Gaskam : an extended version of the quarterly projection model for Madagascar

Randrianarisoa, Radoniaina

University of Antananarivo

5 April 2024

Gaskam[1] : an extended version of the quarterly projection model for Madagascar

Randrianarisoa, Radoniaina

University of Antananarivo

05 April 2024

[1] Gap semi-Structural neo-Keynesian Model for Madagascar.

Abstract

This article presents an essay of a macroeconomic modeling dedicated on monetary policy, a Quarterly Projection Model for the case of Madagascar. Initially, we apply the canonical model, developed by Berg-Karam-Laxton (2006a,b), to the data of the Malagasy economy. Subsequently, we propose an extension of this version to further incorporate features of this economy. The results show simulations that closely replicate the stylized facts of the Malagasy economy and highlight the mechanisms of monetary policy transmission. This tool could be useful to the Monetary Authority of this country in its conduct of monetary policy.

Résumé

Cet article présente un essai de modélisation macroéconomique axé sur la politique monétaire, de type Quarterly Projection Model, pour le cas de Madagascar. En premier lieu, nous appliquons au modèle canonique, développé par Berg-Karam-Laxton (2006a,b), les données de l'économie malgache. En second lieu, nous proposons une extension de cette version de base, pour davantage prendre en compte certaines spécificités de cette économie. Les résultats montrent des simulations reproduisant assez fidèlement les faits stylisés de l'économie malgache et mettent en exergue les mécanismes de transmission de la politique monétaire. Cet outil pourrait être utile à l'Autorité Monétaire du pays dans sa conduite de la politique monétaire.

***Keywords**: monetary policy, inflation, core inflation, output gap, inflation targeting, quarterly projection model.*

***Mots clés** : politique monétaire, inflation, core inflation, output gap, ciblage d'inflation, quarterly projection model.*

Introduction

In 2021, we developed a canonical version of the Quarterly Projection Model (QPM) for the case of Madagascar. This tool is widely used for conducting analyses and making forecasts for a forward-looking monetary policy, including inflation targeting and/or the transitional phase for migrating towards this regime. To achieve this, the pioneering model by Berg-Karam-Laxton (2006a,b) was applied to the data of the Malagasy economy.

Since its adoption, this model integrated the decision-making tools in monetary policy. It supported the Monetary Authority in making appropriate decisions to contain the soaring inflation induced by recent international shocks. The series of monetary policy tightening, along with other measures, has contributed to reduce inflation to 7.5% by the end of December 2023, from 10.8% at the end of 2022[2].

Nevertheless, as we become familiar with the basic QPM, we do observe some needs for its extension to take into account some specificities of the Malagasy economy. Therefore, the aim of this study is to propose an extended version of the QPM model, having the following characteristics compared to the canonical version:

- Addition of blocks on sectors of the economy not previously considered;
- Decomposition of the Consumer Price Index into core, rice, and energy;
- Addition and improvement of the data quality;
- Addition and re-estimation of parameters.

The first section of this paper will describe, through a brief literature review, the recent evolution of the QPM modeling. The second section will revisit the basic version of the QPM applied to the case of Madagascar. The third section will present the extended variant of this model, baptized Gaskam (Gap semi-Structural neoKeynesian Model), along with the interpretation of the various results obtained. Finally, we will provide a concluding remarks.

[2] Source: National Office for Statistics (INSTAT).

Bief literature review on the evolution of QPM modeling

Berg, Karam, and Laxton (2006a,b) are recognized for proposing the first essays of QPM tailored for prospective monetary policy. These authors developed a straightforward macroeconomic model for analyzing and forecasting the implementation of this generation of monetary policy. They based their model on neo-Keynesian analyses, which gained prominence in late 1990s, early 2000s. Their work was largely inspired by the stochastic general equilibrium models.

However, they asserted that their model takes into account other features, such as the mixture of nominal and real rigidities, adaptive and rational expectations, as well as the presence of static equations. They also acknowledged that their model is not derived from microeconomic foundations, in the sense that for the specification of equations, consumers and firms maximize utility functions. The application of the Berg, Karam, and Laxton (2006a,b) model for the case of Madagascar will be described in the following section

Thereafter, the basic version of the QPM has been subject to several attempts of extension, improvement, and/or adaptation. Generally, these variants are empirical models developed within central banks to serve as decision-making tools.

In 2008, Carabenciov et al. (2008) introduced two significant extensions to the basic version of the QPM. They estimated the parameters using Bayesian econometrics, a technique used to reconcile priors parameters with the data. The second improvement was the incorporation of the QPM into a global projection model along with QPMs from other countries such as the Eurozone, Japan, emerging Asian countries, Canada, and Russia. This integrated model offers numerous advantages, including analyzing the effects of shocks hitting one country on other countries or the impacts of global shocks, conducting global forecasts, serving as multi-country empirical models in IMF surveillance, etc.

In 2010, Salas (2010) developed a QPM for Peru, addressing the characteristics of a partially dollarized country. As agents are allowed to borrow in US dollars, the aggregate demand equation includes the domestic interest rate on foreign currencies. This demand equation is also explained by foreign demand and terms of trade. Additionally, this author employed also Bayesian econometrics to estimate the parameters.

The extension of the basic model for a low-income country was elaborated and applied in the case of Kenya. This study was conducted by Andrle et al. (2013). Considering the significance of food products in the household consumption basket in such countries, these authors decomposed inflation into food and non-food components and found that food prices are a significant source of inflation in Kenya. These authors identified elements characterizing low-income and developing countries, including the microstructure of the food sector and its exposure to domestic and international shocks, the importance of other supply shocks, the degree of price and wage rigidity, the limited access to financial services, the alternative monetary policy instruments such as sterilized interventions in the foreign exchange market, and the imperfect capital mobility. These observations, considered as obstacles to the effective functioning of the inflation targeting regime, and requiring specific considerations in the QPM, have paved the way for various modeling initiatives in this field.

