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Policy Analysis Model for the Philippines

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Abstract

This paper aims to present the BSP's Policy Analysis Model for the Philippines (PAMPh) along with its key features and properties. PAMPh is a New Keynesian semi-structural gap model for analyzing monetary transmission mechanism of key macroeconomic variables and generating their medium-term forecast path. The model captures the key transmission mechanisms of the Philippine economy and features endogenous monetary policy. Agents in the model are forward-looking and react to the expectations of future policy decisions. The model is suitable for monetary policy analysis, forecasting, and serves as guide in the BSP's policy-making process. The paper likewise includes an analysis of the transmission mechanism using impulse responses.

JEL Classification: E31; E37; E52; E58

Keywords: quarterly projection model, semi-structural, monetary policy, forecasting, FPAS, transmission mechanism, inflation, Philippines

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Policy Analysis Model for the Philippines (PAMPh)

Sarah Jane Alarcon, Paul Reimon Alhambra, Rosemarie Amodia and Dennis Bautista[1]

1. Introduction

Since 2002, the Bangko Sentral ng Pilipinas (BSP) has adopted the inflation-targeting approach to monetary policy (BSP, 2020b). As with other inflation-targeting central banks, macroeconomic forecasts are among the key considerations in BSP's policy-making process. Inflation forecasts are essential inputs in the formulation of BSP's monetary policy decisions which are forward-looking and data-driven. As such, the BSP adheres to pluralistic approach to modelling and forecasting. The Policy Analysis Model for the Philippines (PAMPh) is part of the BSP's suite of forecasting models and is based on the Forecasting and Policy Analysis System (FPAS) model blueprint developed by the International Monetary Fund (IMF) (Berg, et al., 2006). This paper presents the key features and properties of PAMPh to apprise the public and other researchers of one of BSP's forecasting and policy analysis models. PAMPh serves to complement the current workhorse macro model of the BSP for monetary policy analysis and medium-term forecasting. The model provides a platform to synthesize near-term forecasts generated by econometric models with expert judgment to form a theoretically-consistent and story-driven outlook of the Philippine economy. Moreover, the monetary policy is endogenous to the model, which allows the model to generate a medium-term policy path consistent with the government inflation target. PAMPh likewise provides a tool for analyzing the transmission of shocks to key variables. Thus, PAMPh could serve as a guide in the BSP's policy-making process.

The rest of this paper is organized as follows. Section 2 introduces the theoretical foundations of PAMPh and provides an overview of the model's transmission mechanism diagram. Section 3 presents the data set used. Section 4 presents the key equations of the model including the (a) output gap equation, (b) Phillips curve, (c) monetary policy rule, and (d) uncovered interest rate parity (UIP). The foreign and commodities blocks are likewise shown in this section. Section 5 describes and analyzes the impulse responses of (a) monetary policy shock, (b) domestic demand shock, (c) core cost-push shock, (d) food cost-push shock, and (e) energy cost-push shock. The final section concludes.

2. The PAMPH Framework

The PAMPh follows the quarterly projection model (QPM) structure of IMF's FPAS framework. The FPAS is a structure of data management, forecast generation and reporting, as well as policy communication with the end-goal of delivering an effective monetary policy towards stable price conditions. This structure puts emphasis on macroeconomic data and forecasts in the determination of a central bank's monetary policy direction. In this framework, a central bank utilizes a suite of models over the near- and medium-term horizons to guide decisions of policy-makers towards their price stability objectives.

[1] The authors are officers and staff of the Department of Economic Research of the Bangko Sentral ng Pilipinas.

PAMPh is a New Keynesian semi-structural gap model that extends the BSP's Macroeconomic Model for the Philippines (MMPH) developed by Bautista, et al. (2013). Some updates from the MMPH include (a) disaggregating consumer price index (CPI) into its core, food, and energy components; (b) re-defining real exchange rate with respect to USD as trade-weighted real effective exchange rate(REER); (c) re-defining the structure of interest rates based on the policy rate and market rate; (d) including business process outsourcing (BPO) receipts and Overseas Filipinos (OF) remittances; and (e) re-calibrating of parameters. These refinements are intended to obtain more information about the dynamics of the macroeconomy as well as to capture the idiosyncratic features of the Philippine economy and thus, aid in BSP's policy analysis.

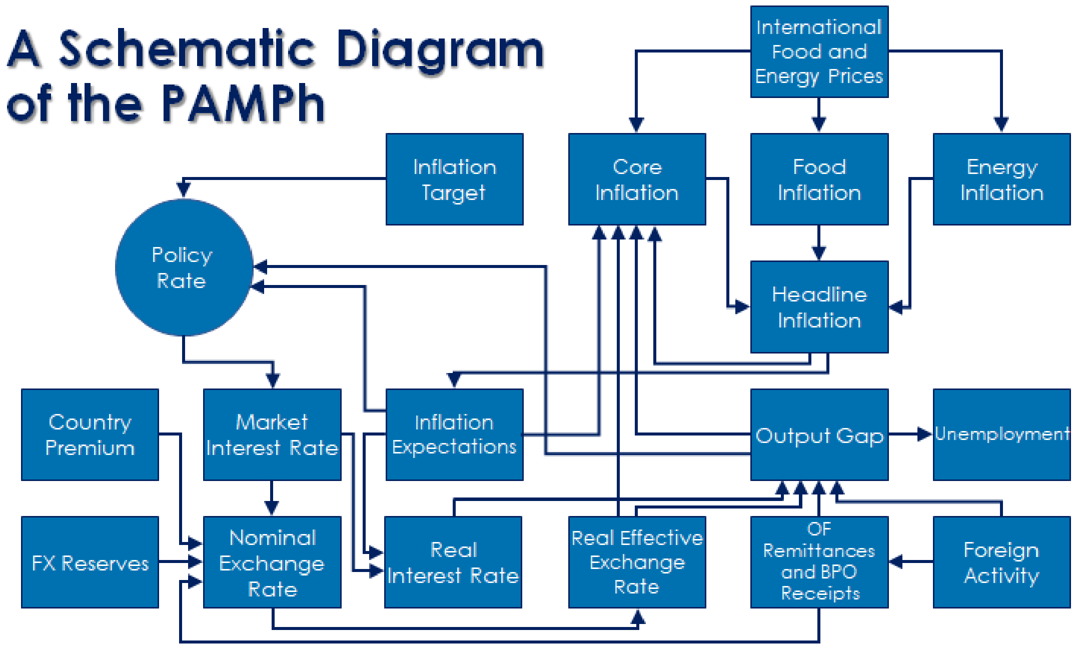
PAMPh takes a spot between a statistical model, e.g., autoregressive integrated moving average (ARIMA) (Box, et al., 2015), vector autoregression (VAR) (Sims, 1980; Christiano, 2012), etc., and a Dynamic Stochastic General Equilibrium (DSGE) model (Christiano, et al., 2010; Tovar, 2018). The PAMPh is built on the blueprint of standard small open economy DSGE models. However, it deviates from the strictly micro-founded DSGE models in order to properly fit the data and describe unique features of the particular economy. Even so, the model exhibits the structural, stochastic, and general equilibrium properties of a DSGE model. The PAMPh also incorporates adaptive and rational expectations of agents. Moreover, the parameters of PAMPh are calibrated, rather than estimated. The coefficients of the model equations provide that the impulse response functions generated by the model are theoretically sound and consistent. At the same time, the goodness of fit over historical data is considered in calibrating the parameters.

As a policy analysis model, PAMPh has limited predictive power for short-run trends as compared with econometric models and therefore, is usually combined with other models. Nonetheless, the PAMPh has the flexibility to incorporate near-term forecasts of other models and expert judgment of sector specialists in the forecasting and scenario-building process. In the case of the BSP, near-term forecasts generated by a CPI disaggregated ARIMA model on inflation (Allon, 2015) and by a Bayesian VAR (Litterman, 1986) on GDP are used as inputs in setting the initial conditions in PAMPh. Moreover, PAMPh complements the BSP's workhorse models – the Multi-Equation Model (MEM) and the Single Equation Model (SEM). MEM and SEM are econometric models where the BSP's policy rate is taken as an exogenous variable i.e., they do not allow a feedback loop to affect the policy rates. In PAMPh, the endogeneity of the policy rate allows it to respond to movements in inflation and other macroeconomic variables in the model, particularly, the deviation of the projected inflation from the target. The model ensures that the monetary policy actions are consistent with the objective of maintaining inflation close to the long-run target. Thus, this model feature is essential in the proper conduct of monetary policy under the inflation-targeting framework.

Furthermore, PAMPh incorporates Philippine-specific features such as the disaggregated CPI into core, food, and energy components as well as the remittances from OFs and BPOs which are important sectors in the Philippine economy. The market interest rate is also defined to reflect BSP's policy rate, the 91-day T-bill rate, and the interbank call loan rate to ensure a more realistic transmission of monetary policy to the real economy. Currently, the model does not explicitly capture some sectors of the economy such as the fiscal sector and the external sector (i.e., Balance of Payments). These and other sectors may later be incorporated as extensions to the model. Nonetheless, it should be recognized that there is a trade-off between model size and model tractability which needs to be carefully navigated with models used for regular forecasting exercises. Nonetheless, PAMPh at its current state can be used to analyze the key features of the Philippine economy for monetary policy analysis and support policy advice.

