measures real sector activity at monthly frequency, including retail sales of selected enterprises, construction activity (cement production volumes), industrial electricity consumption, air passenger arrivals, domestic VAT, port activity (container traffic), imports, exports, and employment contributions.

In the month preceding each MPC meeting, Bank staff conduct business confidence surveys of about 100 companies from all sectors of the economy across the major regional capitals of the country. This is carried out alongside the consumer confidence surveys. The survey findings are collated and analysed, and the respective indices computed to gauge the level of economic sentiments. Similarly, the credit conditions survey is undertaken across all banks to gauge the credit stance towards households, small and medium, and large enterprises. The survey also covers inflation and lending rate expectations over a six to twelve-month horizon.

Alongside the surveys, staff update the economy-wide datasets from both internal and external sources to support the decision-making process. This covers data on the global economy and currency markets, balance of payments, real sector, government fiscal operations, monetary developments, banking and financial sector, and price developments. In addition, the inflation forecasting team at the Bank prepares initial forecasts based on the data obtained and model several scenarios of possible risk factors and the interest rate path needed to anchor inflation within the medium-term target. These are then followed by rigorous analysis to draw out potential risks to the inflation and growth outlook to guide the MPC's decision-making. Staff-level discussions take place in the week preceding the main MPC meeting to ensure consistency across the presentations on the various sectors of the economy. Following this, key emerging issues are identified and incorporated into the initial conditions of the Bank's Macromodel.

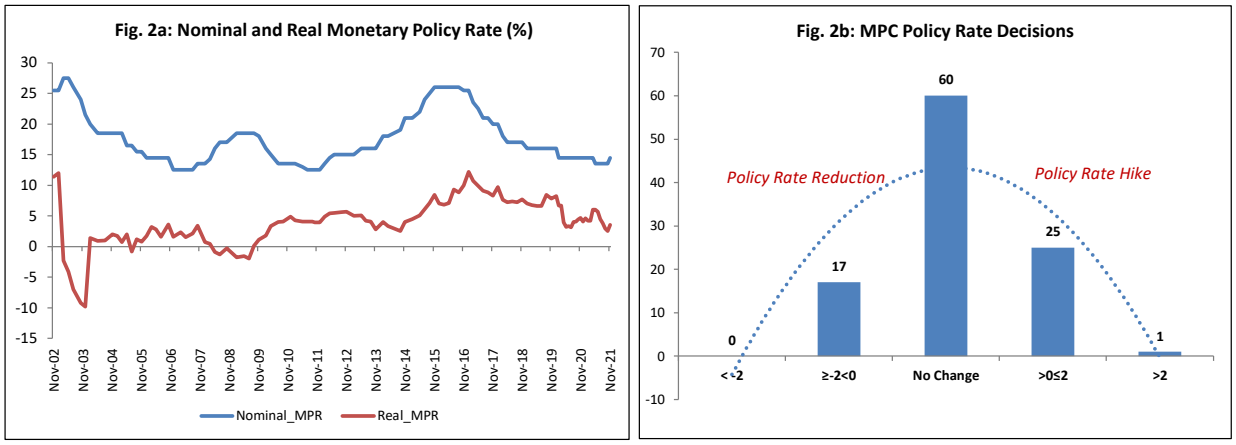
2.4.2 Inflation Forecasting Round

Inflation forecasting has become an integral part of monetary policy formulation since the Bank started implementing the IT Framework. From the use of single equations and an autoregressive framework, the Bank's forecasting process has evolved into more sophisticated models. As a forward-looking approach to monetary policy, inflation targeting requires that the Bank forecast inflation over the policy horizon with reasonable accuracy. To achieve this, inflation forecasts are produced at each MPC round to determine the interest rate path that is consistent with bringing inflation to target in the medium-term. Such inflation forecasts provide useful information for the MPC in setting the appropriate monetary policy stance.

2.4.3 Policy Rate Decisions

Since the adoption of Inflation Targeting, the Bank's MPC has held 103 meetings between November 2002 and November 2021. Analysis of the decisions of the MPC indicates that over more than a decade of inflation targeting practice in Ghana, the MPC maintained the policy rate some 60 times. The rates were hiked 26 times, and on 17 occasions, the policy rate was lowered. To anchor inflation expectations, the MPC was almost equally disposed to hiking or cutting rates depending on the balance of risks between inflation and growth. The nominal Monetary Policy Rate has averaged 17.3 percent, and 4 percent in real terms. These averages provide support to the disinflation process, as well as growth.

Figure 2: Evolution of Monetary Policy Rates (November 2002 – November 2021)



Source: Bank of Ghana

2.4.4 Monetary Policy Transparency and Accountability

Transparency and accountability are key tenets for IT central banks. With increased communication on monetary policy decisions, economic agents are better informed, which helps anchor inflation expectations. The steps taken by the Bank of Ghana to promote transparency and accountability include a press release of key macroeconomic indicators on the last day of MPC meetings and a press conference after each meeting. At the press briefing, the Governor, who is the MPC Chairman, highlights recent macroeconomic developments and macroeconomic outlook that informed the policy decision and explains the latest monetary policy stance. The media engagement offers the Bank of Ghana a broader platform to circulate the policy decisions to all stakeholders and by so doing to anchor inflation expectations.

To further deepen transparency and accountability, the calendar for all six MPC meetings during a calendar year are pre-announced and published at the start of each year. In addition, the transcript of the press conference is published for a wider audience, and MPC infographics, which represents a reader-friendly version of the press release, is circulated on the Bank's various platforms[11]. A summary of economic and financial dataset used during the MPC meetings is also published ahead of the press release to generate discussions on the monetary policy making process. Finally, the Bank of Ghana publishes the Monetary Policy and Banking Sector reports after each MPC meeting. These reports provide additional information on macroeconomic trends, current economic factors driving inflation, risks in the outlook, and financial sector developments, which served as inputs during the MPC session. These publications provide a platform for accountability by the Bank of Ghana and builds public confidence in the monetary policy making process. This paper represents an attempt to further enrich the transparency of the BOG activity and build further central bank credibility.

[11] In recent times, the press conference is streamed live on Facebook for a wider audience.

Chapter 3: Macroeconomic Framework

3.1 Introduction

Macroeconomic modelling is an integral part of the economic analysis and inflation forecasting at the Bank of Ghana. This evolved from the reliance on simple Auto-Regressive (AR) models and Vector Error Correction Model (VECM) to a more structural econometric model (E-MOD) in 2005 and currently a new Keynesian model with the introduction of the Quarterly Projection Model (QPM) in 2008. A major critique of the econometric approaches to inflation forecasting is that the results often lack "story telling" capabilities about the economy to inform the policy making process and do not incorporate the endogenous nature of monetary policy. Notably, introduction of the FPAS – and particularly the semi-structural nature of the QPM – has nuanced this critique, provided deeper understanding of monetary policy transmission mechanism, and enhanced the communication process of the MPC.

3.2 The BOG Macromodel

The core Macroeconomic model within the FPAS is the Bank's version of the semi-structural macroeconomic model used by many central banks. It is also known as the 'Gap' or QPM model. It serves as an effective tool for forecasting and policy analysis across central banks, particularly IT ones. Broadly, the core model reflects how the economy works by explicitly modelling expectations and considering the endogeneity of monetary policy.

The model composes of four blocks or core equations. These are the aggregate demand block, a Phillips curve, an exchange rate block, and a monetary policy rule. Together, these blocks characterize the dynamic interactions or behaviours of four key macroeconomic variables, namely output gap, inflation, exchange rate and short-term nominal interest rate (Berg et al. 2006a, b; Laxton, Rose, and Scott, 2009). A key feature of the core model is that monetary aggregates have no explicit role because the use of Taylor-type rules emphasize interest rate adjustment as main central bank tool. In other words,

1. Domestic economic activity (aggregate demand) is influenced by real sector expectation, foreign sector developments, exchange rate developments and fiscal developments.
2. Domestic price setting (Phillips curve) is determined by domestic price expectation and economic activity, exchange rates, foreign sector economic and price developments.
3. Monetary policy takes the aggregate demand and price developments into consideration and sets the policy rate, which, in turn, influences economic activity and prices.

As in standard literature, we present the Semi-Structural New Keynesian (SSNK) model in log-linearized form with the variables of interest expressed in terms of deviation from their equilibrium levels.

3.2.1 Aggregate Demand (Output Gap Equation)

An expectational IS curve (aggregate demand) relates monetary policy and real economic activity. This is based on a log-linearization of an optimizing household's Euler equation that links consumption or output growth to the real interest rate and exchange rate[12]. We however consider several aspects of the literature on transmission mechanisms of the different determinants of aggregate demand (domestic output gap). Given Ghana's small open economy characteristics, the domestic output is specified as a function of past and future output, real monetary conditions, foreign output gap, and fiscal impulse:

$$\tilde{y}_t = \alpha_1 \tilde{y}_{t-1} + \alpha_2 E_t \tilde{y}_{t+1} - \alpha_3 rmci_t + \alpha_4 \tilde{y}_t^* + \alpha_5 fimp_t + \varepsilon_t^y \quad (3.1)$$

with

$$rmci_t = \alpha_6(\tilde{r}_t) + (1-\alpha_6)(-\tilde{z}_t) \quad (3.2)$$

where $rmci_t$ is the real monetary condition index, defined as a weighted average of real interest rate gap, $\tilde{r}_t$, (defined as deviation of actual real interest rate, r_t, from its neutral level, $\bar{r}_t$) and real exchange rate gap, $\tilde{z}_t$, (defined as deviation of actual real exchange rate, z_t, from the trend or equilibrium, $\bar{z}_t$); $\tilde{y}_t^*$ is the foreign (US) output gap; α_1 is degree of output persistence, while α_2 denotes elasticity of future output gap expectation; α_3 represents monetary policy pass through to real economy; α_4 is the degree of influence of foreign developments via net export demand; α_5 measures the effect of government expenditures or net fiscal impulse ($fimp_t$) on aggregate demand; and ε_t^y is aggregate demand shock. The output gap is measured as the deviation of log of real GDP (y_t) from its potential or trend level ($\bar{y}_t$).

3.2.2 Aggregate Supply (Inflation Equation)

Aggregate supply is described by the Philips curve that combines backward- and forward- looking expectations of inflation[13]. In this regard, current inflation is a function of past and expected inflation, as well as real marginal costs:

$$\pi_t = \beta_1 \pi_{t-1} + (1-\beta_1-\beta_3)\pi_{t+1}^e + \beta_2 mc_t + \beta_3 \mathrm{m_t} + \varepsilon_t^\pi \quad (3.3)$$

with,

$$\pi_{t+1}^e = E_t \pi_{t+1} + \beta_4 incred_t \quad (3.4)$$

$$incred_t = \beta_5 incred_{t-1} + (1-\beta_5)\beta_6(\pi_{t-1} - \bar{\pi}) + \varepsilon_t^{incred} \quad (3.5)$$

$$mc_t = \beta_7 \tilde{y}_t + (1-\beta_7)\tilde{z}_t \quad (3.6)$$

$$\mathrm{m_t} = (\Delta \mathrm{S_t} + \Delta \pi_t^* - \Delta \bar{Z}_t) \quad (3.7)$$

where, π_t is current inflation, mc_t is the real marginal cost which captures costs related to both output gap, $\tilde{y}_t$ (domestic component), and real exchange rate gap, $\tilde{z}_t$ (imported component), in line

[12] Studies such as Gali and Monacelli (2005), Ireland (2004), Smets and Wouters (2003, 2007) and others have provided detailed derivation of the IS curve.

[13] The current version of the QPM was extended to allow for a separate modelling of food and non-food inflation rates using two (rather than a single) Phillips curves, given these are determined by different fundamental factors; the description of that QPM extension is discussed in Chapter 5.

with Walsh (2010)[14]; and $E_t\pi_{t+1}$ is model-consistent expectation of next period's inflation. The value of β_1 determines the behaviour of the economy with respect to past inflation. An economy with a predominantly backward-looking inflation expectations would be characterized by β_1 close to unity[15]. In contrast, an economy with highly forward-looking inflation expectations has β_1 close to zero. The Phillips curve implies that inflation is equal to the sum of all future output gap, exchange rate gap and imported inflation values. Thus, monetary policy drives inflation towards the target level, via its impact on current and future output gap and real exchange rate gap ($0 < \beta_7 < 1$). Hence, when inflation is sufficiently forward-looking, monetary policy can steer it towards the target more easily. Otherwise, monetary policy would need larger changes (and, hence, output costs) to influence inflation.[16]

In terms of exchange rate's impact, we assume an incomplete exchange rate pass-through to inflation. In this partially forward-looking Phillips curve, the consumer price inflation is the result of domestic inflation and foreign inflation with$\beta_1 > 0$, $(1 - \beta_1 - \beta_3) > 0$, $\beta_3 > 0$, $\beta_7 > 0$ (Al Hajj, Dufrenot, Sugimoto and Wolf, 2013). The β_7 coefficient captures the effect of the output gap in the real marginal costs on inflation (the slope of the Phillips curve) and is related to the sacrifice ration – i.e., how much output will be lost to drive a disinflation of one percentage point.

The standard derivation of the New Keynesian Phillips Curve (NKPC) based on explicit optimizing behaviour of firms in a monopolistic competitive market and randomly arriving chances to adjust prices (unlike the traditional Phillips curve) reveals how β_2, the impact of real marginal cost on inflation.

The inflation expectations term (π^e_{t+1}) is a function of model-consistent rational expectations ($E_t\pi_{t+1}$) and a measure of lack of central bank credibility, or "incredibility" ($incred_t$). The level of incredibility depends on how economic agents perceive the Bank to drive and keep inflation at target. The Bank is considered as incredible if agents perceive that it is not able to keep inflation on target. The inclusion of this endogenous policy incredibility strengthens the case for forward-looking inflation forecast, given that inflation expectations and incredibility respond endogenously to the Bank's track record in delivering on-target inflation (Isard, Laxton and Eliasson, 2001).