In recent times, the development of QPMs has proliferated, with versions attempting to incorporate the specific characteristics of the economy under consideration. For instance, Bokan and Ravnik (2018) endeavored to introduce ad'hoc features into their model, especially the monetary policy rule, with a moving target exchange rate equation. This innovation is motivated by the significant degree of euroization in the Croatian economy.

Vlcek et al. (2020) proposed a QPM where GDP is decomposed into agricultural and non-agricultural production, along with their respective determinants. This breakdown of GDP allowed for observing the different implications of sectoral activities on inflation dynamics. In addition, inflation is also broken down into core, food, and energy. This model also takes into account the fact that the exchange rate is managed by the National Bank of Rwanda, which still considers some control over the capital account and observes imperfect substitutability between domestic and foreign assets.

The QPM developed for the WAEMU[3] is particular because it operates within a monetary union, where the exchange rate regime is fixed and capital movements remained under control. In this sense, the model takes into account an implicit target for international reserve levels. This involves incorporating a risk premium, a decreasing function with foreign exchange reserves, into the monetary policy equation.

These works and others not cited in the present study have inspired us in the development of a QPM for the case of Madagascar. In the following section, we will describe the canonic model with an application to the case of Madagascar. The extended QPM are constituted with elements drawn from these different developments of QPM modeling.

[3] West African Economic and Monetary Union.

Canonical version of the QPM

Mechanisms

As mentioned earlier, the basic version of the QPM model was proposed by Berg-Karam-Laxton in 2006. This model consists of four blocks, namely: *aggregate demand, inflation dynamics, exchange rate dynamics, and monetary policy reaction function*.

IS curve for aggregate demand:

$$\hat{y}_t = b_1 \times \hat{y}_{t-1} - b_2 \times mci_t + b_3 \times \hat{y}_t^* + \varepsilon_t^{\hat{y}}$$
$$mci_t = b_4 \times \hat{r}_t + (1 - b_4) \times (-\hat{z}_t)$$

This equation shows that the domestic output gap [$\hat{y}$] is explained by its past level, the monetary condition index [mci], and the foreign output gap [$\hat{y}^*$]. The monetary condition index is a function of the real interest rate gap [$\hat{r}$] and the real exchange rate gap [$\hat{z}$].

New-keynesian Phillips curve

$$\pi_t = a_1 \times \pi_{t-1} + (1 - a_1) \times (E_t[\pi_{t+1}]) + a_2 \times rmc_t + \varepsilon_t^{\pi}$$
$$rmc_t = a_3 \times \hat{y}_t + (1 - a_3) \times \hat{z}_t$$

Contemporary inflation [π] is explained by its value from previous period, inflation expectations, and real marginal cost [rmc]. The latter is determined by the output gap and the real exchange rate gap.

Uncovered interest rate parity

$$\Delta \bar{z}_{t+1} = \bar{r}_t + \bar{r}_t^* - prem_t$$

This relation indicates that the exchange rate differential does not allow tradeoff between investing in the domestic economy and abroad. The investment decision depends solely on the interest rate differential [r] and the risk premium [$prem$].

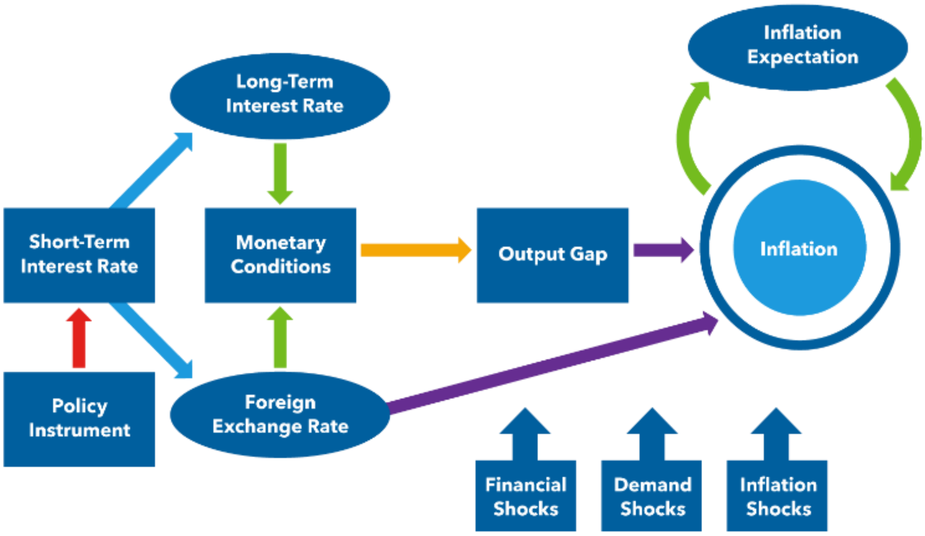
Taylor rule

$$i_t = g_1 \times i_{t-1} + (1 - g_1) \times i_t^{neutral} + g_2 \times (E_t[\pi_{t+4}^4] - \pi_{t+4}^T + g_3 \times \hat{y}_t) + \varepsilon_t^i$$

The monetary authority responds to a deviation of inflation [$E_t[\pi_{t+4}^4] - \pi_{t+4}^T$] from its target and to the deviation of output from its potential level. The monetary policy from the previous period continues to play a significant role in this rule (g_1 represents the weight of the interest rate from the previous period).

Given its structure, the model incorporates three types of elements: *equations (structural, reduced form), parameters (steady state, coefficients in equations, standard deviations of shocks), and variables (observed and unobserved*. The monetary policy transmission mechanism is summarized by the diagram below:

Figure 1: Transmission mechanism in the canonical QPM



Source: International Monetary Fund

This graph indicates that the ultimate goal of monetary policy is to achieve the medium-term inflation target. There are two transmission channels: *interest rate and exchange rate*.