Figure 1 is a schematic diagram which highlights key relationships in the model. Similar to the Gou's (2019) Philippine model, PAMPh introduces a disaggregated headline inflation in the model. This extension allows the researchers to understand, in more detail, the demand and supply sources of domestic inflation. It can be observed that core, volatile food, and volatile energy components comprise headline inflation. These components are influenced by international prices, among others. There is a two-way causation between core inflation and headline inflation[2] to account for possible secondary round effects of sustained high inflation from volatile food and volatile energy that could feed into the non-volatile items of the CPI. At the same time, the link from inflation expectations to core inflation reflects the role of market expectations in domestic price dynamics. Headline inflation affects inflation expectations, which when taken against the inflation target, influences the monetary policy direction of the BSP. The policy interest rate is likewise affected by the output gap, or the deviation of actual output from its potential. Remittances gap, which is partly explained by foreign activity, is also a determinant of output gap and nominal exchange rate. Changes in the foreign exchange reserves has a direct link to nominal exchange rate, accounting for BSP's foreign exchange intervention during times of excessive volatility.

Figure 1. Schematic Diagram of Key Transmission Channels in PAMPh



[2] Core inflation is an indicator of the underlying price pressures or long-term inflation trend, commonly computed by excluding volatile components such as food and energy items from the CPI. Meanwhile, headline inflation is the rate of change in the CPI, a basket of goods and services consumed by a typical Filipino household (BSP, 2020a).

Any change in BSP's policy rate influences movements in market interest rate that subsequently determine the real interest rate. The real interest rate then feeds these variations back to the real economy. To be specific, monetary policy exerts its influence on the economy through three channels: interest rate, exchange rate and expectations.

a. Interest rate channel

The changes in real interest rate determines the short-run decisions of economic agents' current demand versus future demand. An increase in real interest rate influences agents to forego current consumption and increase their savings which in turn, reduces price pressures.

b. Exchange rate channel

Lower policy interest rate is associated with lesser desirability for domestic assets. Thus, the demand for domestic currency weakens, resulting in a depreciation of domestic currency. Price pressures could come from higher cost of imported goods. However, external competitiveness could improve with the weaker currency providing support to economic activity, which could lead to demand-side inflationary pressures.

c. Expectations channel

The monetary policy direction influences expectations on future economic growth, inflation, and interest rate path. Thus, a credible central bank plays a crucial role in economic agents' intertemporal decisions on consumption, investments, and savings. A credible conduct of monetary policy assures firms and households that future shocks will be assessed prudently and if necessary, policy actions will be implemented to mute their possible adverse effect to the economy.

3. Data

The PAMPh uses key macroeconomic variables for the Philippines, as listed in Table 1 below. For the external sector including commodities part of the model, the PAMPh uses data and forecasts from the Global Projection Model++ (GPM++), prepared monthly by the Global Projection Model Network (GPMN) Research Inc.[3] As applicable, variables were seasonally adjusted using X12 in IRIS toolbox.

[3] The GPM++ is a series of country or regional small macro models incorporating carefully articulated real and financial linkages that allow forecasters to project a coherent world economic outlook. The latest version of the GPM, GPM++, has 10 regions (+commodities block) that covers about 83 percent of the world economic output.

Table 1. PAMPh key macroeconomic variables

Variable	Data Source*
Domestic Variables	
Gross Domestic Product (2018=100, in million PhP)	PSA
Unemployment Rate (in percent)	PSA
Inflation target (in percent)	DBCC
Consumer Price Index (2012=100)	PSA
Consumer Price Index – Core (2012=100)	PSA
Consumer Price Index – Food (2012=100)	PSA
Consumer Price Index – Oil (2012=100)	PSA
Nominal exchange rate (PhP:1USD)	BSP
Gross international reserves (in million USD)	BSP
OF remittances (in million USD)	BSP
Reserve requirement rate (in percent)	BSP
Weighted monetary operations rate (in percent)	BSP
91-day PH treasury bill rate (in percent)	PDEx
Interbank call loan rate (in percent)	BSP
Business Process Outsourcing Revenue (in million USD)	BSP
Emerging markets bond index – Philippines	Bloomberg
Commodity Variables	
World oil price (USD per barrel)	GPM++
World food price index (USD per basket)	GPM++
World real oil price gap (in percent)	GPM++
World real food price gap (in percent)	GPM++
Annualized equilibrium world real oil price (USD per barrel)	GPM++
Annualized equilibrium world real food price (USD per basket)	GPM++
External Variables – US	
US core inflation target (in percent)	GPM++
US core inflation (in percent)	GPM++
US nominal interest rate (in percent)	GPM++
US equilibrium real interest rate (in percent)	GPM++
US output gap (in percent)	GPM++
US domestic spillover effect (in percent)	GPM++
US GDP (2012=100, in million USD)	GPM++
External Variables - Other Regions (Euro Zone, Japan, China, 'Rest of the World)	
Core inflation (in percent)	GPM++
Nominal interest rate (in percent)	GPM++
Output gap (in percent)	GPM++
Real exchange rate (RER) with respect to USD (LCY:USD)	GPM++
Equilibrium RER with respect to USD (LCY:USD)	GPM++
Equilibrium RER with respect to USD depreciation rate (percent)	GPM++
RER to USD gap (percent)	GPM++
Nominal exchange rate (NER) with respect to USD (LCY:USD)	GPM++
Domestic spillover effect (in percent)	GPM++
GDP (in million local currency)	GPM++

**DBCC – Development Budget Coordination Committee; PSA – Philippine Statistics Authority; PDEx – Philippine Dealing & Exchange Corporation*

4. Key Equations

This section outlines the key equations of PAMPh including the (a) output gap equation, (b) Phillips curve, (c) monetary policy rule, and (d) UIP equation. The foreign and commodities blocks are likewise presented in this section.

4.1 Output gap equation

Output gap, Yg, is the deviation of actual GDP from potential output, Yt, which is the level of domestic output consistent with the inflation being on target. The IS curve describes the relationship between the output gap and determinants of the domestic demand. Output gap depends on its lagged and lead terms, real interest rate gap, real remittance gap, REER gap, gap in foreign activity, foreign residual activity, and a shock to domestic demand:

$$\begin{aligned} Yg = \alpha_1 * Yg\{-1\} + \alpha_2 * Yg\{1\} - \alpha_3 * (RRg + RRg\{+1\})/2 + \alpha_4 * RMTg \\ + \alpha_5 * \left(REER_{Tg}\{-1\} + REER_{Tg}\{-2\} + REER_{Tg}\{-3\} + REER_{Tg}\{-4\}\right)/4 \\ + \alpha_6 * FACT + \alpha_9 * FACT_{RES} + RES_{YG} \end{aligned} \quad (1)$$

where:

Yg	Output gap (%)
RRg	Real interest rate gap (pp)
$RMTg$	Real remittances gap in local currency (%)
$REER_{Tg}$	Trade-weighted REER gap (100*log)
$FACT$	Foreign activity (%)
$FACT_{RES}$	Foreign residual activity
RES_{YG}	Domestic demand shock

The real interest rate gap, RRg, affects aggregate demand through the interest rate channel. When real interest rate is high relative to the neutral rate, households will prefer to delay their consumption in favor of savings due to higher opportunity costs. Likewise, investors will curb investments due to higher borrowing costs. Thus, the real interest rate gap enters into the output gap equation with a negative sign. The lead term of the real interest rate gap represents the forward-looking behavior of households and investors.

In the Philippines, aggregate domestic demand is partly driven by remittances from OFs and receipts from BPOs. Increased remittances compared to its trend positively boost domestic demand through higher household consumption, reflecting its procyclical nature with domestic demand. Real remittances gap, $RMTg$, is a function of its past values, foreign activity, and shock to remittances gap. Recent data indicates that both OF remittances and BPO sector account for about 15 percent of the country's nominal GDP.

$$\begin{aligned} RMTg = RMTFg + Zg \\ RMTFg = \rho_{rmtfg} * RMTFg\{-1\} + \omega_1 * FACT + RES_{RMTFg} \end{aligned} \quad (2)$$

where:

$RMTFg$	Real remittances gap in foreign currency (%)
RES_{RMTFg}	Remittances gap shock

The REER gap ($REER_{Tg}$), affects the domestic demand of an open economy like the Philippines. When REER depreciates with respect to its trend, i.e., REER gap is positive, imported goods become relatively more expensive than local goods. Hence, higher demand for local goods vis-à-vis imported goods stimulates domestic demand. The moving average of REER gap in the output gap equation captures the lagged effect of exchange rate to domestic prices and domestic demand.

Global economic activity affects domestic aggregate demand mainly through the exports channel. Foreign activity, $FACT$, is the weighted sum of the output gaps of other regions in GPM++ (i.e., US, Euro zone, Japan, China, and the rest of the world) incorporated in the model. Similarly, foreign residual activity, $FACT_{RES}$, is the weighted sum of the innovations to the IS curves of the respective external regions in the GPM++ model which serves as a source of external assumptions.