[14]Real marginal cost is not directly observable. Therefore, several proxies have been proposed to capture marginal costs, including labour share of income (see, Clarida, Gali and Gertler, 1999; and Sbordone, 2002; Abbas and Sgro, 2011), unemployment rate (see, Gruen et al., 1999), output gap (see Adams and Padula, 2003; Zhang et al, 2009; Abbas and Sgro, 2011) and a combination of output gap and exchange rate gap in small-open economy models for IT central banks. The policymakers' preference of using the output gap rests on its critical to estimate the sacrifice ratio that measures the amount of cost (output loss) required for reducing the rate of inflation over a period (Baxa, Plasil and Vasicek, 2015).

[15] The economy with a more flexible price-setting and higher credibility can have a smaller value of β_1, while a value of β_1 greater than 0.5 is more consistent for developing and emerging economies (see Berg et al, 2006).

[16] In this case, current inflation is a function of lagged values of the output (and exchange rate) gaps and only an accumulation of many periods of interest rate adjustments can steer current inflation towards the desired path. But since the central bank cannot deceive the public in perpetuity, β_1 must lie between zero and one, so that the coefficient of the expected inflation remains positive. The coefficientβ_3, which captures the pass-through of real exchange rate to prices (via cost of production), is expected to be large for developing economies like Ghana.

Therefore, forward looking expectations are modelled as a positive function of model-consistent inflation expectations ($E_t\pi_{t+1}$) and incredibility ($incred_t$). Incredibility is modelled as an AR(1) process reacting to deviations of previous quarter annual inflation from the target ($\pi_{t-1} - \bar{\pi}$). This implies that higher levels of incredibility make inflation more backward-looking and monetary policy actions would need to be more aggressive to anchor inflation expectations. As incredibility declines, economic agents have trust in the central banks' ability to deliver price stability, and hence the central bank needs to do less to deliver it. The central bank can only gain credibility over time. When $\beta_4 = 0$, it mutes the incredibility block, which implies that economic agents do not consider credibility of the central bank when forming expectations.

3.2.3 Uncovered Interest Policy Condition

In the QPM exchange rate is determined by a modified version of the Uncovered Interest Parity (UIP) condition. As in standard versions, interest rate differential compensates for the exchange rate depreciation and a proxy of risk premium, while the modification involves making exchange rate expectations partly backward-looking. Hence, by allowing for certain persistence in exchange rate movements (Beneš, Vávra, Vlcek, 2002, henceforth BVV), we relate the behaviour of domestic and foreign interest rates, as well as the nominal exchange rate (NER), as follows:

$$S_t = S^e_{t+1} + (i^*_t - i_t + prem_t)/4 - c_1\tilde{z}_{t+1} + \varepsilon^s_t \tag{3.8}$$

with

$$S^e_{t+1} = c_2 E_t S_{t+1} + (1 - c_2)(S_{t-1} + 2/4\Delta\bar{S}_t) \tag{3.9}$$

and

$$\Delta\bar{S}_t = \bar{\pi} - \pi^*_t + \Delta\bar{z}_t \tag{3.10}$$

where S_t is the log NER, defined as units of domestic currency per one unit of foreign currency (US dollar); S^e_{t+1} is the expectation of the NER in period t+1 (with E_tS_{t+1} being the model-consistent fully forward-looking expectation); i^*_t is foreign (US) nominal interest rate and i_t is domestic nominal interest rate; $prem_t$ is the risk premium, which is endogenously determined; given QPM's quarterly frequency and annual expression for interest rates, the term in the brackets is divided by 4; ε^s_t is exchange rate shock. Equation (3.9) also allows a non-zero growth rate of the exchange rate in the long run as reflected by the term $(2/4\Delta\bar{S}_t)$. The coefficient c_2 captures the degree of forward-looking behaviour in the financial market. The backward-looking expectation term of exchange rate is captured by $(S_{t-1} + 2/4\Delta\bar{S}_t)$, which shows agents' projection of nominal exchange rate in period *t+1* as an extrapolation of the past exchange rate adjusted for the trend rate of growth of the real exchange rate ($\Delta\bar{z}_t$) and the average inflation differentials (BVV); the multiplication by 2 implies that financial market analysts do a projection about nominal exchange rate for two periods, from *t-1* to *t+1*. Although model-inconsistent in the short-run, the term $\Delta\bar{S}_t$, which is the change in "trend" NER, is consistent with the long-term economic fundamentals epitomized by inflation targets and real exchange rate trend. It is therefore in tune with finding that the PPP only holds at longer time horizons. Essentially, the long run properties

of the model remain intact by the model construct, since $\Delta\bar{S}_t = \Delta S_t$ in the long run (Benes, Hurnik and Vavra, 2008).

3.2.4 Monetary Policy Rule

The main monetary policy instrument is the short-term nominal interest rate. Central bank adjusts the rate to bring inflation to its target and output to its equilibrium (potential) level:

$$i_t = \eta_1 i_{t-1} + (1-\eta_1)[E_t\pi_{t+1} + \bar{r}_t + \eta_2(E_t\pi_{t+3} - \bar{\pi}) + \eta_3\tilde{y}_t] + \varepsilon_t^i, \qquad (3.11)$$

where i_t is the policy short-term nominal interest rate; π_t is the current rate of inflation; $\bar{\pi}$ is the desired rate of inflation (i.e. inflation target); $\bar{r}_t$ is the real interest rate trend, η_1 is an indicator of the degree of smoothing of interest rate changes (or policy inertia); η_2 measures the strength of interest rate reaction to future inflation deviation from target; η_3 represents the interest rate reaction to output gap; ε_t^i is the monetary policy shock.

Particularly inherent in the model structure is that a stable inflation warrants a positive η_2. By specifying $\eta_2 > 0$, the policy (Taylor) rule says that an increase in inflation by one percentage point should prompt the central bank to raise the nominal interest rate by more than one percentage point. Intuitively, $\eta_2 > 0$ implies that when inflation rises, the real interest rate should be increased to stabilize the economy. In line with standard macroeconomic theory and as perceived by policymakers and market participants alike, interest rate rule characterized by $\eta_2 > 0$ (specifically, $1 + \eta_2 > 1$, the sum of the two coefficients on π_t in the equation 1) will tend to be stabilizing, while those with $1 + \eta_2 \leq 1$ are likely to be destabilizing or, at best, accommodative to shocks to the economy.

Essentially, the rule recommends a relatively high interest rate (a "tight" monetary policy) when inflation forecast is above target or when output is above its potential level to return inflation to target or dampen inflationary pressures. On the other hand, it recommends a relatively low interest rate ("easy" monetary policy) when inflation is below its target or when output is below its potential level, in order to stimulate output. Nevertheless, in the case of stagflation, when inflation is above its target but output is below potential level, Taylor (1993) suggests a specification of the relative weights that hold a right balance between inflation and output in the short-term, while in the long-term inflation would still go back to the target and output to its (possibly new) potential level.[17]

[17] Several studies of monetary policy reaction function (including Clarida, Gali and Gertler [CGG, 2000] for USA; Nelson [2000] for UK; Takáts [2012] for selected emerging and developed economies) have found a significant positive coefficient of the lagged dependent variable, i_{t-1}, though η_1 is less than one. This provides a logical interpretation that central banks conduct interest rate smoothing, by deliberately making gradual changes in interest rates to moderate potentially damaging interest rate volatility, with important implications of financial stability. In the long run, however, equation (6) would converge to the standard forward-looking rule because the smoothing would diminish provided that $\eta_1 < 1$ and there are no changes in inflation, the target, or the output gap.

3.2.5 The Long Run Trends and Foreign Variables

The external sector is exogenous to the core model. As a result, the long run values of real exchange rate ($\bar{z}_t$), real interest rate ($\bar{r}_t$), changes in potential output ($\bar{y}_t$), inflation target ($\bar{\pi}$) and long-term UIP premium ($\overline{prem}_t$) as well as foreign variables (proxied by US variables) such as inflation (π_t^*), output gap ($\tilde{y}_t^*$) and interest rate (r_t^*) are assumed to follow a first order autoregressive process with high enough inertia. Thus, in line with empirical literature, we model the steady state and external variables as highly persistent processes.

3.3 Model Solution and Parameterization

The model solution is obtained in two steps. The first step is to attain the steady-state solution of the model. The steady-state solution can be found by using contemporaneous values to replace the leads and lags of each endogenous variable. For instance, the model initially replaces the variables such as $\tilde{y}_t$, $\tilde{y}_{t-1}$ and $\tilde{y}_{t+1}$with $\tilde{y}$. This similarly applies to the other endogenous variables. Afterward, this transformed system of equations is solved, setting all the gaps to zero at the initial stage (i.e., $\tilde{y} = 0$, $\pi_{t+3} = \bar{\pi}$, $\tilde{r} = 0$, and $\tilde{z} = 0$).

The second step reveals or deduces the dynamic properties of the model. Practically, it is not straightforward to ascertain where to begin in unravelling the impact of a shock given that the model equations have leads and lags.

Following the literature (Berg et al. 2006a, 2006b), the model parameter values are calibrated to reflect certain stylized facts and dynamic interlinkages of the main variables based on economic theory, international experiences, and Ghana's business-cycle conditions. Table 4 provides the key parameters in the four main behavioural equations for Ghana, together with the standard deviations of the shocks.

For instance, the parameter of the backward-looking component in the Phillips curve (α_1) is set at 0.6, to match the persistence in headline inflation and the slow convergence of inflation to the target. The one-year inflation expectation in the Phillips curve is modelled as a function of incredibility of the central bank, with parameter 0.5, reflecting how much consideration agents give to the incredibility of the Bank when forming expectations. With a positive parameter for the incredibility variable, monetary policy actions need to be more aggressive to anchor inflation expectations at higher levels of incredibility. The stock variable for incredibility has a persistence, represented by the parameter value of 0.5 and penalizes strongly for positive deviations of inflation from the target with a parameter value of 0.75. The coefficient of the real marginal costs is set at 0.4, reflecting a strong pass-through of domestic and imported production costs to prices. Ghana is a small open economy with about 30 percent share of imported factors of production in total production costs. Consequently, the parameter of output gap in real marginal cost is set at 0.7 to reflect the larger share of domestic production costs, and that of the real exchange rate is pinned at 0.3.

Table 4: Parameter Calibration

Parameters	Description	Calibrated Value
Aggregate Demand/IS Curve		
α_1	Coefficient for persistence in domestic output gap	0.4
α_2	Coefficient for expected domestic output gap	0.3
α_3	Impact of real monetary condition index (RMCI) on output gap	0.1
α_4	Impact of foreign output gap on domestic output gap	0.1
α_5	Impact of fiscal impulse on output gap	0.5
α_6	Share of real interest rate gap in RMCI	0.8
Aggregate Supply/Philip Curve		
β_1	Inflation persistence parameter	0.6
β_2	Pass through coefficient of real marginal cost (RMC) to inflation	0.4
β_3	Coefficient of imported inflation	0.1
β_4	Policy incredibility pass-through to inflation	0.5
β_5	Persistence in policy incredibility	0.5
β_6	Coefficient for deviation in lagged inflation from target	1.5
β_7	Share of output gap in RMC	0.7
UIP Equation		
c_1	Coefficient of expected real exchange rate gap	0.0
c_2	The degree of forward-looking behaviour in the financial market	0.8
Monetary Policy Rule		
η_1	Interest rate persistence	0.75
η_2	Interest rate reaction to deviation of expected inflation from target	1.3
η_3	Interest rate reaction to output gap	0.1
Steady-state values		
π_{ss}	Steady-state inflation	8%
$prem_{ss}$	Steady-state risk premium	5%
$\tilde{z}_{gap,ss}$	Steady-state real exchange rate gap	-1%
$\tilde{y}_{ss}$	Steady-state growth	6%
π^*_{ss}	Foreign (US) inflation target at steady state	2%
i^*_{ss}	Foreign (US) real interest rate at steady state	1%
$fimp_{ss}$	Structural fiscal deficit at steady state	5%
Standard Deviation of Shocks		
ε_t^{π}	Domestic supply-side shock	1.5
ε_t^{y}	Aggregate demand shock	0.5
ε_t^{uip}	Exchange rate or risk premium shock	1.5
ε_t^{i}	Monetary policy shock	0.8
ε_t^{incred}	Incredibility shock	0.1
ε_t^{TARG}	Inflation target shock	0.1
ε_t^{*i}	Foreign interest rate shock	0.2
ε_t^{*y}	Foreign aggregate demand shock	0.3
$\varepsilon_t^{*\pi}$	Foreign inflation shock	0.8

Source: BOG QPM

The parameter on the lagged domestic output gap term, α_1, lies between 0.50 and 0.90 for most economies (Berg et al., 2006a). It also suggests that the coefficient of the lead output gap, α_2, might range from 0.05 to 0.15. Broadly, the relative sizes of α_6 and α_7 are determined by the degree of openness of a country. Therefore, the value of α_7 is expected to be smaller than α_6 for more open and industrial economies, while the ratio of α_7 to α_6 converges toward zero for fairly closed economies. Due to significant lags in the transmission of monetary policy, the sum of α_6

and α_7 is expected to be small relative to the parameter on the lagged domestic output gap, α_1. Especially, the literature suggests that the sum of α_6 and α_7 would lie between 0.10 and 0.20. The pass through of monetary policy to the real economy (i.e., α_1) varies between 0.1 (low impact) and 0.5 (high impact). The higher the latter parameter the more responsive is the output gap to changes in monetary policy and hence policy reaction needs to be less pronounced to support economic growth.

There is little consensus in the literature regarding the reasonable value for c_1, the degree of backward-looking behaviour in the financial markets. For instance, Isard and Laxton (2000) show that a value of c_1 slightly below 0.5 is prudent under uncertainty, as extreme values such as zero and one would result in larger and asymmetric costs. As implied by the UIP condition, the coefficient of interest rate differential is assumed to be one. Although this has often been challenged in the empirical literature, it is very cumbersome to accurately estimate this coefficient due to endogeneity between exchange rate and interest rate. Besides, the monetary authorities frequently "lean against the wind" of exchange rate movements. Therefore, the estimated coefficient on the interest rate differential has the tendency to have a downward bias (Chin and Meredith, 1998).