For the interest rate channel, when the Central Bank adjusts its primary interest rate through short-term operations in the money market, the trajectory of interest rates across the economy would be influenced. When all interest rates in the economy rise, there is a tightening of monetary and financial conditions, leading to a decrease in aggregate demand in the short term, which induces a decline in production. This situation alleviates pressure on marginal costs and consequently on inflation.

Regarding the exchange rate channel, the initial assumption is a perfect mobility of capital. Under this condition, when faced with a high domestic interest rate compared to abroad, a holder of foreign currency is prompted to invest in the domestic country. This movement causes an influx of foreign currencies to be exchanged into local one, leading in an appreciation of the latter. In turn, this appreciation of the local currency alleviates inflationary pressures as imported goods become cheaper.

The resolution of the model begins with assigning a value to each structural parameter. When parameters are properly calibrated, the model should have a unique stable solution (Blanchard-Kahn condition). The dedicated software manages the computation of algorithms.

Application of the canonical version to the case of Madagascar

Data

The following time series are used:

- Quarterly GDP from the National Statistics Office;
- Consumer price from the National Statistics Office;

- NEER[4] from the Central Bank of Madagascar ;
- Quarterly weighted average of interbank interest rates from CBM;
- Quarterly composite index of GDPs of Madagascar’s main trading partners;
- Quarterly composite index of CPIs of Madagascar's trading partners;
- Euribor 3-months from the European Central Bank database;
- Medium-term inflation target: convergence criteria.

The observation period starts in 2007 on a quarterly basis, coinciding with the availability date of quarterly GDP data. These latter are seasonally adjusted.

Parameters values

As in most QPMs, parameter values are assigned through three approaches: *estimation from data for available series, calibration from previous studies, and expert judgment*. The table in appendices presents the values of the model's structural parameters, namely steady states, coefficients, and shocks, along with their respective justifications.

Results

As mentioned in the description, the QPM adequately explains the functioning of the economy. The series of graphs below describe the response of key variables to a 1.0 percentage point shock. Then, figure 2 shows that an inflationary shock of 1.0-point intensity leads to an instantaneous inflation of over 1.0 percent (blue line).

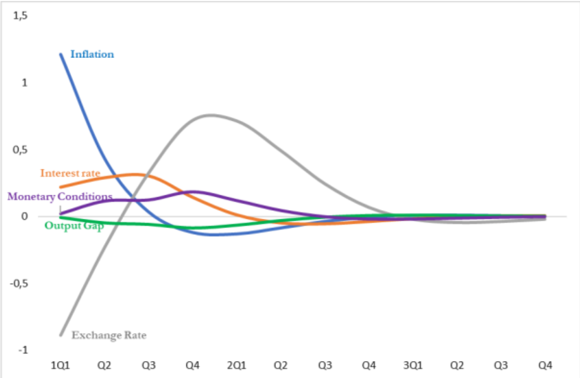
The orange line displays the central bank's response to this phenomenon. It gradually increases the interest rate to reach a peak in the third quarter. The path of the interest rate starts to decelerate as inflation converges towards its target. The return of inflation to its equilibrium takes some time (about 1 year), explained mainly by the existence of a fraction of firms (40.0% for the case of Madagascar) that set their prices on past information (backward-looking agents). This is one of the flexibilities provided by the QPM model compared to typical DSGE[5] models.

The restrictive monetary policy reduces the supply of domestic currency and immediately appreciates its nominal value (grey line). This situation lasts for two/three quarters. After this, the national currency experiences depreciation. The local currency only regains its equilibrium value after a quite long period. Due to restrictive monetary policy, monetary conditions tighten gradually, which remain moderate when the domestic currency appreciates.

The reaction of the output gap is almost symmetrical to the tightening of monetary conditions. Otherwise, production does not reach its potential level in a context of restrictive monetary policy and depreciation of the national currency. Nonetheless, the negative values of the output gap during this period are relatively moderate.

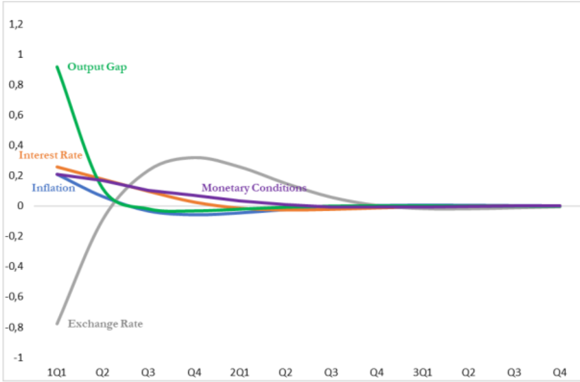
[4] Nominal Effective Exchange Rate.
[5] Dynamic Stochastic General Equilibrium

Figure 2: Impulse responses of main variables to an inflationary shock



Source : author via Matlab

Figure 3: Impulse responses of main variables to a demand shock



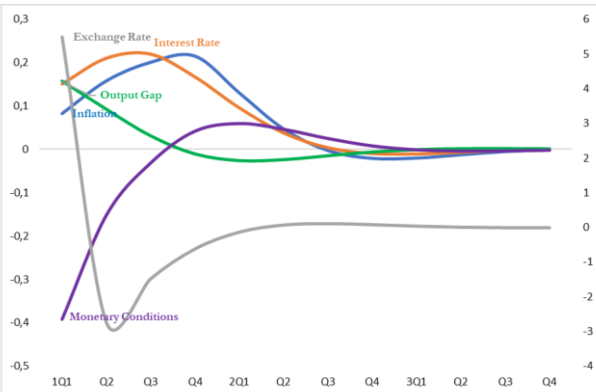
Source : author via Matlab

The figure 3 illustrates the responses of key variables to a 1.0 percentage point shock in aggregate demand. Immediately, output rises by nearly 1.0 point. This reaction dissipates after two quarters.