Potential Output and Output Gap

A positive output gap can signal that the economy is operating at a level above its trend and is thus, inflationary. Potential output is a function of its lagged term, steady-state output growth, ss_{dy}, and a measurement error term, RES_{YME}, which captures high frequency volatility of the output.

$$\begin{gathered} Yt = Yt\{-1\} + gYt/4 + YME - YME\{-1\} + RES_{Yt} \\ gYt = \rho_{gyt} * gYt\{-1\} + \left(1 - \rho_{gyt}\right) * ss_{dy} + RES_{gYt} \\ YME = \rho_{YME} * YME\{-1\} + RES_{YME} \end{gathered} \tag{3}$$

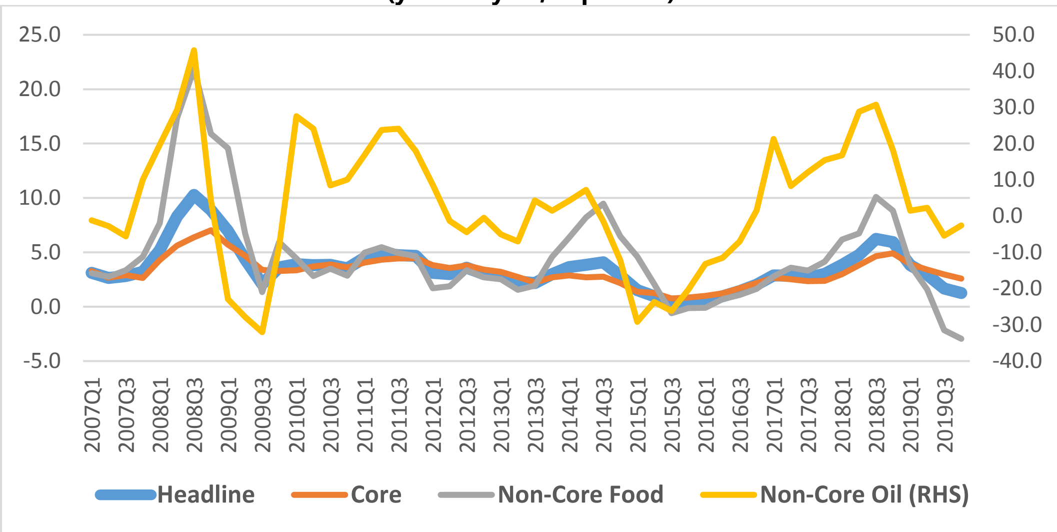
where:

Yt	Potential output level (100*log)
gYt	Potential output trend growth (% QoQ)
YME	GDP measurement error (100*log)
RES_{Yt}	Potential output level shock
RES_{gYt}	Potential output growth shock
RES_{YME}	GDP measurement error shock

4.2 Phillips Curve

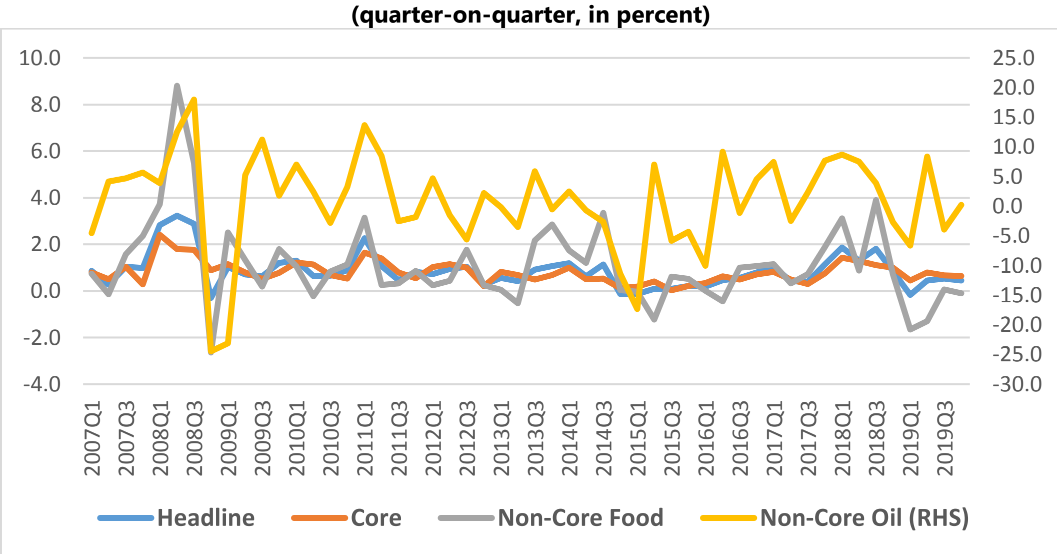
Inflation-targeting central banks, like the BSP, implement appropriate monetary policy actions to ensure that the average headline inflation falls within a target band set by the government. Although the BSP is concerned primarily on headline inflation, distinct differences on the dynamics of CPI components merit modeling separate equations for each major component. Figures 2 and 3 show year-on-year (YoY) and quarter-on-quarter (QoQ) inflation of headline CPI as well as its components modeled in PAMPh.

Figure 2. Headline Inflation and Components
(year-on-year, in percent)



Source: PSA

Figure 3. Headline Inflation and Components
(quarter-on-quarter, in percent)



Source: PSA

Here, we specify three inflation equations for core, food, and energy components of the CPI basket. The headline inflation is then, aggregated as the weighted sum of food, energy, and core inflation.

$$dP = w_f * dPF + w_e * dPE + \left(1 - w_e - w_f\right) * dPC + RES_{dP} \tag{4}$$

where:

dP	CPI inflation (% QoQ)
dPF	Volatile food CPI inflation (% QoQ)
dPE	Energy CPI inflation (% QoQ)
dPC	Core CPI inflation (% QoQ)
RES_{dP}	Inflation discrepancy

In the identity, core inflation has the largest weight (77.2 percent) followed by food inflation (20.8 percent) and energy inflation (2.0 percent). The inflation discrepancy, RES_{dP}, is a balancing term that accounts for rounding off errors, ensuring that the identity holds.

Core Phillips curve

Core inflation measures the underlying price pressures by excluding volatile items such as food and energy items.[4] Core inflation depends on its lagged and lead terms, headline inflation, output gap, REER, real international oil and food prices, imported oil and food inflation, as well as shocks to food and core inflation.

$$\begin{aligned} dPC = \beta_{C1} * (\iota * d4PC\{-1\} + (1-\iota) * d4P\{-1\}) + (1 - \beta_{C1} - \beta_{C6} - \beta_{C7}) * d4PC\{+4\} \\ + \beta_{C2} * Yg\{-1\} \\ + \beta_{C3} * \left(REER_{Tg} + REER_{Tg}\{-1\} + REER_{Tg}\{-2\} + REER_{Tg}\{-3\}\right)/4 \\ + \beta_{C4} * \left(LRP_{OIL_{GAP}} + Zg\right) + \beta_{C5} * \left(LRP_{FOOD_{GAP}} + Zg\right) \\ + \beta_{C6} * (dPM_{OIL} + dPM_{OIL}\{-1\})/2 \\ + \beta_{C7} * (dPM_{FOOD} + dPM_{FOOD}\{-1\})/2 + \beta_{C8} * TRANSM_{dPF} + RES_{dPC} \end{aligned} \quad (5)$$

where:

dPC	Core CPI inflation (% QoQ)
$d4PC$	Core CPI inflation (% YoY)
$d4P$	CPI inflation (% YoY)
Yg	Output gap (%)
$REER_{Tg}$	Trade-weighted REER gap (100*log)
LRP_OIL_GAP	Real oil price gap (%)
LRP_FOOD_GAP	Real food price gap (%)
Zg	Real exchange rate with respect to USD (%)
dPM_{OIL}	Imported oil inflation (% QoQ)
dPM_{FOOD}	Imported food inflation (% QoQ)
$TRANSM_{dPF}$	Transmission of food cost-push shock
RES_{dPC}	Core cost-push shock

[4] PAMPh uses data on core inflation based on the official definition of PSA, which excludes 18.4 percent of the CPI basket as follows: rice, corn, fruits & vegetables, fuel items, (gas, LPG, kerosene, gasoline and diesel). Meanwhile, the BSP publishes alternative measures of core inflation:

(i) The trimmed mean represents the average inflation rate of the (weighted) middle 70 percent in a lowest-to-highest ranking of year-on-year inflation rates for all CPI components;
(ii) The weighted median represents the middle inflation rate (corresponding to a cumulative CPI weight of 50 percent) in a lowest-to-highest ranking of year-on-year inflation rates; and
(iii) The net of volatile items method excludes the following items: educational services, fruits and vegetables, personal services, rentals, recreational services, rice, and corn, which represent 37.59 percent of all items.

Please see http://www.bsp.gov.ph/statistics/keystat/coreinflation.htm.

The lagged values of core and headline inflation reflect the persistent nature of inflation or inflation inertia, and the spillover of domestic food and energy prices to core inflation. While core inflation excludes volatile items such as food and energy, an increase in the prices of food and energy can influence the trend in non-volatile items (e.g., clothing and footwear). When domestic oil price increases, other items in the CPI basket such as the cost of some garments could also increase due to higher costs of transporting raw materials. Similarly, the expected core inflation incorporates the forward-looking behavior of agents as well as the expectations channel through which the central bank can influence core inflation.