3.4 The near-term forecast system

The near-term forecast (NTF) system produces forecasts for one-quarter ahead for three key variables (real GDP, inflation, and exchange rate) to be imposed in the BOG Macromodel. A suite of models is used to forecast real GDP and inflation, and then averaged. Near-term forecast for nominal exchange rate is based on informed guess.

3.4.1 The near-term forecast for Inflation

- **Error Correction Forecasting (ECF) Framework**

The ECF is used in forecasting both monthly and quarterly inflation. A three-variable VAR model is estimated with inflation depending on its lagged values, exchange rate depreciation and the monetary policy rate, with crude oil price entering as an exogenous variable. In certain quarters in which monthly data for the quarter being estimated is available, this additional data is incorporated into the ECF forecast.

- **AR Process Framework**

The framework states that the value of a variable depends on its past values only. It studies the historical trends to produce future values. As a statistical approach, the framework is used to generate a 1-step or 2-step forecast of inflation to minimize the possibility of forecast errors in the forecast horizon. The framework does not incorporate useful information about the structure of the economy and thus is less informative when clarifying policy decisions.

- **Method of Calibrating the CPI Path**

This framework looks at the calibration of the monthly path of the CPI based on staff informed judgement of the price dynamics. The forecasting ability of this framework appears to be accurate in the short-term. It is done in two ways. The first is to model the likely path of the CPI using past trends in the monthly sub-indices to forecast inflation. Occasionally, scenarios are built considering the likely risks to inflation by adjusting the path for the CPI sub-indices upwards or downwards. The second is a naïve specification which also exploits information embedded in past trends of CPI inflation. Here, the monthly inflation forecast for a period is simply the average of the past monthly growth rates in the CPI for that same month in previous years.

3.4.2 Nowcasting real GDP[18]

- **Dynamic Factor Model**

Dynamic Factor Model involves the use of variables with high frequency to estimate lower frequency variable based on filtration methods. The high frequency variables selected tend to correlate with the variable of interest. For example, data on private sector credit, Real CIEA, oil production (coincident variables), which are published much earlier than GDP, are used to obtain a nowcast of GDP growth by employing the Kalman smoother.

- **Bridge Equations**

Bridge equations regress quarterly GDP on a small set of preselected high frequency data (monthly) for the purpose of nowcasting growth. There are four processes involved. First, each high frequency variable is projected one-year ahead using AR (1) process. Second, compute quarterly averages of the high frequency variables over the forecast horizon. Third, regress the quarterly GDP on each variable derived in step 2, and then project quarterly GDP for each of the regressions. Finally, the nowcast GDP is the average of the projected GDP in step 3.

- **Machine Learning**

The machine learning (ML) method uses several time series (with mixed frequencies) to produce GDP nowcast. The ML method does not require strong assumptions about what particular series are important for forecasting the variable of interest. For the Bank's ML method, we utilize about 22 competing models to determine the best fit for the interested variable (real GDP) based on mixed frequency predictors (including 25 monthly and 4 quarterly time series).

In the ML modelling process, the dataset is segregated into three, namely (1) Training dataset (i.e. the estimation sample used to fit the model), (2) Test dataset (i.e. the validation set) - additional data used to determine how good each model fits the data, and (3) Cross-validation – which takes advantages of the entire datasets by using all combinations of the testing and training datasets. By feeding the model with the inputs (high frequency indicators – predictors) and output (say real GDP) data, the ML method provides the nowcast value for output in three phases. Namely,

[18] Based on IMF Technical Assistance

- Tuning – set parameters of each model to maximize the out-of-sample performance of the model using cross-validation in the training data set;
- Evaluation – assess the actual out-of-sample performance to choose the best model (using forecast performance criteria) in the testing dataset; and
- Nowcasting – use the chosen optimal model to nowcast GDP growth for the quarter.

- **Three-Pass Regression**

The Three-Pass Regression (3PR) method uses mixed frequency (25 monthly and 4 quarterly) time series variables, same as in the ML method. The 3PR identifies only the subset of predictors (high frequency variables) that influence the dynamics of quarterly real GDP and discards those that are irrelevant but may be pervasive among predictors. To make forecasts, the 3PR method uses proxies – variables driven by target-relevant factors[19].

3.5 Data and Data Treatment

The main domestic and foreign datasets used for the estimation and analysis of the core model are presented in Table 5.

Table 5: Data description and sources

Data	Source	Description
Domestic Variables		
Headline CPI	GSS	Monthly Inflation Rates, Base year 2018=100
GDP (Real and Nominal)	GSS	Quarterly GDP estimates, Base year 2013
Fiscal Deficit (Nominal)	MOF	Annual fiscal deficit target announced in the national budget
Exchange Rate (Cedi/USD)	BOG	End-month Interbank exchange rates
Interbank Rate	BOG	Interbank rate (Monthly) interest rates
Policy Rate	BOG	Bank of Ghana monetary policy rate (Monthly)
Foreign Variables		
Fed Rate	US FED	Fed funds rate (Quarterly average)
US CPI	BLS	US CPI (Quarterly average)
US Output gap	CBO	Output gap (Quarterly average)

Note: GSS: Ghana Statistical Service, MOF: Ministry of Finance, BOG: Bank of Ghana, FED: US Federal Reserve Board, BLS: Bureau of Labour Statistics, CBO: Congressional Budget Office

3.6 Monetary Policy Transmission Mechanism (MPTM)

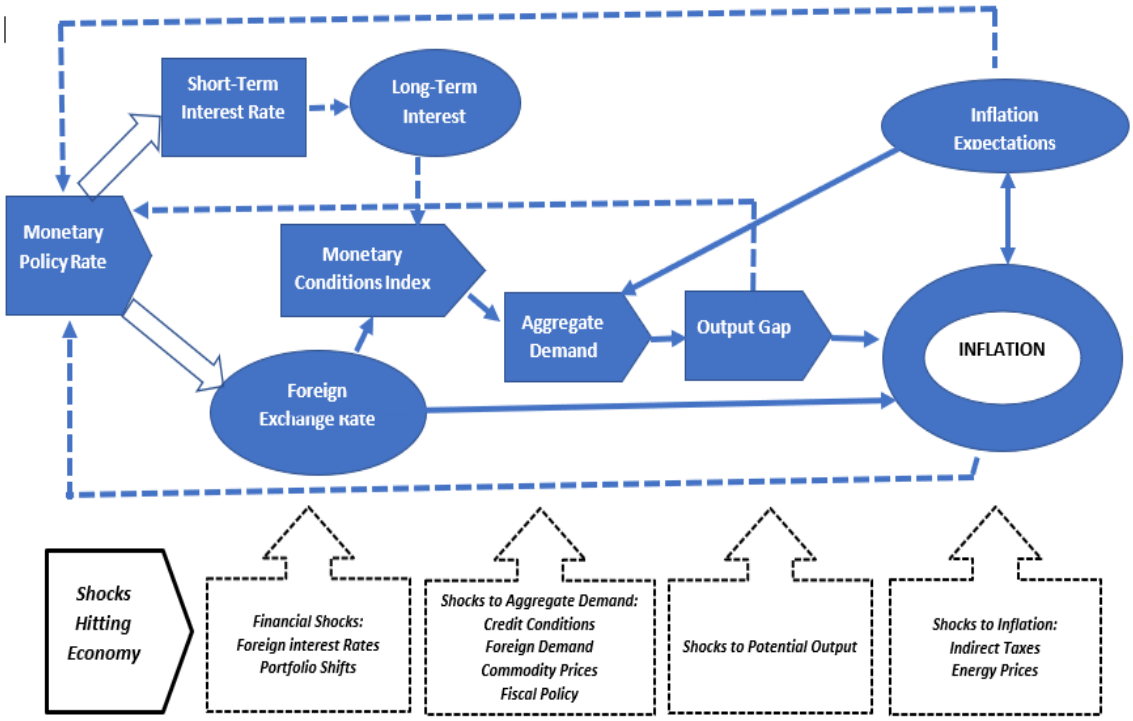
MPTM portrays how policy-induced changes in the nominal money stock or the short-term nominal interest rate impact real variables such as aggregate demand (see Ireland, 2005). The theoretical literature classifies the channels of monetary policy transmission to the real economy into two basic categories. The first category is the traditional or neoclassical channels (which assume perfect financial markets), built on models of consumption, investment, and international trade dynamics during the mid-20th century[20]. The second category is the non-neoclassical

[19] For details, see Kelly and Pruitt (2011)

[20] In this category, the investment-based channel focuses on the both interest rate and Tobin's q channels (Jorgenson, 1963; Tobin, 1963); consumption-based model illustrates the channels of wealth effect and intertemporal substitution effect

channels which involve financial market frictions in the credit markets and are typically referred to as the credit view. However, the theoretical literature remains unsettled about the dominant channel(s) of monetary policy transmission. For instance, Taylor (1999) puts emphasis on the neoclassical channels, while Bernanke and Gertler (1995) stress the credit channel. The Ghana QPM, like many other central bank models, approximates two main monetary policy transmission channels; the interest rate channel and the exchange rate channel with expectations playing a major role. The subsequent subsections briefly describe monetary policy transmission to the Ghanaian economy, with reference to Figure 3.

Figure 3: Schematic Diagram of Monetary Policy Transmission Mechanism (MPTM)



Source: *Adapted from Benes et al. (2016).*

Interest rate channel of monetary policy transmission has been the standard feature in the teaching of traditional Keynesian IS/LM macroeconomic models over 50 years. According to the traditional Keynesian view of monetary policy transmission, contractionary monetary policy (increases in short-term nominal interest rate) induces an increase in real interest rate of commercial banks, as prices are assumed to be sticky in the short run[21]. The positive real interest rate increases user cost of capital which in turn adversely affects investment and household consumption of durables, ultimately leading to a decline in aggregate demand and inflation. The opposite is also true for expansionary monetary policy (e.g., Taylor 1993; Hayashi, 1982).

(Modigliani and Brumberg, 1954), while the international trade dynamics focus on the exchange rate channel (see international IS/LM-type models of Mundell, 1963; and Fleming, 1962).

[21] Essentially, the key for this transmission mechanism is sticky prices. That is, an increase in short-term nominal interest rate does not lead to a one-to-one increase in prices, resulting in an increase in real interest rate.

The crux of interest rate transmission mechanism is the weight on the long-term real interest rate (instead of nominal short-term) as the main conduit of influence on consumer and business decisions. In view of this, the expectations of future short-term official interest-rate changes also influence medium- and long-term interest rates. This is because longer-term interest rates depend partly on market expectations about the future course of short-term rates (in line with the expectations hypothesis). Accordingly, monetary policy can guide economic agents' expectations of future long-term interest rate and thereby influence current investment and consumption decisions and hence price developments.

The main feature of the international trade-based mechanism of monetary policy transmission is the **exchange rate channel**. The mechanism is that an increase in interest rate by monetary authority increases the returns on domestic assets relative to foreign assets, resulting in inflows of foreign capital and hence appreciated domestic currency. The higher value of domestic currency makes domestic goods expensive than foreign goods, leading to expenditure switching in favour of foreign goods with adverse consequences on net exports and aggregate demand. The opposite is equally true for monetary policy easing. On the other hand, changes in the exchange rate can directly affect inflation, if imported goods are directly used in domestic consumption. Nevertheless, the literature clearly posits that the effectiveness of the exchange rate channel is contingent on the degree of sensitivity of exchange rate to interest rate movements[22].

[22] Studies such as Bryant, Hooper and Mann (1993), Taylor (1993) and Smets (1995) found the effects of the exchange rate channel to be larger for smaller and for more open economies.

Chapter 4: Properties of BOG's Core QPM

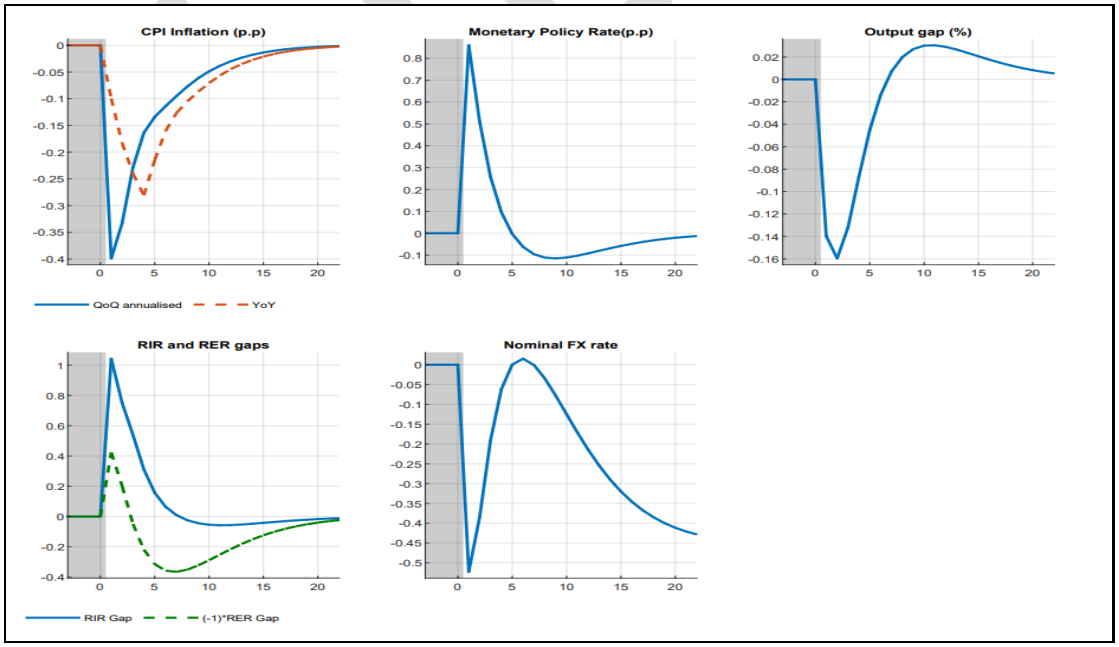
4.1 Introduction

A convenient way to communicate the properties of a model is to provide graphic simulations of the model's solution to ascertain how the key macroeconomic variables respond to specific shocks[23]. Starting from an equilibrium condition, the model separately considers a one-time shock propagation. However, in practice shocks do not occur one at a time neither do they arrive when everything is in equilibrium. This, among others, explains why forecasting with a model is cumbersome. Notwithstanding, it is beneficial to keep the model as simple as possible and to explore one shock at a time.