A shock on the exchange rate yields more chaotic effects (figure 4). Indeed, this phenomenon leads to an instantaneous depreciation of nearly 5.5 points (grey line, right axis). The loss of value lasts only one quarter and even transforms into appreciation during the following three quarters before gradually returning to its equilibrium. This shock is quite detrimental, as even though the depreciation is temporary, its impact on inflation (pass-through) persists. Inflation continues to rise until reaching its peak after one year, and it only returns to its medium-term target value three quarters next this peak.

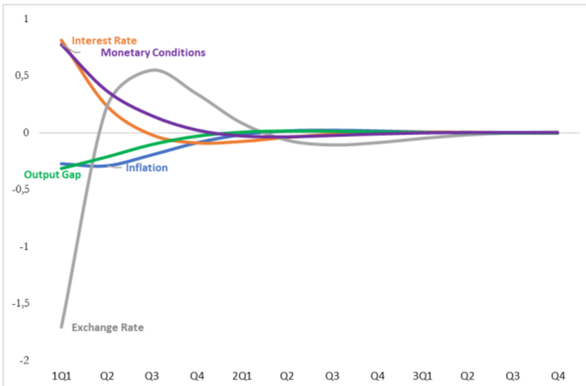
The Monetary Authority, to address this rise in prices, increases its interest rate. This action is expected to last until the return of inflation to its equilibrium. Paradoxically, the monetary conditions remain accommodative, because of the cumulative magnitudes of the national currency appreciation which absorb the moderate increases in interest rate.

Figure 4: Impulse responses of main variables to a real exchange rate shock



Source : author via Matlab

Figure 5: Impulse responses of main variables to a real interest rate shock



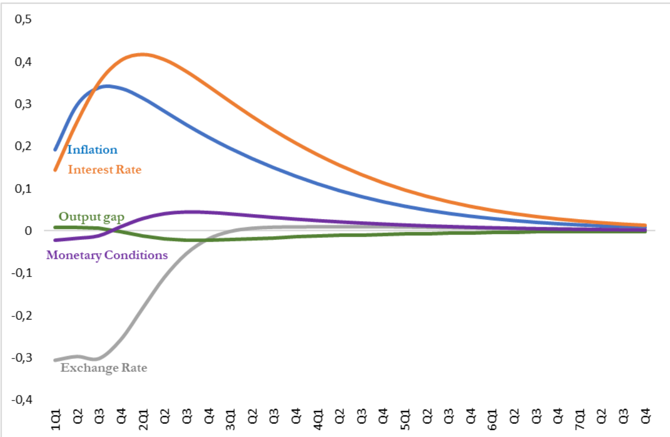
Source : author via Matlab

A 1.0-point shock on the real interest rate leads to an increase in the nominal interest rate of 0.8 point, which dissipates after three quarters (figure 5). Inflation decreases in reaction to this central bank's measure. The exchange rate also experiences a significant appreciation. Monetary conditions tighten as the appreciation of the national currency is not sufficient to offset the increase in the interest rate. This is due to the weight of the interest rate in the monetary conditions index. As before, the reaction of the output gap is almost symmetric to that of the monetary conditions.

A shock to foreign inflation has a significant impact on domestic inflation, which increases to reach a peak of 0.4 point after three quarters. The domestic inflation only returns to its medium-term target after nearly seven years, as shown by the figure 6. The central bank reacts to this inflationary phenomenon, by increasing the interest rate more strongly, but in a smooth manner. This measure continues until the inflationary surge dissipates.

The strictly restrictive monetary policy reduces the supply of local currency and leads to its appreciation. Monetary conditions remain neutral during the first three quarters, as the increase in interest rates almost offset the appreciation of the national currency. As soon as the exchange rate begins to converge towards its equilibrium value, the interest rate alone tightens the monetary conditions, inducing a deterioration of the output gap.

Figure 6: Impulse responses of main variables to a foreign inflation shock



Source : author via Matlab

Presentation of Gaskam

The basic model presented earlier adequately explained the conduct of monetary policy. However, there are rooms for improvement to better capture the specificities of the Malagasy economy. This section will therefore outline the addition of blocks and new equation specifications, the inclusion of new time series and enhancement of data quality, as well as the increase and re-estimation of parameters.

Addition of blocks and new equation specifications

IS curve

The aggregate demand curve from the canonical version is replicated, but augmented by the fiscal impulse, which will be detailed in the section on the fiscal block. The equation is as follows:

$$\hat{y}_t = b_1\hat{y}_{t-1} - b_2 mci_t + b_3 FImp_t + b_4\hat{y}^*_t + \varepsilon_t^{\hat{y}_t}$$

$\hat{y}_t$: domestic output gap

$\hat{y}^*_t$: foreign output gap

$mci_t = b_5\hat{r}_t + (1 - b_5)(-\hat{z}_t)$: monetary conditions

$FImp_t$: fiscal impulse (variation in the Government's overall balance resulting from changes made in expenditures and taxation; measured by the variation in the ratio of the cyclically adjusted budget deficit to GDP.)

$\varepsilon_t^{\hat{y}_t}$: Shock affecting demand

Phillips Curve

For the case of Madagascar, we disaggregate the Consumer Price Index (CPI) into three components to better observe the inflation dynamics: *core, rice, and energy*. The core component is one whose evolution is considered to be influenced by monetary policy. Rice is the Malagasy population's staple food, and its isolation from the consumption basket appears to be interesting because its price movement affects quite significantly the general price level. Energy, mainly composed of petroleum products, is a strategic commodity in this economy. Although oil prices are "administered" in Madagascar, it is essential to isolate them from the consumption basket. For instance, if there are sustained pressures on oil prices, particularly stemming from a substantial increase in international prices and a significant depreciation of the national currency against the US dollar, the Government is compelled to abruptly adjust pump prices.