Core inflation is also positively related to output gap and REER gap. An increase in aggregate demand drives production costs up and leads to higher inflation. Similarly, a depreciation in REER with respect to its trend translates to higher domestic costs of imported goods and imported inputs into domestic production, thus, raising inflation. Moreover, the core Phillips curve captures both the direct and indirect effects of international commodity prices. The direct effect of world oil and food prices, denoted by dPM_{OIL} and dPM_{FOOD}, respectively, are positively associated with core inflation. The imported oil inflation is calculated from the nominal oil price growth adjusted with equilibrium exchange rate and real oil price trend. The imported food inflation is defined similarly.

$$\begin{aligned} dPM_{OIL} &= dS + dL_{OIL} - dZt - dLRP\_OIL\_TND \\ dPM_{FOOD} &= dS + dL_{FOOD} - dZt - dLRP\_FOOD\_TND \end{aligned} \tag{6}$$

where:

dS	Nominal exchange rate depreciation (% QoQ)
dL_{OIL}	Nominal oil price growth (% QoQ)
dL_{FOOD}	Nominal food price growth (% QoQ)
dZt	Equilibrium real exchange rate with respect to USD (% QoQ)
$dLRP\_OIL\_TND$	Real oil price trend (% QoQ)
$dLRP\_FOOD\_TND$	Real food price trend (% QoQ)

The deviation of real oil prices from its trend, LRP_OIL_GAP, measures the indirect effect of world oil prices to core inflation. Similarly, LRP_FOOD_GAP, represents the indirect effect of real food price gap to core inflation. Meanwhile, the transmission term of food cost-push shock, $TRANSM_{dPF}$, is the same food inflation shock, RES_{dPF}, that enters the volatile food Phillips curve.

Volatile food equation

The volatile food equation relates food inflation with its past values, expected core inflation, imported food inflation, and shock to food inflation. Modelling food inflation separately is apt for an economy like the Philippines with volatile food prices as it is susceptible to food supply disruptions due to severe weather disturbances or climate change.

$$dPF = \beta_{F1} * dPF\{-1\} + (1 - \beta_{F1} - \beta_{F2}) * d4PC\{+1\} + \beta_{F2} * dPM_{FOOD} + RES_{dPF} \tag{7}$$

where:

dPF	Volatile food CPI inflation (% QoQ)
$d4PC$	Core CPI inflation (% YoY)

dPM_{FOOD}	Imported food inflation (% QoQ)
RES_{dPF}	Food cost-push shock

Volatile energy equation

Similar to the food equation, energy inflation is defined as the weighted sum of its past values, the expected core inflation, imported oil inflation, and shock to energy inflation. Volatilities in the international oil prices could translate into fluctuations in the domestic oil market.

$$dPE = \beta_{E1} * dPE\{-1\} + (1 - \beta_{E1} - \beta_{E2}) * d4PC\{+1\} + \beta_{E2} * dPM_{OIL} + RES_{dPE} \quad (8)$$

where:

dPE	Energy CPI inflation (% QoQ)
$d4PC$	Core CPI inflation (% YoY)
dPM_{OIL}	Imported oil inflation (% QoQ)
RES_{dPE}	Energy cost-push shock

4.3 Monetary policy rule

The monetary policy rule describes the policy reaction of the central bank in response to a deviation of expected inflation to the target and the output gap. The monetary policy rule is forward-looking where the policy rate reacts to expected future inflation deviations with model-consistent expectations. This equation hinges from the Taylor Rule which suggests that interest rate should be increased to temper inflationary pressures. The policy rate is a function of its lagged term, the long-term nominal interest rate, inflation deviation, output gap, and a monetary policy shock.

$$RS = \gamma_1 * RS\{-1\} + (1 - \gamma_1) * \big((RRt + d4P\{+3\}) + \gamma_2 * INFL_{DEV} + \gamma_3 * Yg\big) + RES_{RS} \quad (9)$$

where:

RS	Policy rate (%)
RRt	Real rate trend (%)
$d4P$	CPI inflation (%)
$INFL_{DEV}$	Deviation from the inflation target (pp)
Yg	Output gap (%)
RES_{RS}	Monetary policy shock

The lagged policy rate, $RS\{-1\}$, reflects the typical practice of central banks in implementing policy adjustments in a gradual manner to avoid generating inadvertent noise in the market. Moreover, the policy rate is anchored by neutral nominal interest rate, defined as the sum of the real interest rate trend, RRt, and expected inflation, $d4P\{+3\}$.

The real interest rate reflects both the market rate, RSM, and policy rate, RS, adjusted with the past and expected inflation. This structure of the real rate aims to account for possible deviations of the market rate from the policy rate and thus, able to have a more representative transmission of monetary policy to the real economy.

$$RR = RSM - (\theta * d4PC\{-1\} + (1-\theta) * dPC\{+1\})$$
$$RSM = \gamma_4 * RSM\{-1\} + (1-\gamma_4) * RS + RES_{RSM} \quad (10)$$

where:

RSM	Market rate (%)
$d4PC$	Core CPI inflation (% YoY)
dPC	Core CPI inflation (% QoQ)
RS	Policy rate (%)
RES_{RSM}	Market rates shock

The policy rate is positively related with inflation deviation, $INFL_{DEV}$, and output gap, Yg. Higher deviation of expected inflation from the target requires the central bank to increase its policy rate by higher magnitude to steer inflation back to the target. The inflation deviation depends on expected inflation (rather than on current inflation) to reflect the forward-looking behavior of the central bank in its monetary policy setting. The monetary policy rule reacts to expected future inflation as monetary policy adjustments work with a lag and thus, can only influence future inflation. The inflation target is consistent with the steady state inflation, currently set at 3.0 percent which is the midpoint of the 3.0 percent ± 1.0 percentage point target of the BSP for 2020-2022.[5] The output gap is also an important consideration in policy decisions as it could indicate how domestic demand could influence inflation. A positive output gap could indicate a build-up of inflationary pressures in the future. Consequently, the central bank could consider tightening its policy rate to rein in excess demand. In contrast, a negative output gap could moderate inflation. The resulting decline in inflation could prompt the central bank to take a more accommodative monetary policy stance to foster economic activity and steer inflation back to the target.

$$INFL_{DEV} = d4P\{+4\} - PIETARGET$$
$$PIETARGET = \rho_{PIETARGET} * PIETARGET\{-1\} + (1-\rho_{PIETARGET}) * ss_{dp} + RES_{PIETARGET} \quad (11)$$

where:

$PIETARGET$	Inflation target (% YoY)
$RES_{PIETARGET}$	Inflation target shock

4.4 Uncovered Interest Rate Parity (UIP)

The UIP models the relationship between risk-adjusted interest rate differential and expected change in nominal exchange rate. In the model, the expected depreciation moves to match the interest rate differential adjusted with the country risk premium along with remittances gap and the change in foreign exchange reserves.

[5] The Development Budget Coordination Committee (DBCC), in consultation with the BSP, reviews and approves the medium-term government inflation target every year. In a press statement published on 18 December 2019, the BSP announced the decision of the DBCC to maintain the inflation target at 3.0 percent ± 1.0 percentage point for 2020-2022. Please see http://www.bsp.gov.ph/publications/media.asp?id=5239&yr=2019.

$$(RSM - RS_{US}) = 4 * (Se - S) + PREM - \omega_4 * RMTFg + \omega_5 \ * dFXRES + RES_{UIP} \qquad (12)$$

where:

RSM	Market rate (%)
RS_{US}	US nominal interest rate (%)
Se	Expected exchange rate (100*log)
S	Nominal exchange rate (100*log)
$PREM$	Country spread (premium)
$RMTFg$	Real remittances gap in foreign currency (%)
$dFXRES$	Change in foreign exchange reserves (% QoQ non-annual)
RES_{UIP}	UIP shock

The US nominal interest rate, RS_{US}, is used as proxy for foreign interest rate since majority of the country's foreign assets and liabilities are denominated in US dollars. Under the assumption of freely floating exchange rate and full capital mobility, higher domestic yield vis-à-vis foreign yield attracts capital inflows to the domestic market contributing to appreciation in the local currency. The appreciation stops when the interest rate differential equals the expected depreciation which also increases due to the domestic currency strengthening.

The expected exchange rate, Se, is defined as the weighted sum of lead nominal exchange rate and lagged nominal exchange rate adjusted for the equilibrium exchange rate movement. The factor 4 in the UIP equation annualizes the expected change in exchange rate consistent with the interest rate in annual terms. Meanwhile, the factor $2/4$ in the definition of Se converts the long-term change in exchange rate to a quarterly basis and then, extrapolates the expected quarter-on-quarter (QoQ) change in nominal exchange rate. Moreover, the country risk premium, $PREM$, is determined by its lagged and steady-state values.

$$Se = \xi_s * S\{+1\} + (1 - \ \xi_s) * \left(S\{-1\} + 2/4 * (dZt + PIETARGET - PIETARGET_{US})\right) \qquad (13)$$

where:

Se	Expected exchange rate (100*log)
S	Nominal exchange rate (100*log)
dZt	Equilibrium RER with respect to USD (% QoQ)
$PIETARGET$	Inflation target (% YoY)
$PIETARGET_{US}$	US inflation target (% YoY)

The deviation of international remittances relative to its trend is negatively related with nominal exchange rate. Increased foreign exchange inflows from OFs and BPOs lead to an appreciation in the domestic currency. Meanwhile, the change in foreign exchange reserves, $dFXRES$, represents the central bank's participation in the currency market to manage sharp exchange rate fluctuations. In time of excessive depreciation in the local currency, the central bank draws from its exchange rate reserves to sell foreign currency (and buy domestic currency) in the market, posing appreciation pressures in the local currency. Thus, $dFXRES$ enters into the equation with a positive sign.