4.2 Effect of Monetary Policy Shock

The role of monetary policy is broadly to provide a nominal anchor to the economy by raising interest rates when inflation is above target (which usually happens during periods of high economic growth) to moderate inflationary pressures and by reducing policy interest rates when inflation is below target (which usually happens during economic downturns) to help boost inflation and economic growth. To ascertain policy pass-through, we first analyse the properties of BOG's core model by graphically illustrating the impact of a one-time monetary policy shock. In this case, we consider the impact of 1 percent increase in policy interest rate. Figure 4 exhibits the responses of main macroeconomic variables to a one-time increase in monetary policy shock. The rise in short-term nominal interest rate leads to a positive real interest rate gap.

Figure 4: Effect of Monetary Policy Shock



Source: BOG QPM

[23] Capek et al. (2003)

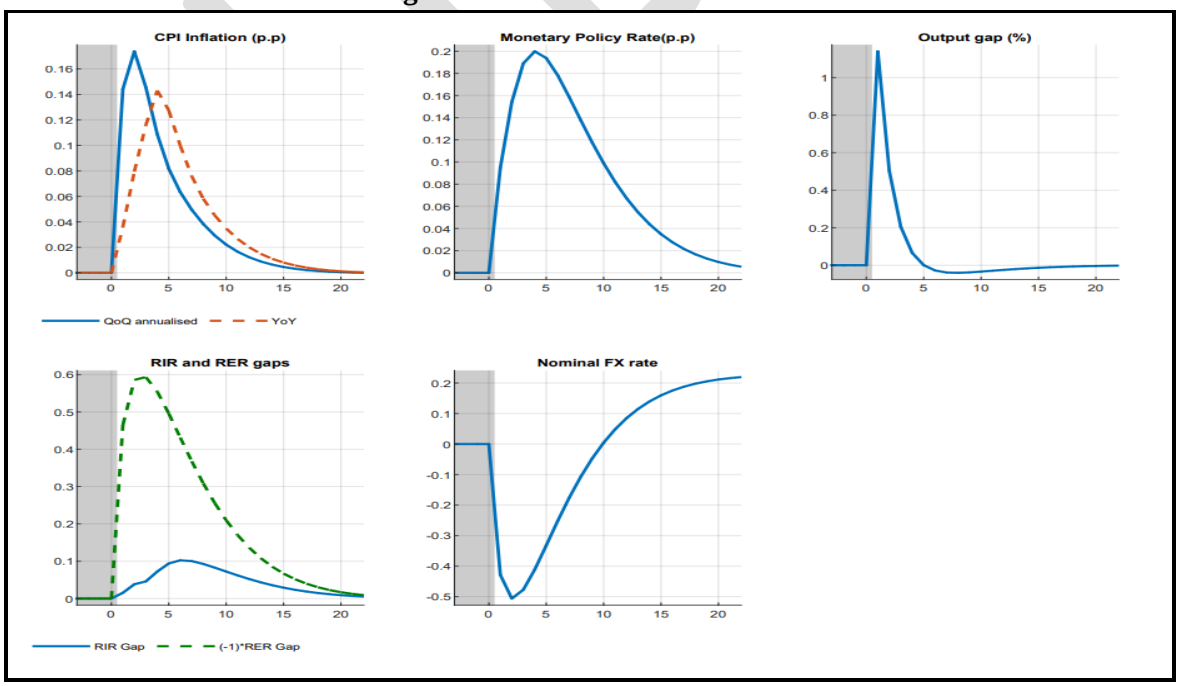
This, together with a real appreciation in domestic currency, results in tighter real monetary conditions, which in turn dampen output gap, reaching a trough by the 3rd quarter with a magnitude of about 0.17 percent drop. The decline in aggregate demand pressures in tandem with real appreciation of the domestic currency drives disinflation of about 0.4 percent during the first period.

Most shocks that must be dealt with in a forecast are those that arise elsewhere and require a response from the central bank to respect the inflation target. Hence, monetary policy should be such that it responds to other shocks instead of itself being a source of a shock. However, analysing monetary policy shocks is still useful for gauging the transmission channels in the model.

4.3 Effect of Aggregate Demand Shock

As a typical example, we examine the effect of one-percentage-point positive shock to the aggregate demand (i.e., the output gap) and Figure 5 displays the resultant impulse response functions. This shock puts immediate upward pressure on inflation, as positive output gap widens by more than 1 percentage-point in the first quarter. The central bank raises the short-term interest rate to fend off the inflation pressure. The rise in interest rate facilitates an appreciating domestic currency in both nominal and real terms (via the capital flow channel). The effect of currency appreciation on inflation through import prices play out and inflation reverses to its trend level by the 5th quarter. The tighter real monetary conditions, which peaked by the 4th quarter, induced primarily by a substantial positive real exchange rate gap, also narrows the initial large positive output gap to reach its equilibrium level by the 5th quarter.

Figure 5: Effect of Demand Shock



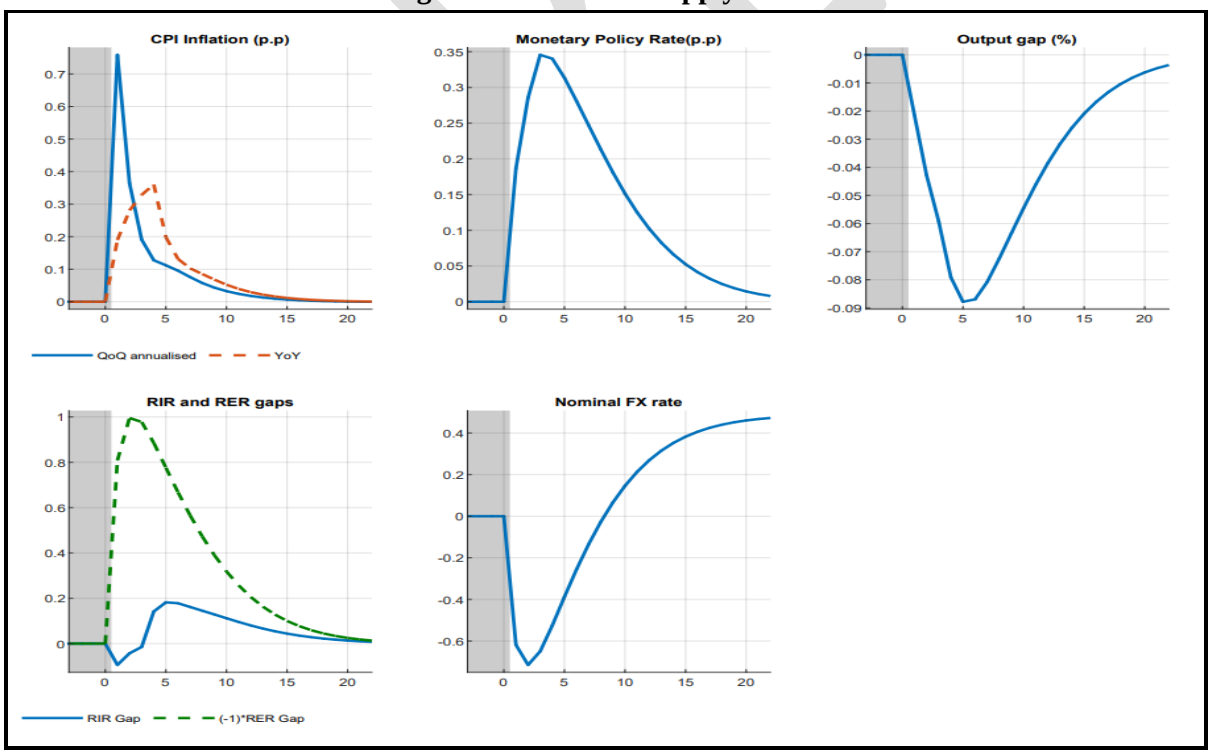
Source: BOG QPM

4.4 Effect of Aggregate Supply Shock

We assume a negative shock to prices directly in the form of a negative one-percentage-point Phillips curve shock. In addition, we assume that the central bank acknowledges the shock and responds without delay. Figure 6 illustrates the impact of this supply-side shock implied by the core model. The negative supply-side shock reflects a spike in inflation in the first quarter. The pick-up in inflation induces a negative real exchange rate gap (i.e., appreciation), which in turn leads to a negative output gap (via the trade channel) in the 1st quarter.

In response, the central bank increases the short-term nominal interest rate but less than proportionately in the first quarter, which results in negative real interest rate in the immediate quarter. The additional increase in nominal interest rate to about 35 basis points by the 4th quarter, which lead to a positive real interest rate gap. This, together with a further positive widening in the real exchange rate gap, results in a prolonged negative output gap, reaching a trough by the 5th quarter. The initial real appreciation is eventually reversed as the policy task later becomes one of limiting the impact on aggregate demand, leading to narrowing of the negative output gap after the 5th quarters. Nevertheless, the subdued aggregated demand after several quarters, underpinned by tighter real monetary conditions, support the disinflation after the 1st quarter towards the trend level.

Figure 6: Effect of a Supply Shock



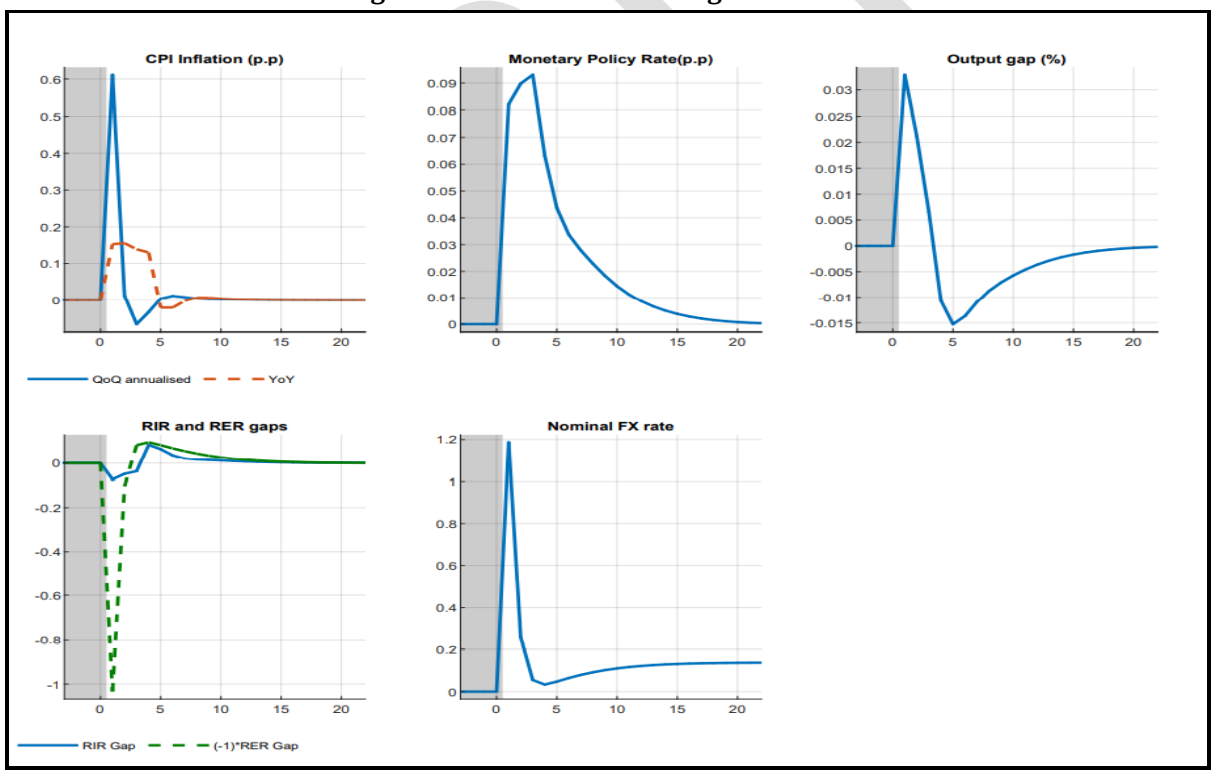
Source: BOG QPM

4.5 Effect of Exchange Rate Shock

Figure 7 shows the response to a positive exchange rate shock (i.e. depreciation). This shock is inflationary via two channels. On one hand, the depreciation increases aggregate demand, opening a positive output gap but the effect appears to be relatively small. On the other hand, the depreciation leads to higher imported prices, and a subsequent pass through to inflation due to a sizeable proportion of imported items in the CPI basket.

The central bank responds by raising the short-term interest rate to moderate the inflationary pressures. In this case, it takes roughly 9 basis points in the nominal rate for first quarter[24], which yields a negative real interest rate. The subsequent pick-up in both the nominal and real interest rates after the first quarter is sufficient to reverse the direct effects of the depreciation on the output gap. This then widens the negative output gap by the fifth quarter and only recovers to its equilibrium level after twenty quarters ahead. Inflation declines on account of depressed aggregate demand, undershooting its long-run equilibrium by the third quarter but reverts to its trend level after the fifth quarter, following tighter monetary conditions.

Figure 7: Effect of an exchange rate shock



Source: BOG QPM

[24] Interest rate reaction is small because the effect on inflation is just one-off due to the nature of the UIP shock.

Chapter 5: Model Extensions and Recalibration

5.1 Introduction

The Forecasting and Policy Analysis System (FPAS) is an analytical framework consisting of various dynamic processes in which key relationships and structures are examined continuously to better capture an ever-changing economic landscape and increasing complexities of the modern economy. The objective of FPAS is to provide real-time rigorous quantitative support for the central bank policy making process. The conceptual and practical underpinnings of FPAS are widely described in Berg et al. (2006a).