The general price level is the aggregation of these three components:

$$cpi_t = w^{core} cpi_t^{core} + w^{rice} cpi_t^{rice} + w^{erg} cpi_t^{erg} + \varepsilon_t^{cpi}$$

The core component follows the dynamics of the new Keynesian Phillips curve:

$$\pi_t^{core} = a_{11}\pi_{t-1}^{core} + (1 - a_{11})(E_t[\pi_{t+1}^{core}]) + a_{21} rmc_t^{core} + \varepsilon_t^{\pi^{core}}$$

Contemporary inflation is explained by its past level, inflation expectations, and real marginal costs. The latter are determined by the output gap and the real exchange rate gap:

$$rmc_t^{core} = a_{31}\hat{y}_t + (1 - a_{31})\hat{z}_t$$

The real marginal cost for the core is explained, as in the basic model, by the output gap and the real exchange rate gap.

For rice, inflation is also determined by the following Phillips curve:

$$\pi_t^{rice} = a_{12}\pi_{t-1}^{rice} + (1 - a_{12})\left(E_t\left[\pi_{t+1}^{rice}\right]\right) + a_{22}rmc_t^{rice} + \varepsilon_t^{\pi^{rice}}$$

However, the marginal real cost is different for rice, as given by the following equation:

$$rmc_t^{rice} = a_{32} * \left(\widehat{cpi}_t^{rice*} + \hat{z}_t - \widehat{cpi}_t^{rice}\right) + (1 - a_{32})\hat{y}_t$$

The real marginal cost of rice is determined by two elements:

- Domestic output gap;
- As the country remains a rice importer to fill the local production gap, imports are captured by the gap in the world rice price and the real exchange rate gap, but adjusted by the relative price of rice to the overall price.

For energy, since prices of oil products are "administered", the inflation dynamics are given by the following AR(1) process:

$$\pi_t^{erg} = a_{13}\pi_{t-1}^{erg} + \varepsilon_t^{\pi^{erg}}$$

Uncovered interest rate parity and determination of exchange rate dynamics

We start from the assertion of Resende et al. (2022), « *the purely forward-looking behaviour of investors forces the current exchange rate to adjust immediately to the foreign-domestic interest rate differential and to the evolution of the risk premium while the observed exchange rate shows smaller variations*". These authors have proposed a modified version of the UIP equation with nominal exchange rate, as follows:

$$s_t = e_1\left(s_{t-1} + \frac{2}{4}\Delta\bar{s}_t\right) + (1 - e_1)E_t s_{t+1} + \frac{(i_t^* - i_t + prem_t)}{4} + \varepsilon_t^s$$

where $\Delta\bar{s}_t = \bar{\pi}_t - \bar{\pi}_t^* + \Delta\bar{z}_t$ is the long-term variation of the exchange rate equilibrium.

For the case of Madagascar, it is normal to capture in this exchange rate dynamics the behavior of the country's foreign trade. The weakness of the industrial sector means that the country remains dependent on imports. For the same reason, Madagascar's main exports are are constituted by commodities, with a very volatile prices in the global market. Then, our modified UIP relationship should be written as follows

$$s_t = e_1 E_t s_{t+1} + (1 - e_1) s_{t-1} - e_2 \left(\frac{i_t - i_t^* - prem_t}{4}\right) - e_3 td_t + \varepsilon_t^s \ .$$

The dynamics of the trade deficit will be described in the external sector subsection.

Fiscal sector

The main equation is the fiscal impulse, which measures the effect of fiscal policy on economic activities. The fiscal impulse is discretionary, as the government does not follow a predefined rule to support the economy through budget execution. The definition of the fiscal impulse is standard in the literature, as the deviation of the structural primary deficit from its target level, which is:

$$FImp_t = pd_t^S - \overline{pd}_t^S$$

with : $pd_t^S = pd_t - pd_t^C$, the structural primary deficit is obtained by subtracting the cyclical deficit from the primary deficit. The cyclical deficit is defined as : $pd_t^C = elasticity * \hat{y}_t$.

The primary deficit is given by

$$pd_t = rho_{pd} * pd_{t-1} + \left(1 - rho_{pd}\right) * pd_t + \varepsilon_t^{pd}$$

and $\overline{pd}_t^S = rho_{pdsbar} * \overline{pd}_{t-1}^S + (1\text{-}\, rho_{pdsbar}) * \overline{pd}_t^S + \varepsilon_t^{\overline{pd^S}}$

External sector

The simple dynamics of the trade deficit are specified as follows:

$$td_t = exp_t - imp_t$$

with:

$exp_t = ex * \hat{y}_t^* + \varepsilon_t^{exp}$, as exports are influenced by a fraction of the foreign output gap, which is the elasticity of external demand with respect to the relative price of exports;

$imp_t = em * \hat{y}_t + \varepsilon_t^{imp}$, where imports are a function of the domestic output gap, em being the elasticity of domestic demand with respect to the relative price of imports.

Additionally, the external sector is complemented by the identification of the foreign output gap, the foreign price level, the foreign interest rate, as well as world prices of rice and energy.

Addition of variables and enhancement of data

Compared to the basic version of the QPM, significant improvements have been made to the data. Furthermore, the following time series have been added:

- Decompositions of the CPI into core, energy and rice;
- Global prices of rice and energy;
- Exports and Imports.

Furthermore, the exchange rate series is replaced to a composite euro-USD index, instead of the nominal effective exchange rate (NEER) in the previous version. Indeed, upon analyzing foreign trade, it is observed that the majority, if not all, transactions are settled in either one of these currencies, even if commercial operations are conducted with other trading partners.

Based on this reasoning, Madagascar's trading partners have been "reduced" to two, namely the United States and the Eurozone. Therefore, both GDP, CPI, and the global interest rate are weighted averages of the variables from these two countries.