4.5 External Block

The external block consists mainly of the output gap equation for different regions, US core Phillips curve, and US monetary policy rule. The other regions covered in the model include the US, Euro zone, Japan, China, and the rest of the world.

$$
\begin{gathered}
Yg_{region} = \rho_{Yg} * Yg_{region}\{-1\} + RES\_YG\_REGION \\
dPC_{US} = \lambda 1_{US} * dPC_{US}\{-1\} + (1 - \lambda 1_{US}) * PIETARGET_{US} + RES\_dPC\_US \\
RS_{US} = \lambda 2_{US} * RS_{US}\{-1\} + (1 - \lambda 2_{US}) * (PIETARGET_{US} + RRt_{US}) + RES\_RS\_US
\end{gathered} \tag{14}
$$

where:

Yg_{region}	Output gap for region (%)
dPC_{US}	US core CPI inflation (% QoQ)
$PIETARGET_{US}$	US inflation target (% YoY)
RRt_{US}	US equilibrium real interest rate (%)
RS_{US}	US nominal interest (%)
RES_YG_REGION	Demand shock for region
RES_dPC_US	US Core cost-push shock
RES_RS_US	US nominal interest shock

The equations under the external block are simpler since the external sector variables are imposed from outside. The output gap of each region is modelled as an AR(1) process. The US core inflation is a linear combination of its lagged term and the inflation target for the US. Similarly, the US policy rate is a weighted sum of its backward-looking component and the trend nominal interest rate in the US.

4.6 Commodities block

The commodities block includes equations for the imported oil and food inflation as well as changes in the trend global oil and food prices. These variables represent the indirect effects of international commodity prices to the domestic market, which enter the Phillips curve.

$$
\begin{aligned}
LRP\_OIL\_GAP &= \rho\_oil\_gap * LRP\_OIL\_GAP\{-1\} + RES\_LRP\_OIL\_GAP \\
LRP\_FOOD\_GAP &= \rho\_food\_gap * LRP\_FOOD\_GAP\{-1\} + RES\_LRP\_FOOD\_GAP
\end{aligned} \tag{15}
$$

where

LRP_OIL_GAP	Real oil price gap (%)
LRP_FOOD_GAP	Real food price gap (%)
$RES\_LRP\_OIL\_GAP$	Temporary oil price shock
$RES\_LRP\_FOOD\_GAP$	Temporary food price shock

The real commodity prices relative to the trend are modelled as AR(1) processes. The real oil price gap, which is the deviation of oil prices from the equilibrium, depends on its past values and temporary shock to oil prices. Similarly, the real food price gap, which is the deviation of food prices from the equilibrium, depends on its past values and temporary shock to food prices.

(16)

$$dLRP\_OIL\_TND = \rho\_oil\_tnd * dLRP\_OIL\_TND\{-1\} + (1 - \rho\_oil\_tnd) * ss_{doil} + RES\_dLRP\_OIL\_TND$$

$$dLRP\_FOOD\_TND = \rho\_food\_tnd * dLRP\_FOOD\_TND\{-1\} + (1 - \rho\_food\_tnd) * ss_{dfood} + RES\_dLRP\_FOOD\_TND$$

where:

$dLRP\_OIL\_TND$	Real oil price trend (% QoQ)
$dLRP\_FOOD\_TND$	Real food price trend (% QoQ)
$RES\_dLRP\_OIL\_TND$	Permanent oil price shock
$RES\_dLRP\_FOOD\_TND$	Permanent food price shock

The trends in real oil prices and real food prices are determined by their past and steady-state values, currently set at 0 based on GPM++, as well as permanent shocks to commodity prices.

5. Impulse Response Functions

The transmission mechanism in the model is illustrated using charts generated from impulse-response functions (IRFs). IRFs simulate the impact of a one-period shock of unit size to the model. The functions present the reaction over time of an introduced shock to each variable, and the length of time over which each variable return to a state of equilibrium after the shock, or if it does at all. IRFs rely solely on how a model is defined and are generally data agnostic. That is, IRFs evaluate a model based on the specification of each equation, that includes the parameters and steady states set. As such, IRFs can typically help provide an assessment of a model's consistency with economic theory without the need to introduce any dataset. In this paper, six key shocks are discussed in the following sub-sections.

a. Monetary policy shock (Annex 1.A)

This IRF shows the transmission of BSP monetary policy tightening, RES_{RS}, to the real economy. A policy interest rate hike causes a rise in market interest rates, which are reference rates of firms and consumers alike. Higher cost of borrowing discourages households and investors to consume or invest more. As a result, aggregate domestic demand declines while nominal and real exchange rates appreciate. Moreover, higher interest rates induce consumers to buy less and save more, thus, ensuing a decline in overall consumption and therefore, disinflation. Expectations of lower core inflation then feed into lower food and energy inflation.

Given domestic output below potential and inflation below target, the central bank reacts by reducing the policy rate to stimulate demand and boost inflation. As the real market rate returns to its neutral rate, the output gap closes and inflation goes back to the target.

b. Domestic demand shock (Annex 1.B)

A shift in the preference of households to consume more and save less, say due to expected higher income in the future, is an example of a positive demand shock, RES_{Yg}. Higher demand for goods in the domestic market could result in increased domestic prices and pose threat to projected inflation breaching the high-end of the inflation target range. Such inflationary pressures warrant a policy response from the central bank to temper demand-side price pressures by tightening the policy rate. The same action brings about nominal and real exchange rate appreciation.

The monetary policy tightening of the BSP, consequently, dampens consumption, investment and in the end, overall growth after five to six quarters. As inflation pressures wane and policy rates go back to equilibrium, inflation and output return to their steady-state values.

c. Core cost push shock (Annex 1.C)

The imposition of consumption taxes such as value added tax (VAT) or excise taxes can be considered as core cost-push shock, RES_{dPC}. A positive shock here leads to an immediate uptick in core and headline inflation. Volatile food and energy inflation likewise go up due to forward-looking expectations of a higher core inflation.

When higher inflation leads to elevated inflation expectations far from the target, the BSP may raise its policy rate to mitigate the build-up of inflation pressures, upon consideration of other indicators. At the same time, this monetary policy tightening will result in a negative output gap and exchange rate appreciation in the short run. As price pressures fall, the policy rate returns to its optimum level and with it, pulling output back to its potential.

d. Food cost push shock (Annex 1.D)

Accounting for about 20 percent of the CPI basket, any shock to volatile food inflation, RES_dPF, can cause a sudden rise in headline inflation. Weather disturbances (e.g., typhoons), among others, can cause food supply disruptions or road damage, which can trigger higher prices of agricultural products in the domestic market. In this scenario, a one percent increase in food inflation directly increases the headline inflation by its CPI weight.

Consistent with the economic notion that central banks should not be instantly reacting to supply shocks but instead to act only when inflation expectations have begun to rise, the food supply shock has delayed to very little impact to policy rates. In the model, the persistence parameter is quite small due to the short-lived nature of the food cost push shock. However, in cases of sustained price increases of volatile food items and with the inclusion of lagged headline inflation in the core inflation equation, secondary effects could build up. Consequently, monetary policy tightening may be required particularly when the expected inflation becomes dis-anchored from the inflation target.

e. Remittance gap shock (Annex 1.E)

An increase in demand for OFs abroad which can drive a rise in OF remittances can feed into remittances shock, RES_{RMTFg}. The increase in remittances can affect the model through two channels: (1) in the aggregate demand equation through higher household income; and (2) in the UIP equation, to represent capital inflows into the country.

A positive shock in remittances increases the amount of US dollars in the domestic market, generating appreciation pressures on the peso. A stronger peso equates to lower prices of imported goods as such there are disinflations observed for energy, food and core in the short term. In contrast, higher remittances provide consumers with more disposable income to spend on consumer goods, thus increasing total domestic demand. The increase in domestic output then translates into a rise in core inflation and headline inflation over the medium term. To rein in demand-pull price pressures, the BSP may then respond with policy rate hike(s) particularly when projections point to inflation breaching the target.

f. Foreign demand shock (Annex 1.F)

A positive shock to foreign output gap has direct and indirect effects to domestic output gap. An increase in US output gap can directly stimulate aggregate domestic demand mainly through higher exports. At the same time, a shock to foreign demand affects domestic output indirectly through remittances. Positive developments in the global economy, particularly in the US, can provide a boost to OF and BPO remittances and in turn, to domestic output. Meanwhile, remittances enter into the UIP with a negative sign, as higher foreign exchange inflows from remittances can pose appreciation pressures on the peso.

7. Concluding Remarks

The PAMPh, with its theoretical underpinnings and empirically-supported parameters, aims to provide sound monetary policy guidance to the BSP management. Preliminary forecasts and results of the impulse-response analyses show that the model captures the dynamics of the Philippine economy.

The PAMPh continuously undergoes assessment. As needed, the model is re-specified and parameters are calibrated to better reflect the relationship among the variables. For every re-specification, IRFs are used in assessing the theoretical consistency of the revised model.