In recent years, the Ghanaian economy has undergone some changes since the last re-calibration of the Quarterly Projection Model (QPM) - the core of the FPAS - requiring a careful re-examination of model proprieties and an assessment of the potential divergences between model implications and the new economic reality. Some of the noteworthy developments include a significant disinflation process and re-basing of the consumer price index (CPI) basket, which have pushed inflation into single digits. Importantly, food has a significant weight of 43.12 percent in the CPI basket and is driven largely by factors other than those influencing non-food prices, necessitating a need to disentangle the driving forces to better understand and model the factors behind price dynamics; recent developments during the early stages of the pandemic have only accentuated this occasional but non-trivial divergence among CPI sub-indices.

The recent FX market reforms, including the introduction of forward auctions and strict application of the market conduct rules, have led to a switch from high and volatile exchange rate dynamics to more stable developments in recent times. Similarly, an important development has been the introduction of fiscal rules under the Fiscal Responsibility Act of 2018 (Act 982), explicitly legislating the maximum fiscal deficit to 5 percent of GDP, with provision for positive primary balance. This effectively affected the fiscal anchor in the QPM, which was modelled along a maximum debt ceiling. For these reasons, the QPM was recently recalibrated, and its structure updated with extensions that reflect these important developments to ensure it provides relevant guidance to policy makers.

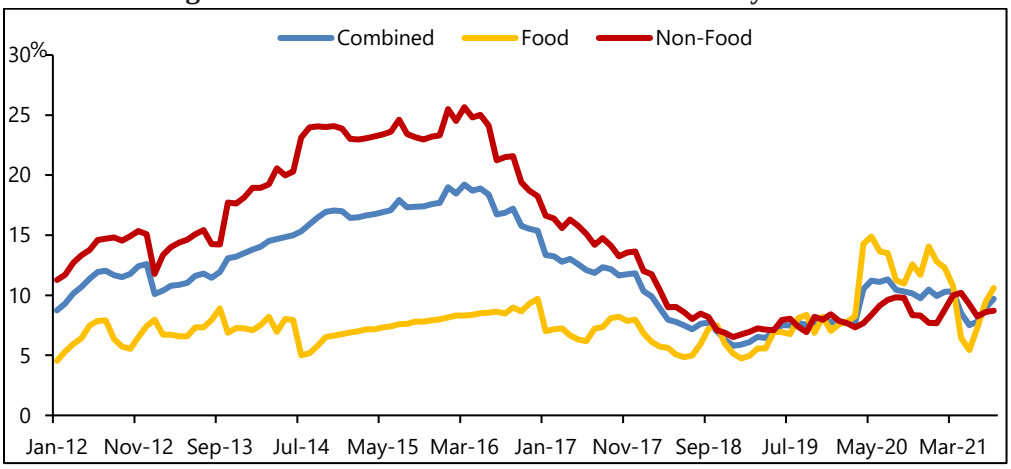
Accordingly, in the recent recalibration and model extension exercises, key modifications included a disaggregation of the Phillips curve equation into two equations, introduction of quarterly GDP series as observable data, a new specification of the fiscal impulse and exchange rate process. A brief description of the changes is discussed below.

A key extension was the disaggregation of the headline CPI Phillips curve into food and non-food equations.[25] This was in recognition of the fact that there are different underlying dynamics that

[25] The disaggregated modelling of CPI inflation features, for example, in the QPM model implemented at the National Bank of Rwanda, as described in Vlcek et al. (2020).

drive changes in food and non-food prices (see Figure 8). It is well-established in the literature that movements in non-food prices are more related to the domestic business cycle (output gap), while food prices are typically driven by exogenous idiosyncratic and structural factors such as weather patterns and international commodity prices. Also, while the real exchange rate may affect both components of the CPI, the degree of its impact could differ. Accordingly, current QPM specifies disaggregated dynamics of food and non-food prices, which are then combined using their respective weights in the CPI basket to arrive at headline inflation. The usefulness of this approach is that it provides policy makers with a richer overview regarding the projected drivers of inflation process in the outlook, thus enhancing the appropriate positioning of the policy rate. For example, a projected pickup in inflation emanating from food price pressures would necessitate a different policy response compared to a scenario in which the pickup in inflation is expected to be driven by the more persistent non-food items. In addition, dedicated modelling of food inflation provides a convenient channel to incorporate climate change narrative into the QPM, given the direct connection between climate- or weather-related disruptions and spikes in food prices observed in the case of emerging markets and developing economies. Therefore, modelling food and non-food inflation separately seems appropriate.

Figure 8: Food and non-food annual inflation dynamics



Source: GSS, BOG

Prior to the model extension, quarterly GDP data used during a forecast round were obtained by QPM filtration of annual GDP estimates. This was the favoured approach at the time of developing the QPM, since it allowed to put emphasis on better-quality annual data while reducing the volatility associated with quarterly GDP, including due to seasonality. Currently, QPM incorporates official quarterly real GDP from GSS releases, thus properly reflecting the information available to market participants at large. At the same time, for quarters in which data is not readily available – usually current and next quarter – additional nowcasting or near-term forecasting satellite tools are used by staff of the Bank. This enhancement was proven particularly useful during the recent pandemic. In the previous approach, the sharp drop in Q2 2020 following the imposition of lockdowns at the height of the Covid-19 pandemic could not have been explicitly

incorporated in Q2 since the filtration may not have been able to glean the quarter with the sharp fall in GDP just from the history. Current framework, with proper satellite analyses, allowed to effectively inform the QPM about the likely drop-in economic activity when the pandemic crisis emerged. In addition, using only annual GDP data may make it harder to identify shocks sufficiently quickly. For example, if inflation picks up in the middle of a year, without quarterly GDP data, the model may not be able to identify whether this is due to a demand shock or a supply shock. Yet this is important for optimal policy decisions.

In recent years, the exchange rate has become considerably more stable than in earlier periods (see Figure 9). Given this continued stability on the exchange rate front, earlier exchange rate calibrations are likely not to be representative anymore, necessitating a recalibration of the persistence in the nominal exchange rate dynamics. Specifically, staff increased the value of the parameter which captures the persistence in nominal exchange rate dynamics compared to past periods. This was also done to prevent the significant jumps or movements in key endogenous variables observed in the initial quarters of the forecast horizon, that was caused primarily by the excessively forward-looking nature of the exchange rate and was requiring additional tunes to be applied to the model.

Figure 9: Exchange rate developments (year-on-year, %)

Source: BOG

In the QPM, the impact of fiscal policy on output is captured through the fiscal impulse (identified as a shock to the structural deficit). Within the model extension work, the fiscal impulse was re-defined as a four-quarter moving average to remove seasonal effects and to capture actual persistence in the implementation of fiscal policy, as well as its longer-lasting effects on the economy. Furthermore, the fiscal anchor was changed to 5 percent, which is consistent with the

deficit level envisaged under the fiscal responsibility law, in place of the previous debt-stabilizing level of 60 percent.

5.2 Overview of QPM extensions and recalibration

5.2.1 Disaggregate modelling of CPI inflation

The main extension to the Phillips Curve block in the model is the disaggregation of the equation into food and non-food sub-indices. Disaggregating the Phillips Curve into the two components' equations ensures that sector-specific idiosyncrasies are properly reflected in the dynamics of the Phillips Curves, which in turn improves the forecasts of the headline inflation and the policy interest rate path projected from the model. In addition, this makes it possible to take a trend in a food/non-food relative price into account. Namely, food and non-food inflations may differ persistently (hence, relative price having an increasing/decreasing trend), and not incorporating this information into the analysis may miscalculate the cyclical position of the economy.

Although the general structure of the two equations remains similar to the former aggregate equation (i.e., food and non-food prices are driven by the same underlying factors), the intensities with which these factors drive sectoral prices are different. For example, while domestic input cost (output gap) is relatively more important for non-food price dynamics, imported input cost (real exchange rate (RER) gap) is more important for food prices; this is a reflection, for example, of the predominantly non-tradable nature of the former component and the largely tradable nature of the latter. These differences are reflected in the parameterization of the sector-specific Phillips Curves. The structures of the two equations are discussed below.

5.2.2 Non-food inflation

Non-food inflation is modelled as a function of its past, expectations, real marginal cost and imported inflation proxy:

$$\pi_{t,nfood} = \beta_{11}\pi_{t-1,nfood} + (1-\beta_{11}-\beta_{31})\pi^{e}_{t+1,nfood} + \beta_{21}rmc_{t,nfood} + \beta_{31}m_t + \varepsilon_t^{\pi_{nfood}} \quad (5.1)$$

where $\pi_{t,nfood}$ is quarter-on-quarter non-food inflation at time t and $\pi_{t-1,nfood}$ is a measure of non-food inflation in the previous quarter, $\pi^{e}_{t+1,nfood}$ is non-food inflation expectations, $rmc_{t,nfood}$ is the real marginal cost in the non-food sector, m_t is imported inflation proxy and $\varepsilon_t^{\pi_{nfood}}$ is the non-food supply shock.

To incorporate a varying degree of anchoring of inflation expectations, non-food inflation expectations are modelled as model-consistent inflation expectations augmented by the 'incredibility' of the central bank:

$$\pi^{e}_{t+1,nfood} = E_t\pi_{t+1,nfood} + \beta_{41}incred_t \quad (5.2)$$

Where $E_t\pi_{t+1,nfood}$ is the model-consistent non-food inflation expectations and $incred_t$ - a measure of lack of central bank's credibility (or incredibility). The lack of central bank credibility, $incred_t$, is measured as a weighted average of its lag (to capture its slow-moving nature),

$incred_{t-1}$, and deviation of annual headline inflation ($4\pi_{t-1}$) from the target ($\bar{\pi}$) in the previous period (to capture the effect of not being able to achieve the inflation target):

$$incred_t = \beta_5 incred_{t-1} + (1-\beta_5)\beta_6(4\pi_{t-1} - \bar{\pi}\,) + \varepsilon_t^{incred} \qquad (5.3)$$

ε_t^{incred} is an incredibility shock.

The real marginal cost in the non-food sector, $rmc_{t,nfood}$, is a weighted average of output gap (domestic input cost), $\tilde{y}_t$, and the real exchange rate gap (imported input costs), $\tilde{z}_t$. Similar to the initial QPM formulation, the imported inflation proxy is computed as the difference between foreign inflation (π_t^*) expressed in domestic currency (i.e. adjusted with a change in the exchange rate ΔS_t) and the change in RER trend ($\Delta\bar{Z}_t$):

$$rmc_{t,nfood} = \beta_{71}\tilde{y}_t + (1-\beta_{71})\tilde{z}_t \qquad (5.4)$$

$$m_t = (\Delta S_t + \pi_t^* - \Delta\bar{Z}_t) \qquad (5.5)$$

5.2.3 Food inflation

Similar to the non-food sector, we model the food sector inflation as follows:

$$\pi_{t,food} = \beta_{12}\pi_{t-1,food} + (1-\beta_{12}-\beta_{32})\pi^e_{t+1,food} + \beta_{22}rmc_{t,food} + \beta_{32}m_t + \varepsilon_t^{\pi_{food}} \qquad (5.6)$$

where $\pi_{t,food}$ is quarter-on-quarter food inflation at time t and $\pi_{t-1,food}$ is a measure of food inflation persistence. $\pi^e_{t+1,food}$ is food inflation expectations, $rmc_{t,food}$ is the real marginal cost in the food sector, m_t is imported inflation proxy and $\varepsilon_t^{\pi_{food}}$ is the food supply shock.

Food inflation expectations are specified as model-consistent food inflation expectations augmented by the credibility of the central bank, just like the non-food prices. However, the relative intensity of credibility in the formation of inflation expectations, measured by the parameters β_{41} (non-food sector) and β_{42}(food sector) are different across the sectors (see more details below):

$$\pi^e_{t+1,food} = E_t\pi_{t+1,food} + \beta_{42}incred_t \qquad (5.7)$$

where $E_t\pi_{t+1,food}$ is the model-consistent food inflation expectations and $incred_t$ is previously defined in Equation (5.3). Note that we assume there is only one aggregate measure for central bank credibility, corresponding to the aggregate CPI inflation.

Similar to the non-food sector, the real marginal cost in the food sector, $rmc_{t,food}$, is a weighted average of output gap (domestic input cost), $\tilde{y}_t$, and the real exchange rate gap (imported input costs), $\tilde{z}_t$. However, the relative weights of output gap and exchange rate gap are different across the sectors, with the latter being more important for the food sector. Imported inflation proxy is common across the sectors:

$$rmc_{t,nfood} = \beta_{72}\tilde{y}_t + (1-\beta_{72})\tilde{z}_t \qquad (5.8)$$

5.2.4 Headline inflation

Headline Consumer Price Index (CPI) is modelled as a weighted average of food and non-food indices (in logs) as follows

$$P_t = w_{food}\, P_{t,food} + \left(1 - w_{food}\right) P_{t,nfood} + disc_t \tag{5.9}$$

where P_t is headline CPI, $P_{t,food}$ and $P_{t,nfood}$ are the food and non-food indices, respectively (all of them in natural logarithms, which simplifies calculations), and w_{food} is the weight of food in the CPI basket. $disc_t$ captures the measurement errors in the CPI, modelled as a random walk:

$$disc_t = disc_{t-1} + e_t \tag{5.10}$$

where $e_t$is a white noise process. This residual component is needed to ensure additivity of the sub-indices; in practice it captures occasional changes in components' weights or measurement errors arriving from independent seasonal adjustment of the two components and the headline, which breaks the perfect additivity propriety.

Year-on-year headline inflation, 4π, is defined as

$$4\pi_t = P_t - P_{t-4} \tag{5.11}$$

and quarter-on-quarter headline inflation (which is annualized with the multiplication by 4) is defined as

$$\pi_t = 4\,(P_t - P_{t-1}) \tag{5.12}$$

5.2.5 Other model changes

As mentioned above, recent evidence based on observed nominal exchange rate evolution points to a less volatile FX market. In order to incorporate this change in economic behaviour within the QPM, the UIP equation was recalibrated. In particular, the nominal exchange rate dynamics was allowed to be more persistent by changing the relative weights of the determinants of exchange rate expectations formation mechanism, presented in section 3.2.3 above.