Finally, the indices have been rebased to have series with the same base year. Other data processing procedures remain unchanged, including seasonal adjustment.

Addition and re-estimation of existing parameters

Due to the addition of numerous equations in this enhanced version of the QPM model, the number of parameters has significantly increased. Additionally, the existing parameters have been re-estimated according to changes in the data. The second table in the appendix describes the assignment of values to the parameters of the Gaskam model.

Results

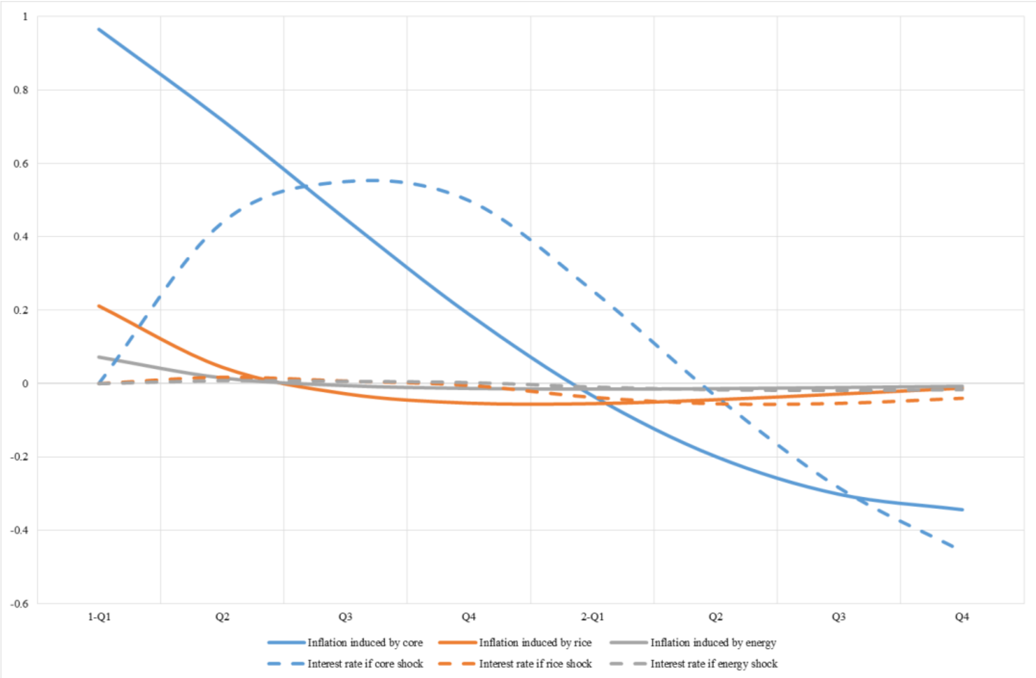
In this section, we will highlight only the gains in results obtained from the extension and enhancement of the basic QPM model.

Impulse responses

Prices dynamics

This improved version of the QPM comprises a decomposition of the CPI into core, rice, and energy components. As expected, the shock to core inflation impacted the most the overall inflation. Indeed, a 1-point cost-push shock to core inflation leads to an increase of inflation by 0.9 point, whereas it is limited to 0.22 point for a shock to rice prices and almost negligible (0.08 point) for a shock to energy prices. So, only the rise in prices of core products generates a response from the Monetary Authority, of around 50 basis points over the next three quarters. Another 25-point increase in the fourth quarter is necessary to dissipate this shock. This situation confirms the assumption that core inflation is closely correlated with monetary policy.

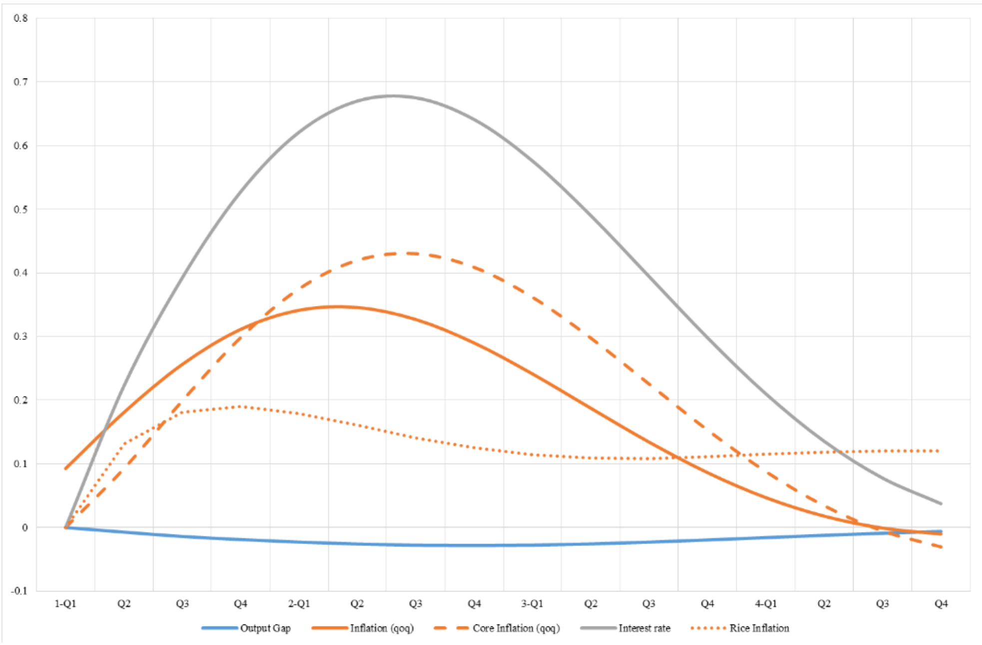
Figure 7: Monetary policy reactions following CPI decomposition



<u>Source</u>: author via Matlab

A shock to foreign inflation also passes through core inflation, which increases steadily to reach a peak of 0.43 point in the third quarter of the second year. Overall inflation follows a similar trajectory but to a lesser extent, with a peak of 0.32 point at the same time. For rice inflation, the magnitude of the increase is limited but persistent. A continuous and significant rise in interest rate is required to bring these inflation rates back to their target level.