Future developments in the model can investigate adding a new sector or further enriching insights from current aggregated variables by looking into their components. One of the enhancements currently being explored by the authors is the disaggregation of the demand components, which can provide deeper insights on what drives growth, each output component and how dynamics in the transmission mechanism is altered. Other possible areas of development include a further deepening of the external sector block. Meanwhile, given the interplay among the variables that are captured by the model, other areas of research where the PAMPh can be used include simulation exercises, assessment of growth drivers, and impact of policy actions, among others.

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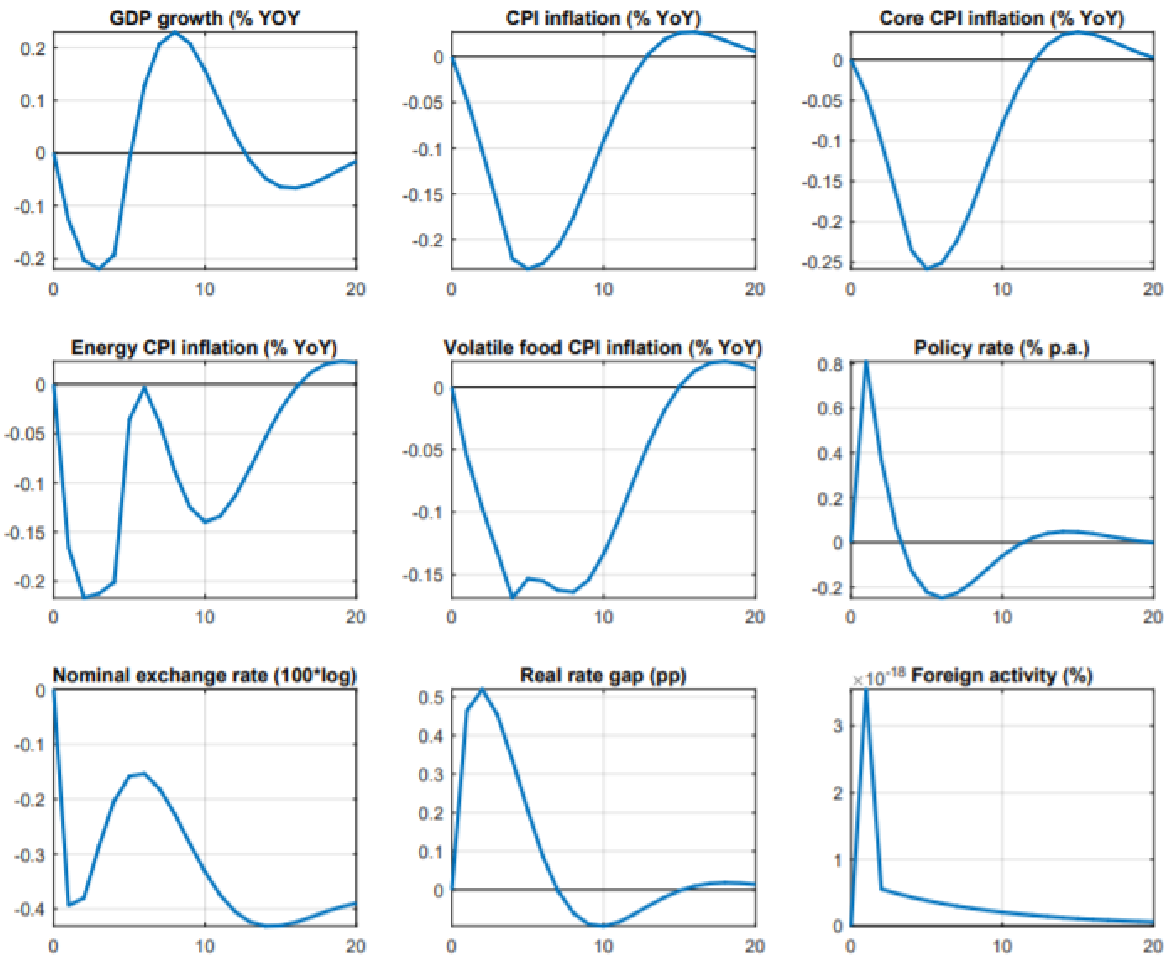
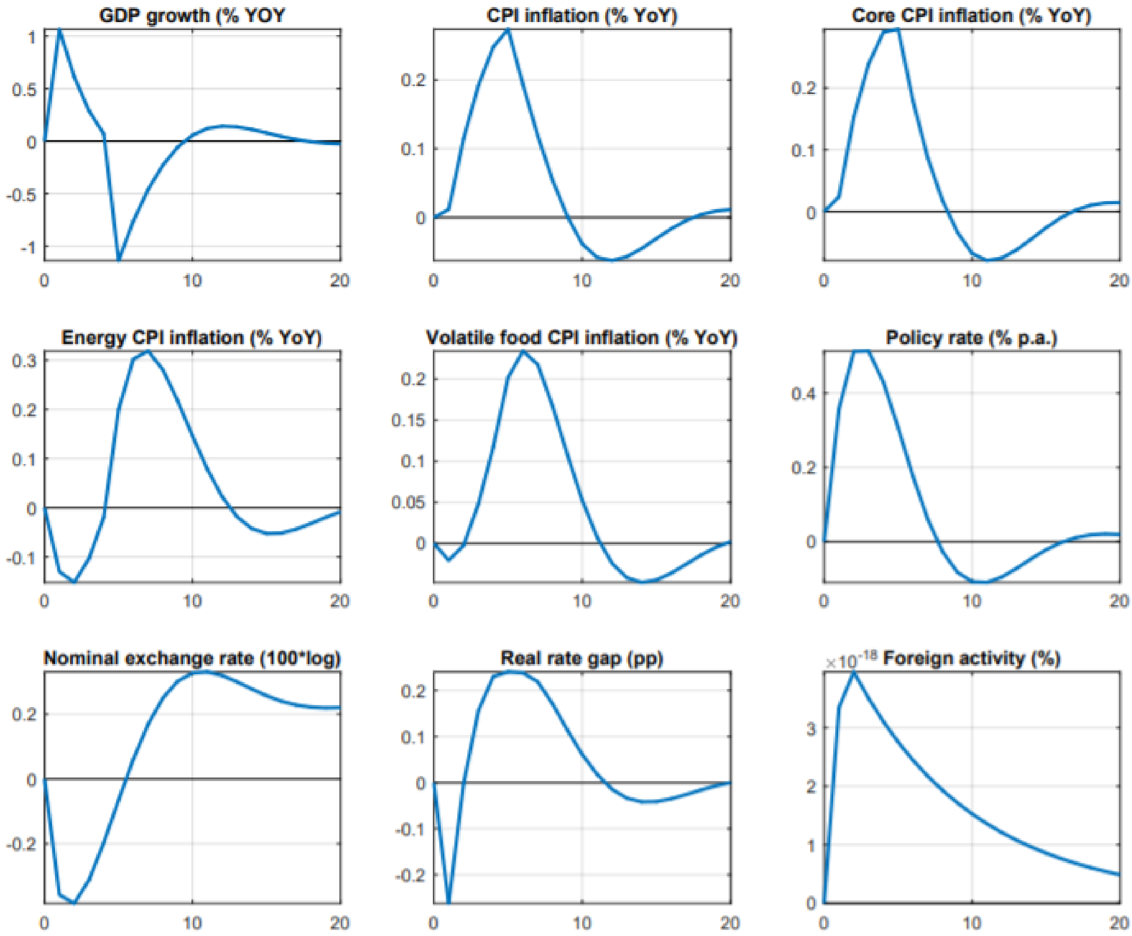
Annex 1. Impulse Response functions of PAMPh