Similarly, in order to account for the more persistent effects (relative to the previous model specification) of the discretionary fiscal policy, the measure of fiscal impulse that enters the aggregate demand equation was adjusted. The contemporaneous fiscal impulse in the previous QPM version was proven to induce unwelcome noise in the business cycle, including on the account that annual fiscal deficit data interpolated to quarterly frequency was producing very volatile estimates; this complicated the building of a consistent narrative about the impact of fiscal policy on domestic demand, inflation, and monetary policy. The revised framework resorted to defining the relevant measure as a four-quarter average of the interpolated quarterly fiscal impulse, which allowed smoothing out occasional spikes and enhanced model-based analysis, being also consistent with the evidence of longer-lasting (more than one quarter) effect of discretionary fiscal policy on the economy.

5.2.6 Introduction of quarterly GDP in the model

Due to the high volatility in the available quarterly GDP numbers, the initial QPM used annual GDP, with quarterly series being estimated by interpolation while running model filtration. In the model extension, we introduced quarterly real GDP as published by the GSS. The primary series is seasonally adjusted using the Census-X12 procedure. The introduction of seasonally adjusted real GDP created measurement errors between the annual GDP and quarterly GDP. To properly account for this statistical discrepancy, a measurement shock, $\varepsilon_t^{d4Y\_yearly\_}$, was defined in the model. Therefore, the annual GDP measurement equation reflects this as

$$d4Y_{yearly\_GSS} = d4Y_{yearly} + \varepsilon_t^{d4Y_{yearly}} \quad 5.13$$

where, the left-hand side denotes annual series from GSS, while $d4Y_{yearly}$ on the right-had side represents the model counterpart of 4-quarter annual GDP growth.

5.2.7 Summary of model calibration

Table 5.1 provides an overview of the newly-introduced and recalibrated parameters. The calibration reflects the following observed stylized facts. Non-food inflation is more persistent and less noisy as compared to the food inflation, so lagged inflation coefficient is larger for the former ($\beta_{11} > \beta_{12}$) and standard deviation of the sectoral supply shock is larger for the latter (capturing also the idiosyncrasies related to weather conditions and international commodity prices swings that impact domestic food prices). Also, non-food prices are explained relatively better by the fundamental factors like aggregate demand conditions, so that the pass-through of real marginal costs is two times larger. The definition of sectoral real marginal costs is specified such as to allow for a relatively stronger impact from domestic input prices (output gap) on non-food items, and for a relatively more pronounced effect coming from imported input prices (RER gap) on food items, thus $\beta_{71} > \beta_{72}$.

Table 5.1: Current QPM calibration

Parameters	Description	Calibrated Value
Phillips Curve (non-food)		
β_{11}	Non-food inflation persistence parameter	0.7
β_{21}	Pass through coefficient of real marginal cost (RMC) to non-food inflation	0.4
β_{31}	Coefficient of imported inflation	0.1
β_{41}	Policy incredibility pass-through to non-food inflation	0.5
β_{71}	Share of output gap in real marginal cost in the non-food sector	0.7
Phillips Curve (food)		
β_{12}	Food inflation persistence parameter	0.5
β_{22}	Pass through coefficient of real marginal cost (RMC) to inflation	0.2
β_{32}	Coefficient of imported inflation	0.1
β_{42}	Policy incredibility pass-through to food inflation	0.25
β_{72}	Share of output gap in real marginal cost in the food sector	0.6
UIP		
c_2	Weight of model-consistent exchange rate expectations	0.6
Central Bank Credibility		
β_5	Persistence in policy incredibility	0.5
β_6	Long-run effect of inflation deviation from target on credibility	1.5
Standard Deviation of Shocks		
$\varepsilon_t^{\pi_{nfood}}$	Domestic non-food supply shock	1.5
$\varepsilon_t^{\pi_{food}}$	Domestic food supply shock	2.0
$\varepsilon_t^{d4Y\_yearly\_}$	GDP measurement error	1.0

Source: BOG QPM

5.3 Impulse response functions

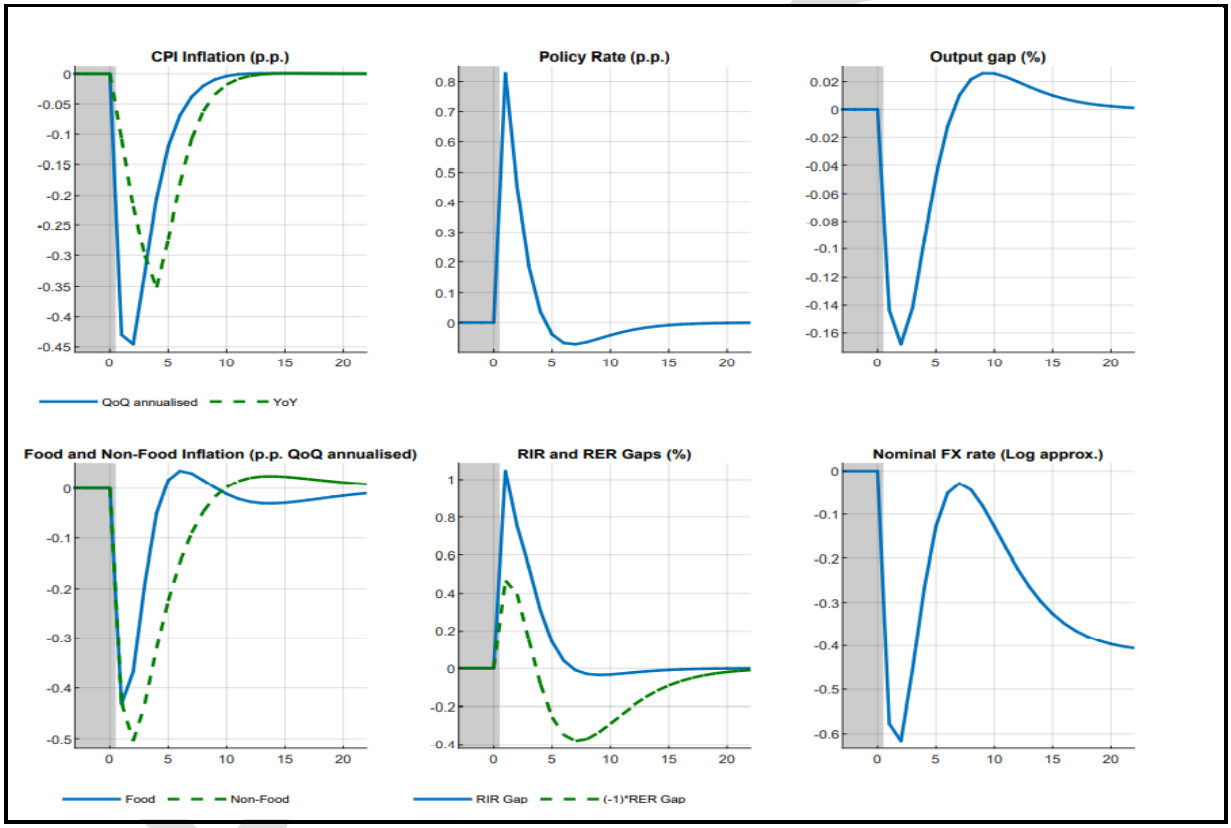
This section briefly analyses the impulse response functions implied by the extended and recalibrated model. In all figures in this subsection, we present dynamic responses to several structural shocks of one unit size, with values being expressed in deviations from the corresponding equilibrium (e.g., for inflation rate this is represented by the target).

5.3.1 Monetary policy shock

We start by examining the properties of recalibrated BOG's QPM and extended to two separate Phillips curves for food and non-food sub-indices by illustrating the impact of a one-time monetary policy shock. In this case, we consider the impact of a one-unit positive shock in the policy interest rate equation; Figure 10 displays the results. Qualitatively, macro responses to monetary policy shock are broadly similar to those in the earlier QPM version with a single Phillips curve, described in Chapter 4. Contractionary effects of the shocks are reflected in a hump-shaped negative trajectory of the output gap. The transmission works through both components of the real monetary conditions: real interest rate (RIR) gap is tightened via higher nominal and, consequently, real rates, while real exchange rate (RER) gap becomes overvalued on the account of the nominal

appreciation. As a result, food and non-food inflation decline by a maximum of 0.43 and 0.5 percent in quarterly annualized terms, respectively. Consistent with the calibration of higher inertia, non-food prices register their largest decline three quarters after the shock, one quarter later than the food prices. The response of headline inflation represents a weighted average of the two components' reactions. Also, the monetary policy shock has a greater impact on non-food inflation than on food inflation. This is largely the result of the assumed higher relative weight of output gap vis-à-vis RER gap in the real marginal costs for non-food items as opposed to food items.

Figure 10: Effects of monetary policy shock



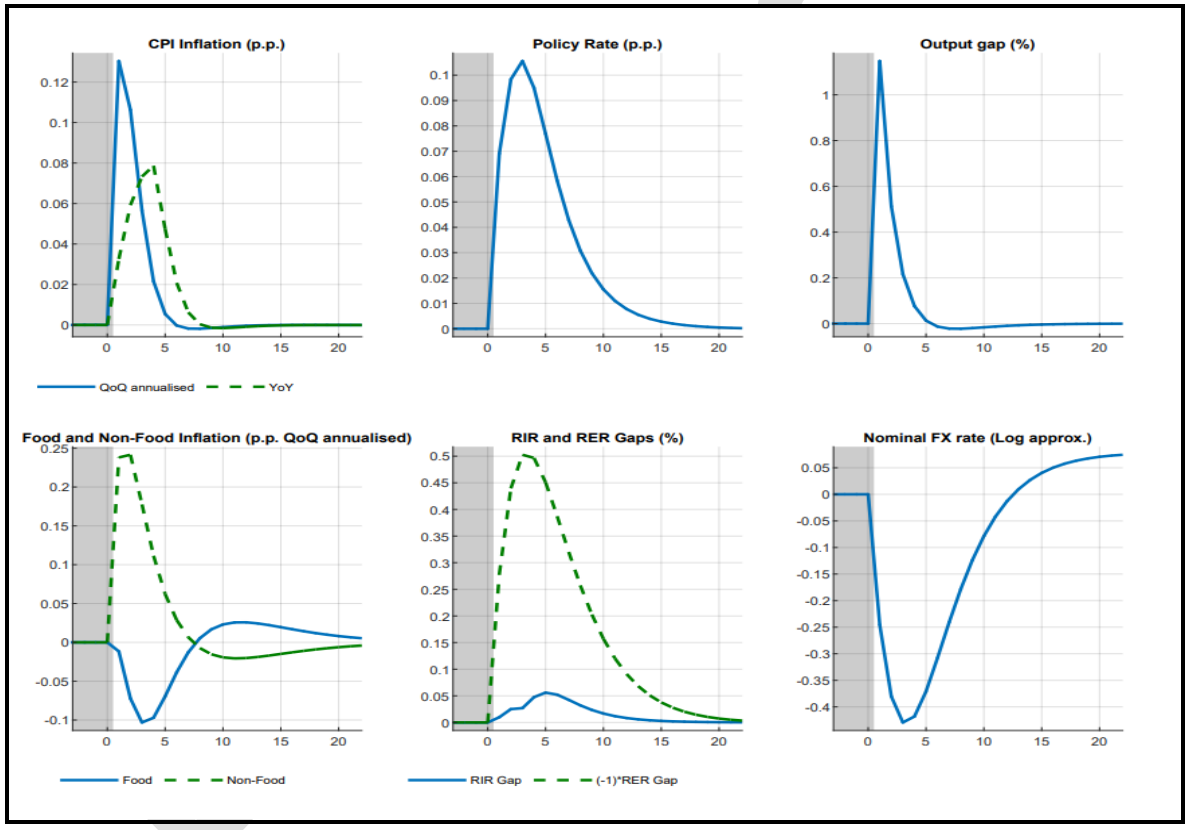
Source: BOG QPM

5.3.2 Aggregate demand shock

Figure 11 displays the responses to an aggregate demand shock in the recalibrated model with two Phillips curves. The resultant impulse response functions reveal that a positive shock raises overall inflation in the first quarter, driven by a surge in non-food inflation. This is the result of the higher demand producing an increase in the domestic component of the real marginal costs, which is relatively more important and has a larger direct pass-through in the case of non-food prices. On the contrary, the aggregate demand shock causes food prices to fall, induced by a positive real exchange rate gap, which dominates the effect coming from higher domestic output gap. Intuitively, this is a reflection of the central bank reacting to this shock. Namely, policy rate

increases, which appreciates the currency and, hence, drives food inflation down (which depends on the exchange rate more), counterbalancing a rise in non-food. The latter still dominates though and, therefore, overall CPI inflation increases above the target. Similar to the old model, the central bank responds not only to higher than targeted headline inflation, but to positive output gap as well, by raising the short-term interest rate. The domestic currency strengthens in both nominal and real terms; together with positive real interest rate gap this causes tighter monetary conditions, which contribute to the gradual closing of the positive output gap and above-target inflation deviation.