Figure 8: Responses of main variables to a foreign inflation shock

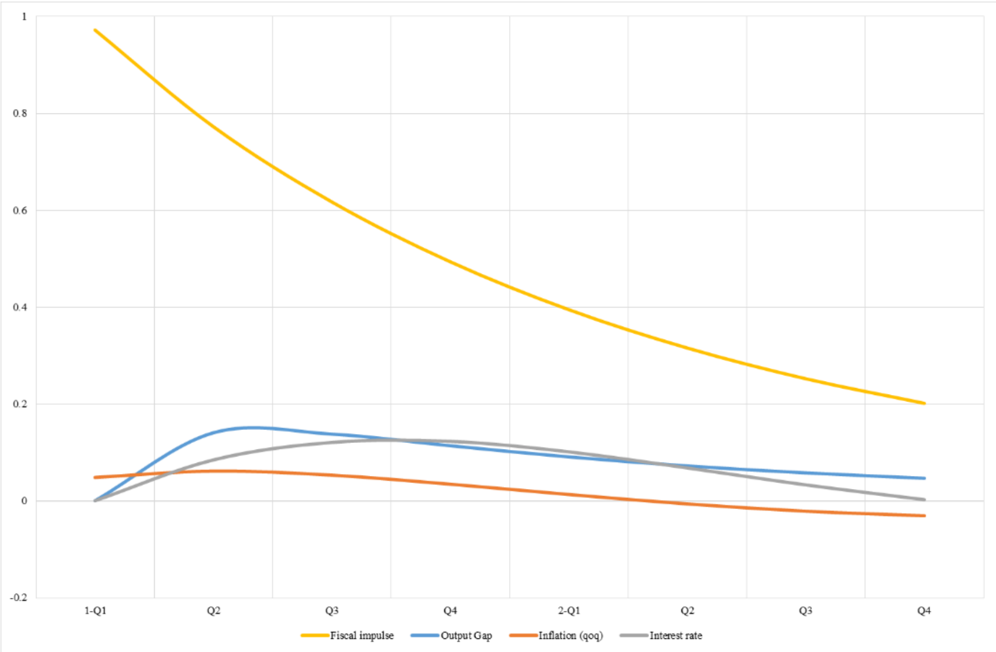


<u>Source</u>: author via Matlab

Fiscal impulse

One of the innovations of this model is the incorporation of fiscal block. We introduced the fiscal impulse, which is defined as the deviation of the structural primary deficit from its target level. Thus, an increase in the structural primary deficit of 1 point leads to a positive fiscal impulse, which lasts for several quarters. This fiscal impulse stimulates demand, yielding an 0.14-point increase. This situation exerts pressure on prices, which increase but quite slightly. A series of interest rate augmentations is required to the Monetary Authority to restore the situation.

Figure 9: Responses of main variables to a structural primary deficit shock

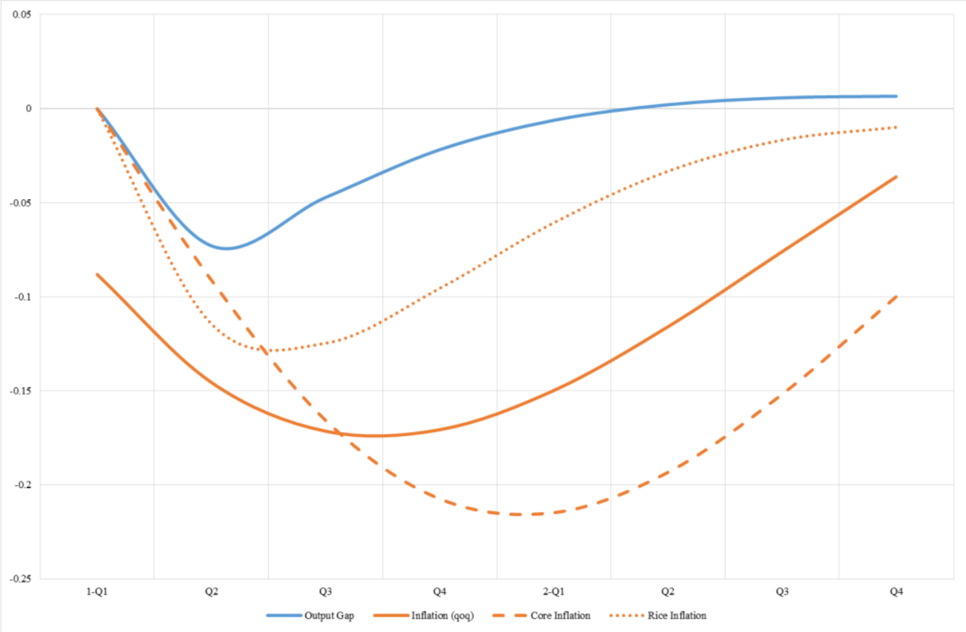


Source: author via Matlab

Monetary policy shock

This shock is already presented in the basic version, but since the CPI is broken down, it is interesting to observe the reactions of its components. As expected, core inflation reacts more to a tightening of monetary policy. Overall inflation contracts instantaneously but with a limited extent, reaching a low of 0.17 point in the third quarter. Rice price inflation also decreases following a monetary policy shock, but with a low magnitude.

Figure 10: Impulse responses to a monetary policy shock



Source: author via Matlab

Variance decomposition

The variance decomposition of inflation is quite narrative. During the observation period, it is noticeable that the quarterly variation in inflation is strongly explained by its previous level, indicating a certain level of persistence. Expectations also explain inflation, and it is observed that the higher the inflation, the more the agents fear that this situation would worsen in the future.