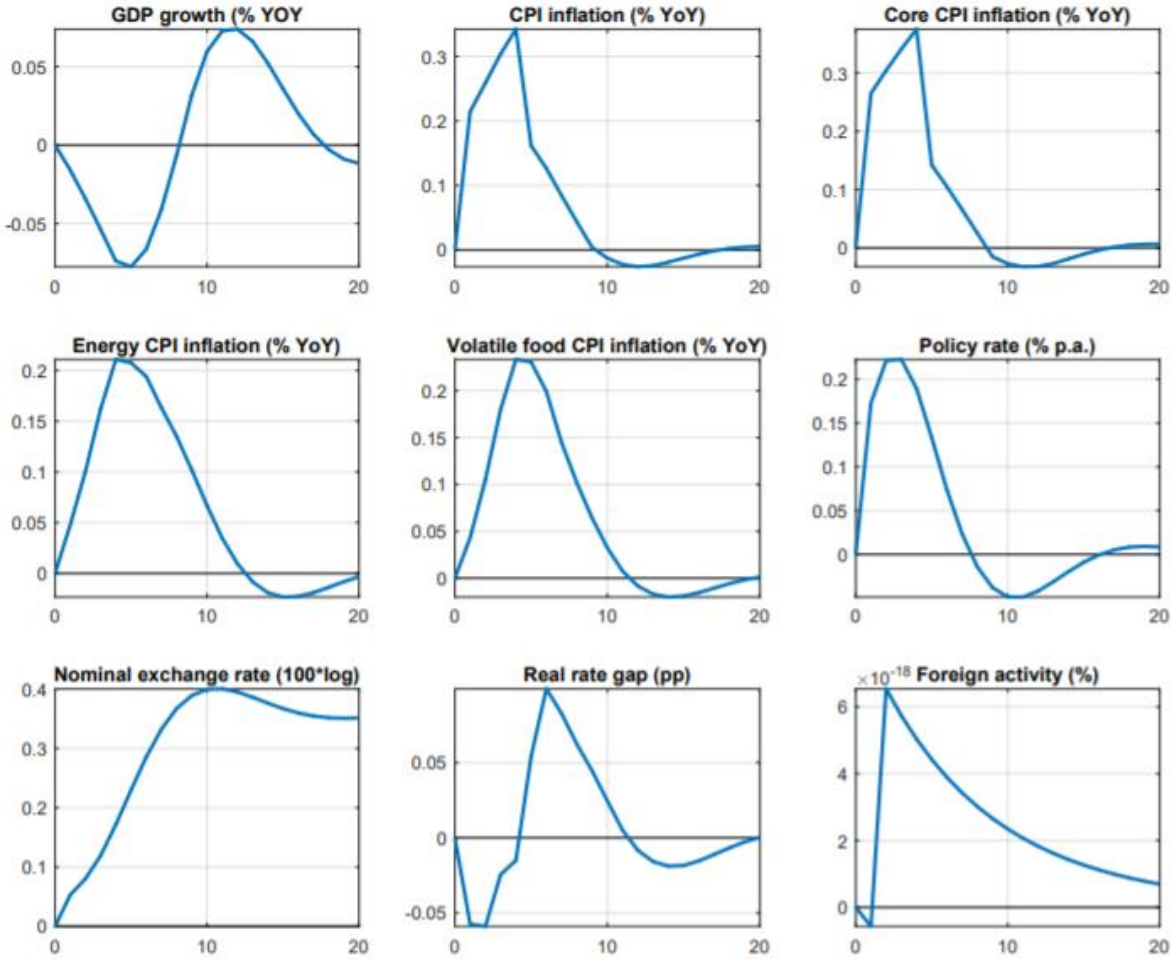
A. Monetary policy shock



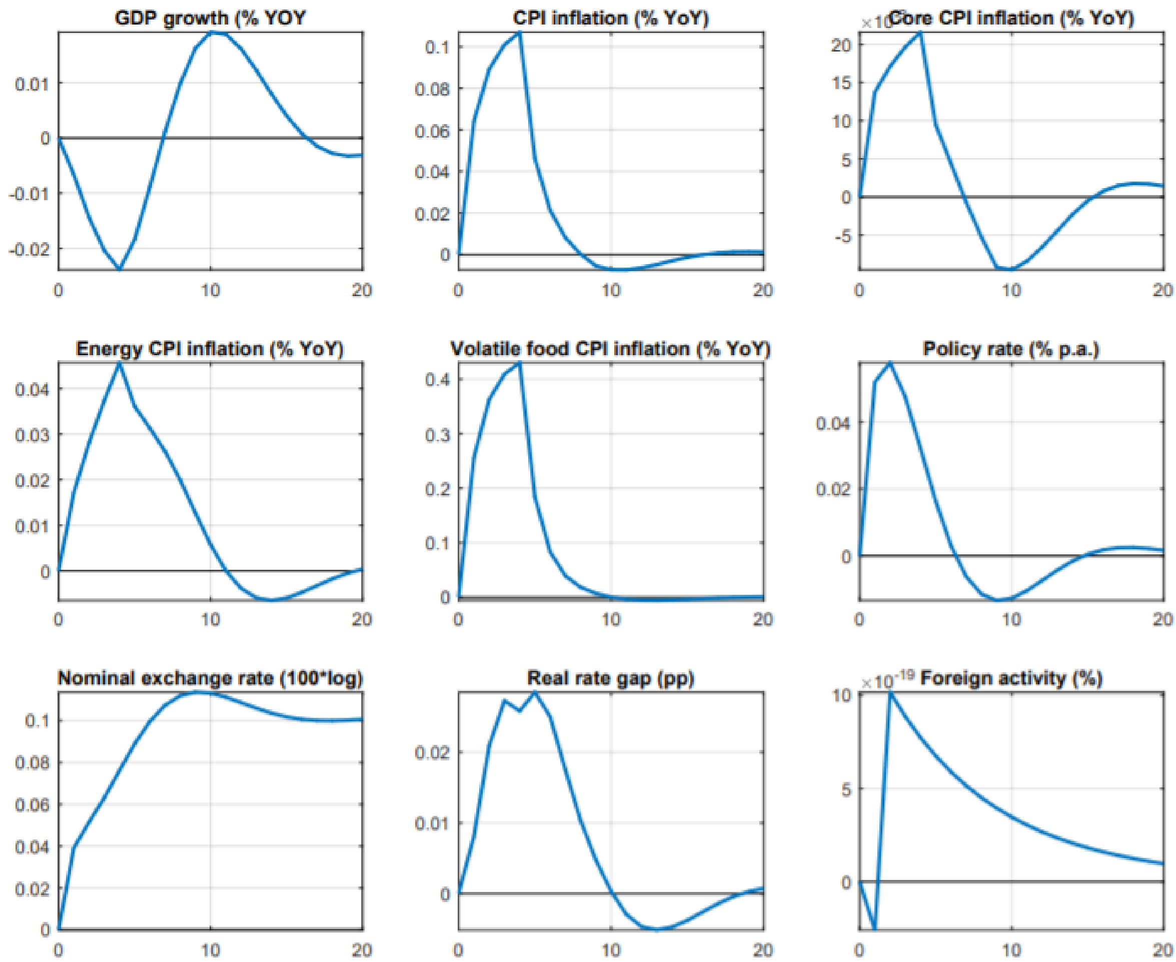
B. Domestic demand shock



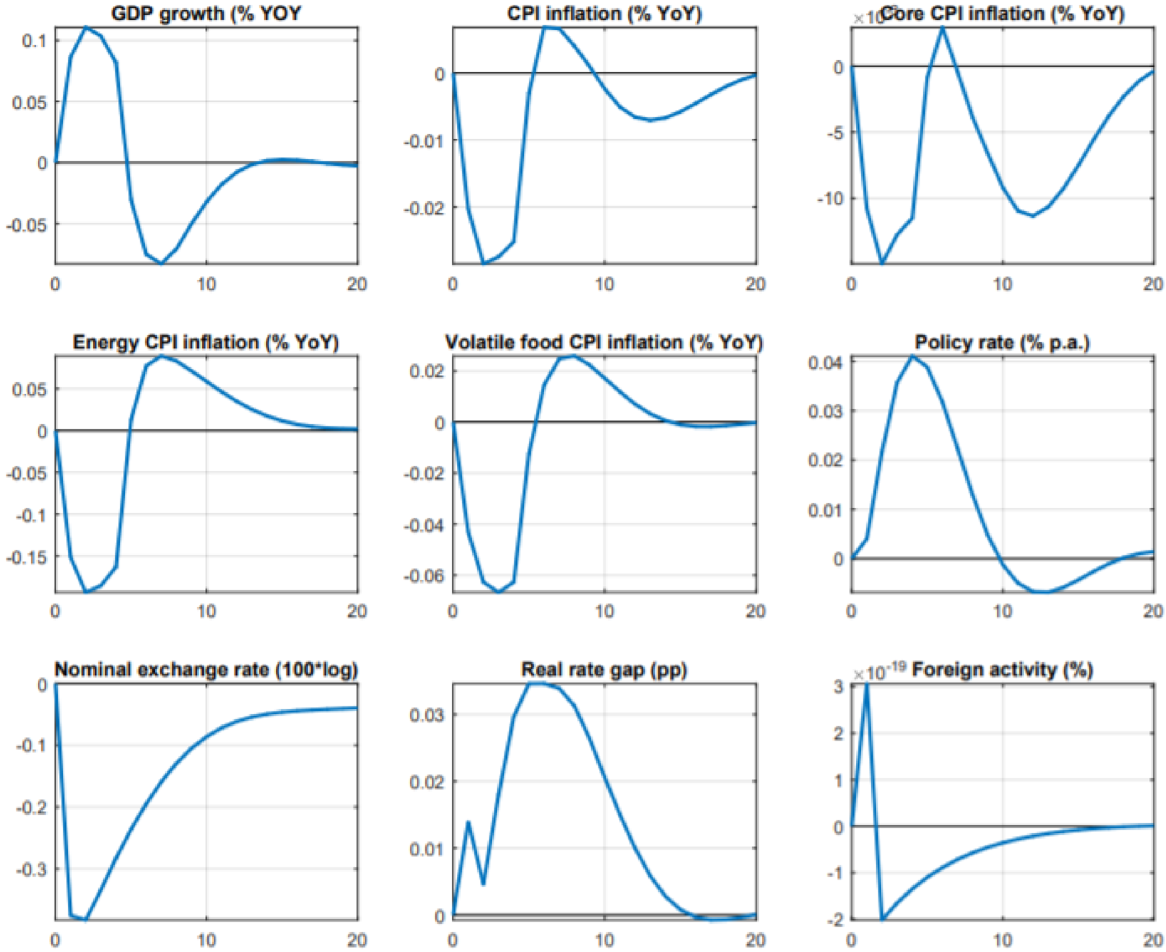
C. Core cost push shock



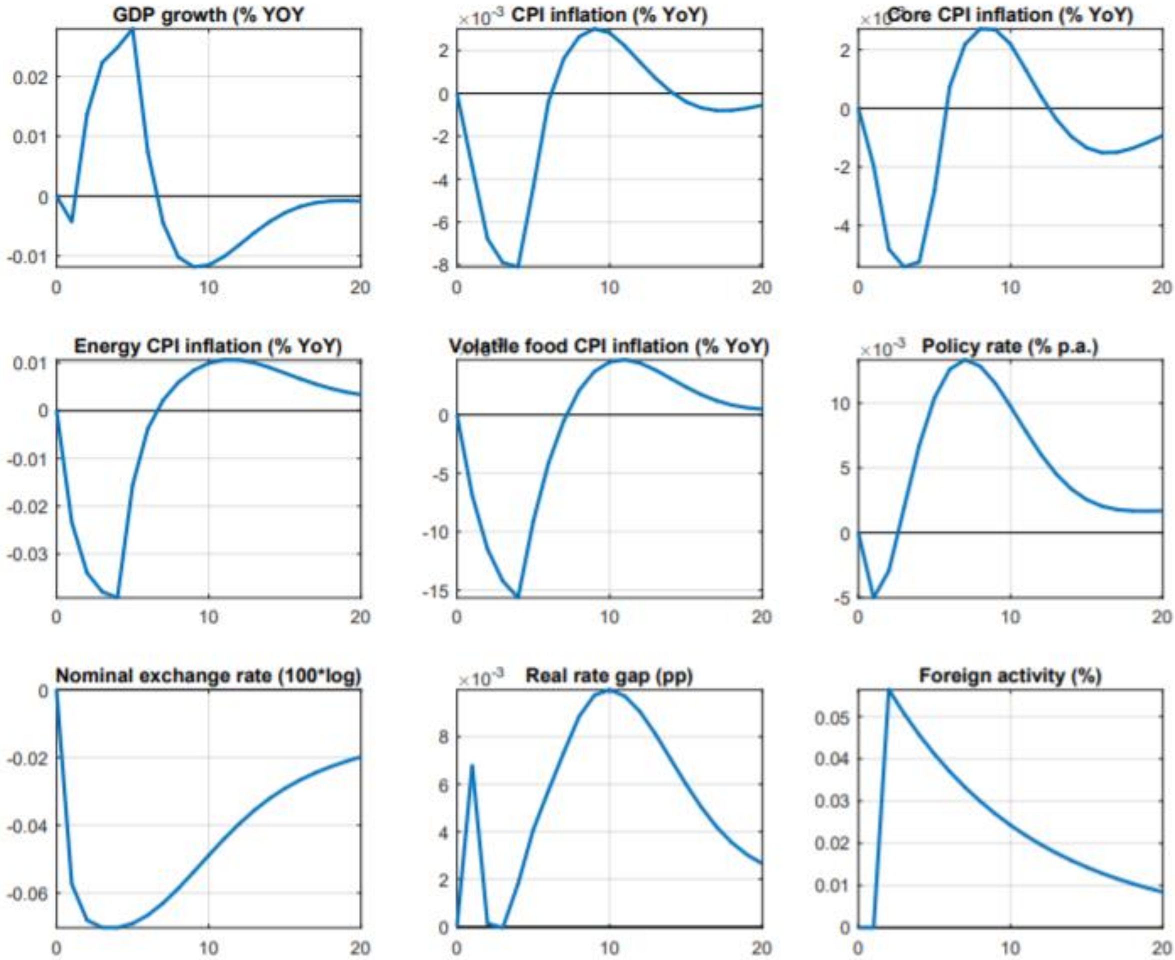
D. Food cost push shock



E. Remittance Gap Shock



F. Demand Shock for US[6]



[6] To illustrate, we show the IRFS\s of a demand shock for US. Nonetheless, the transmission path is similar for other regions with slight variation in the magnitudes of the impact.

Annex 2. Summary Table of Variables

Variable Name	Description
Domestic Variables	
Yt	Potential output level (100*log)
gYt	Potential output trend growth (% QoQ)
YME	GDP measurement error (100*log)
Yg	Output gap (%)
FACT	Foreign activity (%)
$FACT_{RES}$	Foreign residual activity (pp)
RMTg	Real remittances gap in local currency (%)
RMTFg	Real remittances gap in foreign currency (%)
RS	Policy rate (% p.a.)
RSM	Market rate (% p.a.)
PIETARGET	Inflation target (% YoY)
$INFL_{DEV}$	Inflation deviation (pp)
RRt	Real rate trend (%)
RRg	Real rate gap (pp)
dP	CPI inflation (% QoQ)
d4P	CPI inflation (% YoY)
dPC	Core CPI inflation (% QoQ)
d4PC	Core CPI inflation (% YoY)
dPF	Volatile food CPI inflation (% QoQ)
dPE	Energy CPI inflation (% QoQ)
dPM_{FOOD}	Imported food inflation (% QoQ)
dPM_{OIL}	Imported oil inflation (% QoQ)
S	Nominal exchange rate (100*log)
dS	Nominal exchange rate depreciation (% QoQ)
Se	Expected exchange rate (100*log)
$REER_{Tg}$	Trade-weighted REER gap (100*log)
dZt	Equilibrium real exchange rate with respect to USD (% QoQ)
Zg	Real exchange rate gap with respect to USD (%)
dFXRES	Change in foreign exchange reserves (% QoQ non-annual)
PREM	Country spread (premium)
Foreign variables	
Yg_{region}	Output gap for region (%)
dPC_{region}	Core inflation for region (% QoQ)
RS_{US}	US nominal interest rate (% p.a.)
RRt_{US}	US equibrium real interest rate (% p.a.)
$PIETARGET_{US}$	US inflation target (% YoY)
Commodities	
dL_{OIL}	Nominal oil price (% QoQ)
LRP_OIL_GAP	Real oil price gap (%)
dLRP_OIL_TND	Real oil price trend (% QoQ)
dL_{FOOD}	Nominal food price (% QoQ)
LRP_FOOD_GAP	Real food price gap (%)
dLRP_FOOD_TND	Real food price trend (% QoQ)

Variable Name	Description
$TRANSM_{dPF}$	Transmission of food cost-push shock
	Domestic Shocks
RES_{YG}	Domestic demand shock
RES_{dPC}	Core cost-push shock
RES_{dPE}	Energy cost-push shock
RES_{dPF}	Food cost-push shock
RES_{dP}	Inflation discrepancy
RES_{RS}	Monetary policy shock
RES_{RSM}	Market rates shock
RES_{UIP}	UIP shock
RES_{Yt}	Potential output level shock