Figure 11: Effects of demand shock



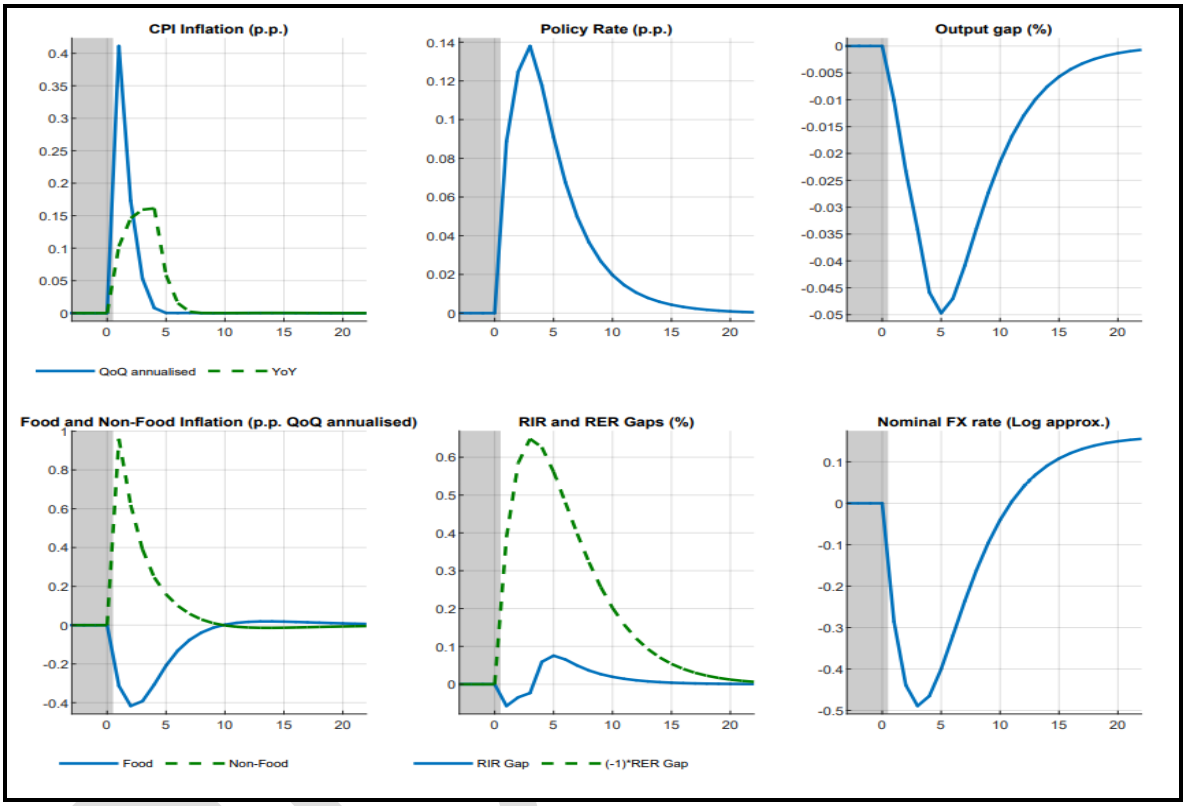
Source: BOG QPM

5.3.3 Non-Food supply shock

In this scenario, we assume an adverse effect on non-food prices directly in the form of a positive one-percentage-point non-food (Phillips curve) shock. Figure 12 exhibits the impact of this non-food supply shock in the extended model. The adverse non-food shock results in a pick-up in non-food prices and overall inflation in the first quarter, despite non-food prices declining slightly thereafter (as a result of lower marginal costs due to both domestic and imported components – see below). In a standard fashion, the central bank raises nominal interest rate in response to the uptick in headline inflation, which in turn induces a nominal appreciation and a positive real exchange rate gap (i.e., overvalued currency). Real interest rate gap becomes negative due to

higher inflation expectations in the initial periods but turns positive as inflation and inflation expectations decline as a result of tighter monetary policy and overvalued RER. Output declines in the short-term, primarily due to appreciation in the real exchange rate and dampening aggregate demand through the trade channels. Hence, it's a monetary policy reaction that drives the non-food and, hence, headline inflation back down to the target.

Figure 12: Effects of a non-food supply shock



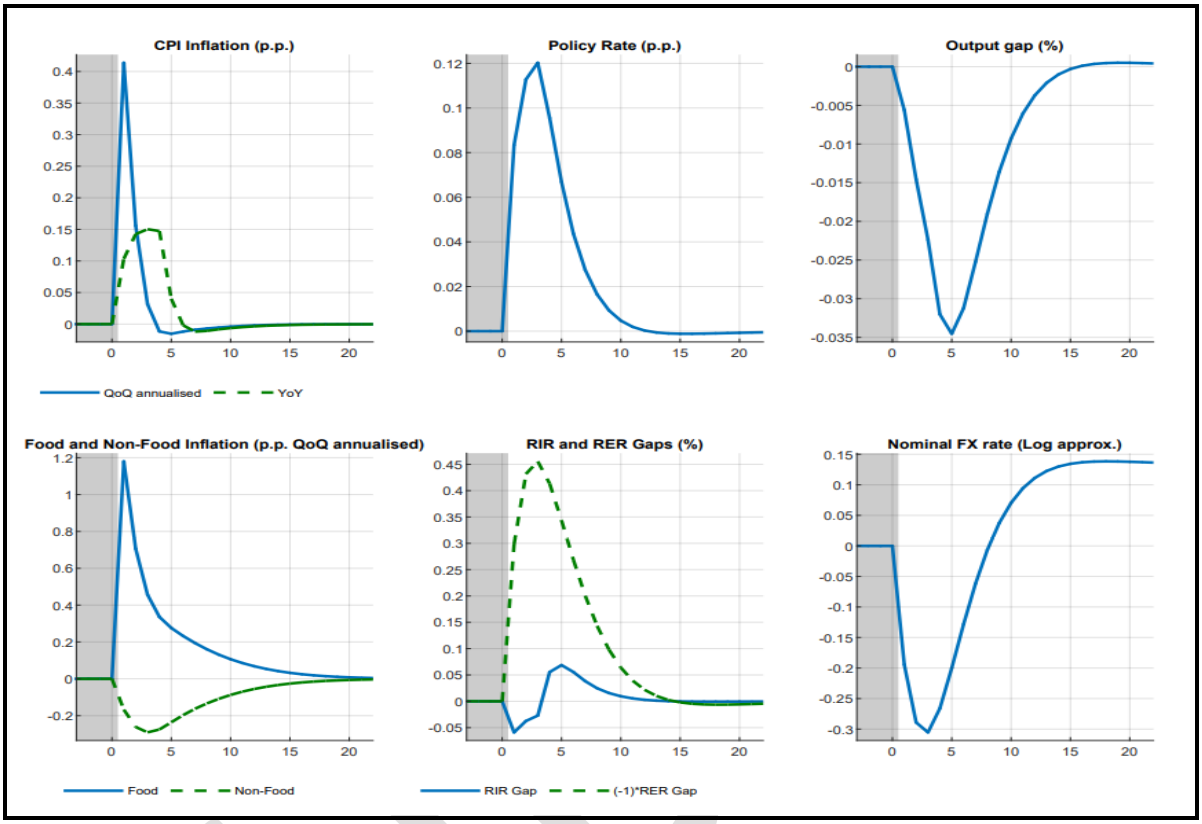
Source: BOG QPM

5.3.4 Food supply shock

Figure 13 illustrates the impact of an adverse (positive) food supply shock implied by the extended model. The shock increases food and aggregate prices, despite non-food inflation declining slightly. To dampen the second-round effects of the adverse food shock, the central bank moderately raises the nominal interest rate. The lower-than-proportionate increase in the nominal interest rate results in negative real interest gap (i.e., loose policy stance) in the initial quarters, but the real interest rate rises subsequently as price pressures taper off. Nevertheless, monetary conditions become restrictive due to the steady appreciation in the domestic currency (in both nominal and real terms). Tighter real monetary conditions put a drag on output, with a trough by the fifth quarter following the shock. Output recovers thereafter towards the steady state level as real monetary conditions gradually ease again. Worth noting is that, while headline inflation dynamics is almost quantitatively the same, monetary policy reacts relatively less in this case relative to the reaction to non-food inflation shock. The reason is that food price shocks are

generally of a more temporary nature, and the disaggregation implemented in the model properly captures this evidence.

Figure 13: Effects of a food supply shock

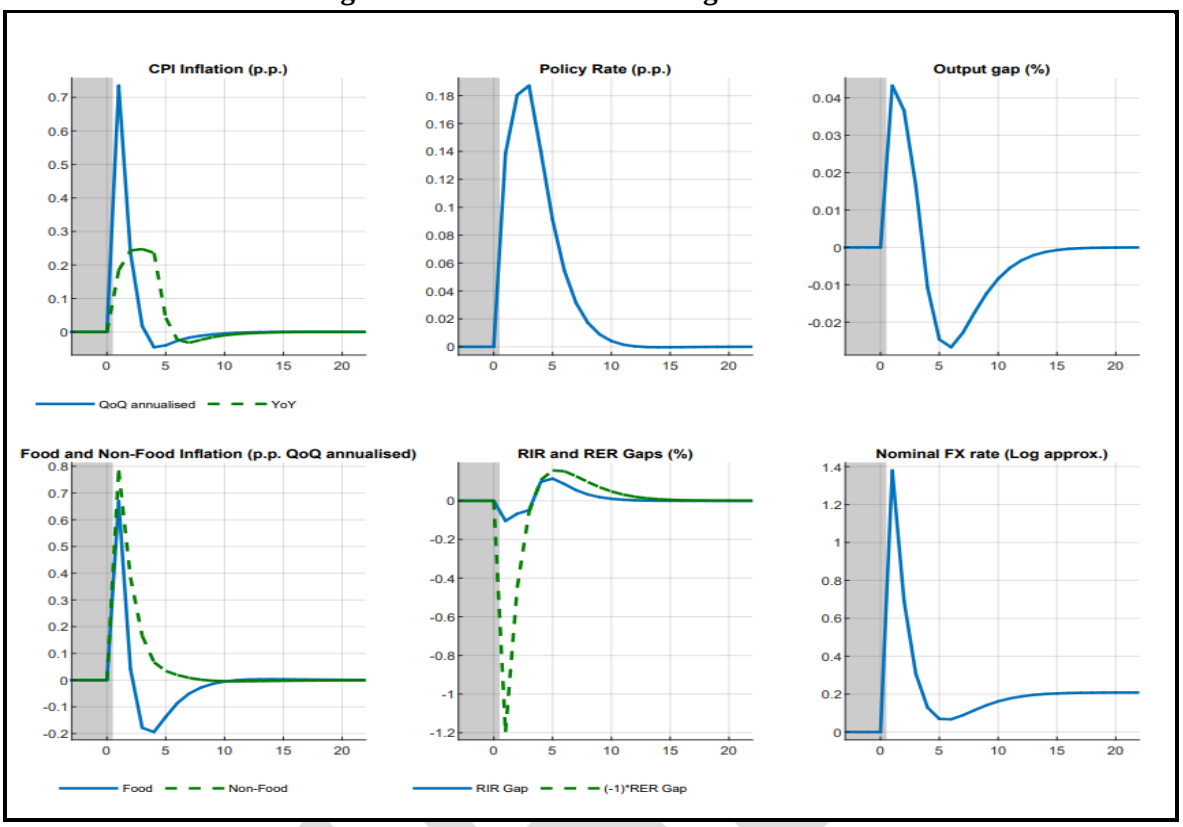


Source: BOG QPM

5.3.5 Exchange rate shock

Figure 14 shows the responses to a positive exchange rate shock in the UIP condition (i.e., depreciation). The emerged qualitative macro responses following a positive exchange rate shock are similar to the previous model version. The shock leads to nominal and real exchange rate depreciation, which passes-through to above-target headline inflation. The surge in headline inflation reflects both food and non-food price increases, primarily via the imported component of the real marginal costs as a result of negative (undervalued) RER gap. Monetary authority responds to these price pressures and the weakening of the domestic currency by raising the short-term interest rate. The real interest rate gap however becomes negative initially due to relatively higher inflation expectations at first. This, together with real exchange rate depreciation, leads to lose real monetary conditions, causing a positive output gap in the initial periods. The gradual increases in both the nominal and real interest rates after the first period strengthen the domestic currency, which in turn tighten real monetary conditions and contribute to the return of the output and inflation towards the steady state levels.

Figure 14: Effects of an exchange rate shock



Source: BOG QPM

5.4 Model-based decomposition of inflation and output

Model equations and parameterization can be used to filter actual data and decompose the variables into the contributions of the structural factors. Generally, and consistent with the specification of the two Phillips curves, a positive output gap (i.e., strong demand pressures) increases inflation due to rising or excess demand pressures feeding into producers' costs; the opposite effect is true for negative output gap (i.e., weak aggregate demand pressures). This is usually the case when inflation is driven at least to some extent by demand-side factors. In the face of adverse (favourable) supply-side shocks, however, costs of production increase (decline) which in turn triggers negative (positive) output gap alongside rising (declining) inflation.

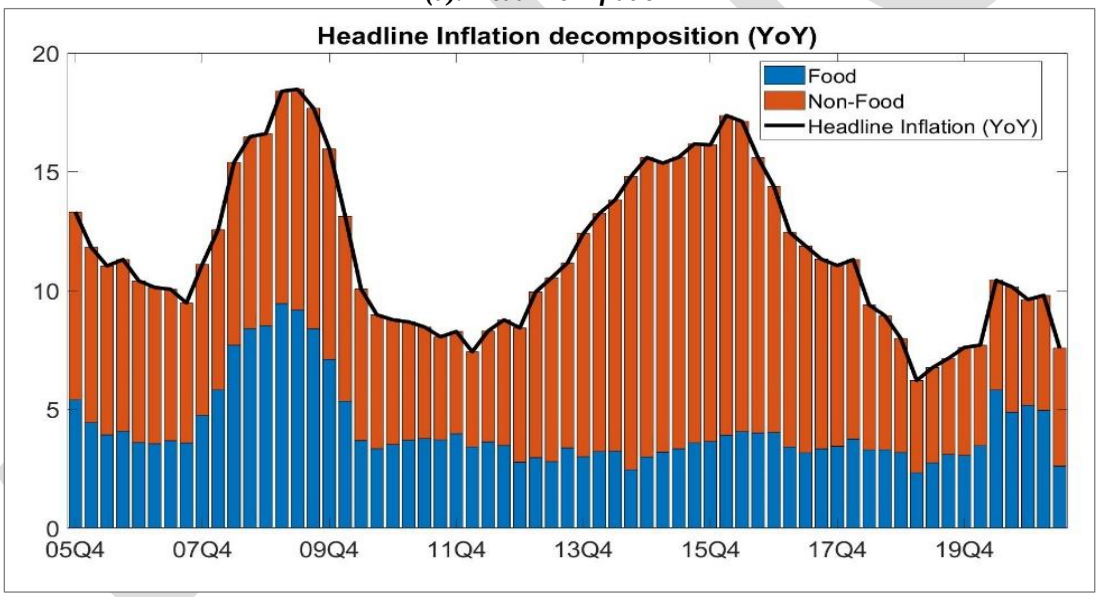
In this context, Figure 15 displays the evolution of inflation (headline in panel (a), food and non-food components in panel (b)) and output gap (panel (c)) in Ghana based on the recalibrated model. Qualitatively, the model satisfactorily captures the key dynamics of inflation, its determinants, as well as the overall macroeconomic developments in Ghana. A conspicuous observation is that there are periods during which inflation rises when output gap is falling or becoming more negative, while increasing or more positive output gap (i.e., rising demand pressures) is associated with disinflation. This demonstrates that supply-side shocks have predominantly and consistently contributed to inflation dynamics in Ghana, which restrained the central bank's ability to maintain

low and stable inflation over the years. Intuitively, the frequent incidence of supply-side shocks is due to inherent structural constraints. However exogenous shocks have also played an important role, such as during the emergence of the COVID-19 pandemic in early 2020. Given the preponderance of supply-side factors in the determination of inflation, the ensuing paragraphs systematically analyse the evolution of inflation and output gap in Ghana implied by the BOG's FPAS model.

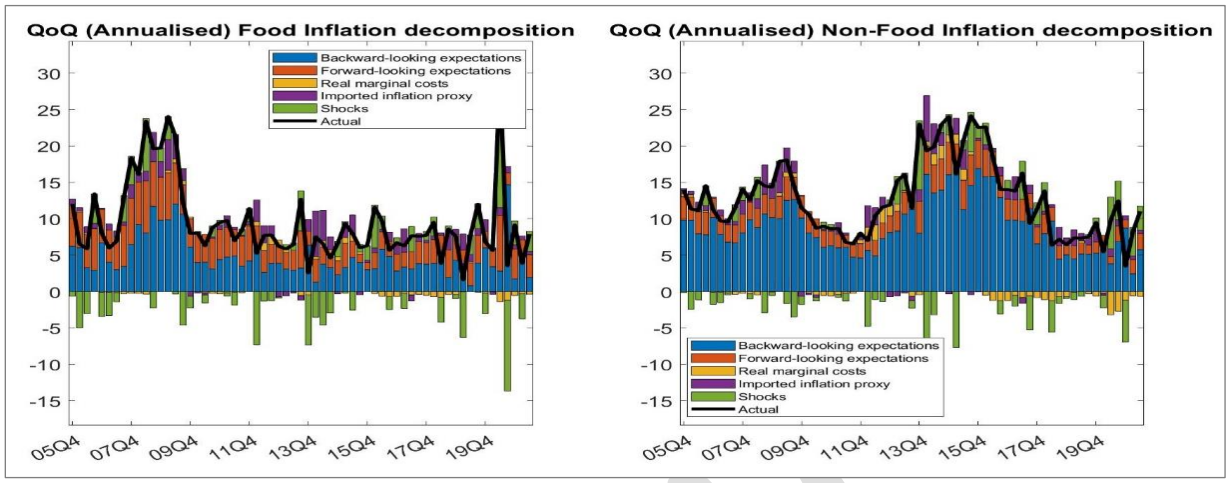
Consistent with Ghana's small-open economy characteristics, both domestic and external factors have also impacted inflation and output over the years. Particularly, the rise in inflation between the late-2007 and early-2009 was broadly explained by adverse supply-side shocks (linked to the negative impact of the Great Recession of 2007-2009 and election-related uncertainties, which negatively impacted domestic currency in 2009), rising inflation inertia and expectations, as well as higher imported inflation (at the back of soaring global commodity prices).

Figure 15: Model-based decomposition

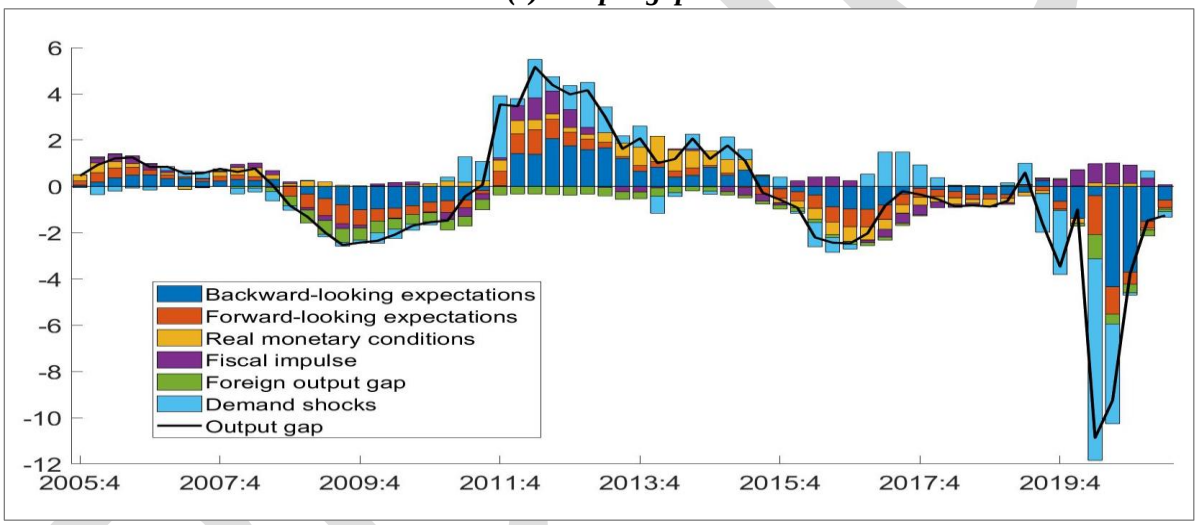
(a). Headline inflation



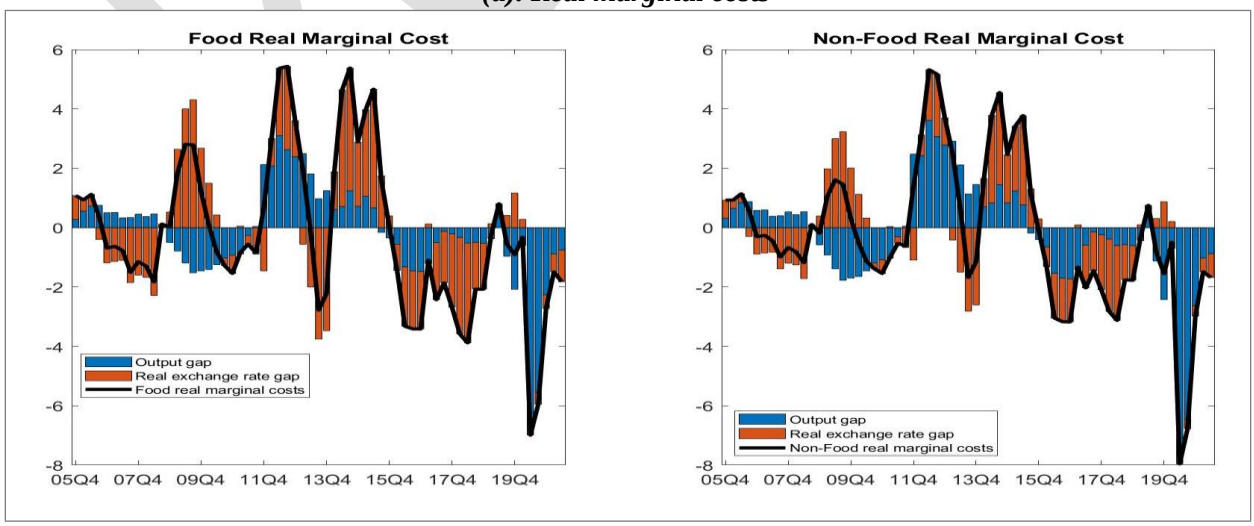
(b) Food and non-food inflation decomposition



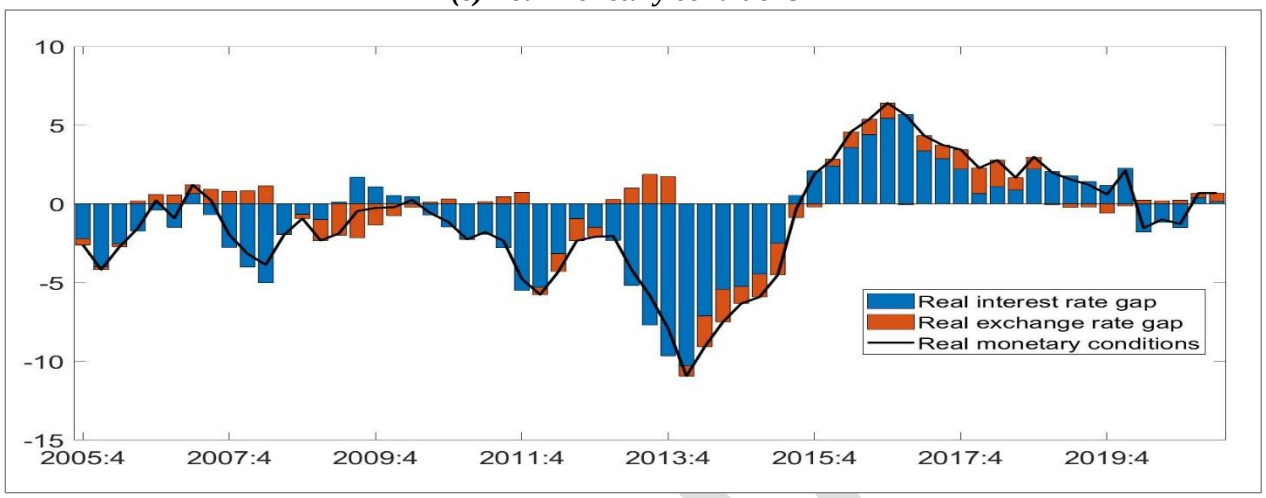
(c). Output gap



(d). Real marginal costs



(e) Real monetary conditions



Source: BOG QPM

At the same time, the negative output gap widened during 2009 due to weaker external demand and negative fiscal impulse, with the latter linked to the stringent post-election fiscal consolidation (see Figure 15c). The disinflationary episode between mid-2009 and end-2011 was attributed to decline in real marginal costs (related to subdued domestic aggregate demand alongside moderate real exchange rate appreciation) and lower inflation expectations. In addition, favourable cost-push shocks supported disinflation and, at the same time, boosted aggregate demand (see Figure 15a, b & c) during the period.

Conversely, the general acceleration in inflation for the period 2012-2014 was driven by rising marginal costs and imported inflation via large real exchange rate depreciation (see Figure 15a & d). In concert, loose monetary conditions, which boosted aggregate demand, further reinforced the acceleration in inflation during the period.

Further spikes in inflation from early-2015 to the first half of 2016 were triggered by adverse cost-push shocks associated with the energy supply challenges, which also negatively impacted domestic aggregate demand. The decline in both real marginal cost and inflation inertia led to a faster disinflation from the second half of 2016 to the first quarter of 2019. Noticeably, subdued aggregate demand pressures on the back of tighter real monetary conditions (primarily via tighter monetary policy stance; see Figure 15e) also facilitated the drop in real marginal cost during this period (see Figure 15d).

The slight increase in inflation between the second quarter of 2019 and first quarter of 2020 was mainly underpinned by higher real marginal costs due to the recovery in aggregate demand (output gap) via greater fiscal impulse and easing real monetary conditions (owing to real exchange rate depreciation).

The spike in inflation during the second quarter of 2020 was predominantly driven by adverse cost-push shocks linked to the COVID-19 containment measures, which also induced a sharp contraction in the output gap. Besides negative demand shocks, the other factors that contributed to the sharp dip in domestic output gap during the period were weaker external demand and greater anticipation of slower domestic economic activities. The extent of contraction in the output gap was conceivably moderated by the provided policy support, with policy rate cuts reflecting an accommodative monetary policy stance (indicated by the negative contribution of real interest rate gap within the real monetary conditions), and fiscal measures captured by a positive fiscal impulse.

All these estimates based on the model capture the historical context reasonably well. This fact, along with theoretically consistent and quantitatively plausible impulse responses, underlines the usefulness of the model for policy analysis and scenario simulations. Following well-established central bank practice, the BOG is continuously monitoring and evaluating its analytical toolkit, reacting in an efficient way to the ever-changing global and national economic landscape. The BOG's QPM that underpins the Bank's FPAS is periodically updated – including through parameter recalibrations, extensions, data-related refinements, etc. – to incorporate latest stylized facts and accumulated empirical evidence, thus remaining representative for the current or expected economic mechanisms. The continuous development and organic evolution of the analytical toolkit is essential for the real-time model-based analysis to remain an important input into building economic narrative and supporting monetary policy making.

Chapter 6: Conclusion

Bank of Ghana's monetary policy framework has gone through three main phases – direct control, monetary targeting, and currently the inflation targeting framework. The direct control era involved the use of interest rate controls, credit ceilings and directed lending. This led to inefficient allocation of resources and imposed significant costs on the financial system. The monetary targeting framework relied heavily on the quantity theory of money and presupposed that money was the only channel through which monetary policy actions could impact the real economy. The large monetary accommodation during this period necessitated further reforms in monetary policy formulation. The objective of the reform process was to strengthen the Bank's policy framework and re-anchor inflation expectations.

With the passage of Act 612 and the subsequent inauguration of the MPC in November 2002, the Bank developed the institutional structures that ultimately led to the adoption of Inflation Targeting (IT) in May 2007. Under the IT framework, monetary policy is designed to drive inflation within the medium-term path consistent with the adopted definition of price stability. As part of the IT process, the Bank developed a core macroeconomic model for forecasting and policy analysis to support the monetary policy formulation.

The model is a Semi-Structural New Keynesian (SSNK) model and referred to as the Quarterly Projection Model (QPM). The QPM approximates two main monetary policy transmission channels; the interest rate channel and the exchange rate channel with expectations playing a major role. The interest rate channel works through the financial intermediaries, aggregate demand, and to prices, while the exchange rate channel works through net exports, aggregate demand, and then to prices. The model comprises four blocks – the aggregate demand, a Phillips curve, an exchange rate block, and a monetary policy reaction function.

After several years of using the QPM for its forecasting processes, the Bank saw the need to re-calibrate and extend the model. This was done through the disaggregation of the Phillips curve (headline inflation) into food and non-food inflation equations to improve policy analysis and communication.

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