RES_{YME}	GDP Measurement error shock
RES_{gYt}	Potential output growth shock
$RES_{PIETARGET}$	Inflation target shock
RES_{RMTFg}	Remittances gap shock
	Foreign Shocks
RES_YG_REGION	Demand shock for region
RES_RS_US	US nominal interest shock
RES_dLRP_OIL_TND	Permanent oil price shock
RES_dLRP_FOOD_TND	Permanent food price shock
RES_LRP_OIL_GAP	Temporary oil price shock
RES_LRP_FOOD_GAP	Temporary food price shock

Annex 3. Summary Table of Parameters

Parameter	Description	Calibrated values
Output gap equation		
α_1	Persistence of output gap	0.60
α_2	Weight of forward-looking component of output gap	0.15
α_3	Real interest rate gap	0.12
α_4	Real remittances gap in local currency	0.11
α_5	Trade-weighted real effective exchange rate gap	0.05
α_6	Foreign demand	0.35
α_9	Foreign demand shocks	1.00
Real remittances gap in foreign currency equation		
ρ_{rmtfg}	Persistence of real remittances gap	0.80
ω_1	Foreign demand	0.10
Potential output trend growth equation		
ρ_{gyt}	Persistence of potential output growth	0.90
ρ_{YME}	GDP measurement error autocorrelation	0.50
Headline inflation equation		
ω_f	Weight of volatile food in headline inflation	0.2077
ω_e	Weight of volatile energy in headline inflation	0.0202
Phillips Curve – Core inflation equation		
β_{C1}	Persistence of inflation	0.50
β_{C2}	Lagged output gap	0.45
β_{C3}	Last one-year trade-weighted REER gap	0.08
β_{C4}	Real domestic oil price gap	0.013
β_{C5}	Real domestic food price gap	0.03
β_{C6}	Imported qoqa oil inflation of past two quarters	0.007
β_{C7}	Imported qoqa food inflation of past two quarters	0.02
β_{C8}	Direct transmission of food cost-push shock	0.05
ι	Second round effects into core inflation	0.70
Phillips Curve – Volatile food equation		
β_{F1}	Persistence of volatile food inflation	0.40
β_{F2}	Imported food	0.11
Phillips Curve – Volatile energy equation		
β_{E1}	Persistence of volatile energy inflation	0.25
β_{E2}	Imported oil	0.40
Monetary policy rule		
γ_1	Inertia in policy-setting	0.70
γ_2	Inflation deviation	1.50
γ_3	Output gap	0.50
Real interest rate equation		
θ	Weight on past vs future inflation	0.25
Market rate equation		
γ_4	Speed of convergence of market rate to policy	0.65
Inflation target equation		
$\rho_{PIETARGET}$	Persistence of inflation target	0.80

Parameter	Description	Calibrated values
Uncovered interest rate parity		
ω_4	Remittance gap in foreign currency	0.20
ω_5	Change in foreign exchange reserves	0.75
Expected exchange rate equation		
ξ_s	Weight of forward-looking nominal exchange rate	0.85

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