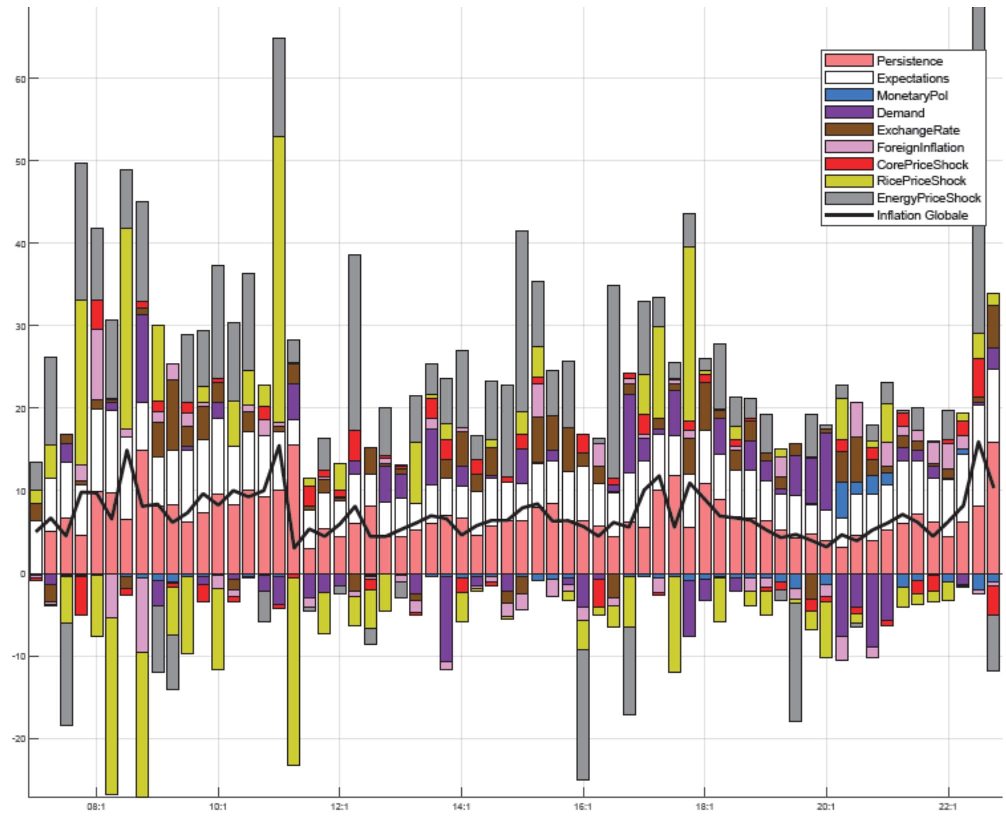
Shocks to rice and energy demonstrate the volatility of the prices of these two products. It is observed that high inflations have been driven by shocks to rice and/or energy prices. The reverse is also true. Even though the price of energy, mainly composed of oil products, is generally administered, there are times when fuel prices have been adjusted, as was the case in the third quarter of 2022, where a +44% revision of pump price was undertaken.

Demand shocks regularly contribute to the variation in quarterly inflation. Generally, they push inflation upwards during periods of prosperity, such as from 2014 to 2019. However, during the lockdown period in 2020, there were negative demand shocks, sustaining a situation of low and stable inflation.

Given the continuous depreciation of the national currency, exchange rate shocks generally contribute to exacerbating inflation.

Throughout the observation period, monetary policy actions are generally restrictive or neutral. However, the extent of tightening remains relatively modest. During the aforementioned lockdown period, monetary policy was eased to support economic activity. However, as inflation increased due to the post-pandemic recovery and the Russia-Ukraine war, the Monetary Authority tightened its monetary policy, with magnitudes relatively larger than in the past.

Figure 11: Inflation (q-oq) variance decomposition

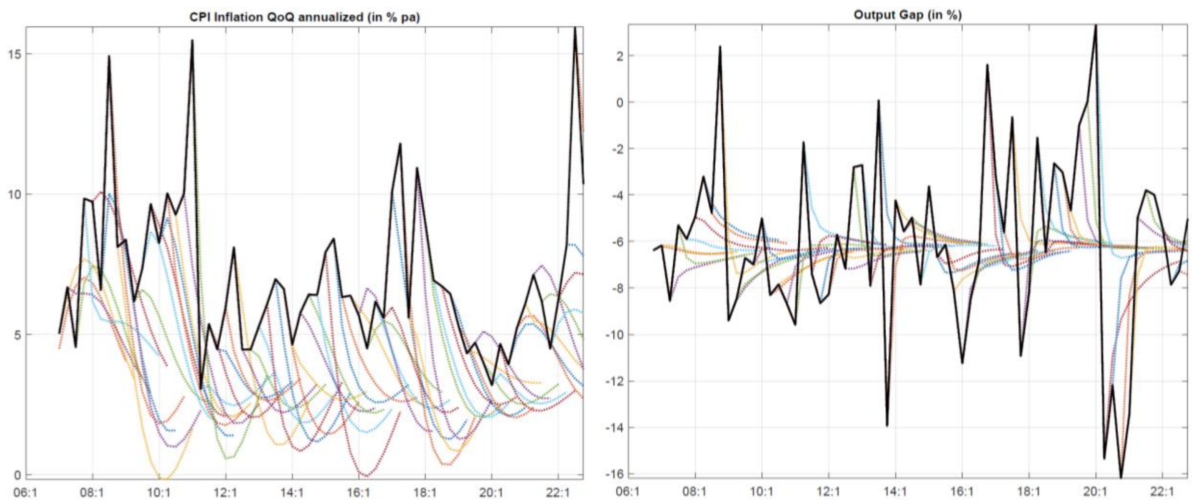


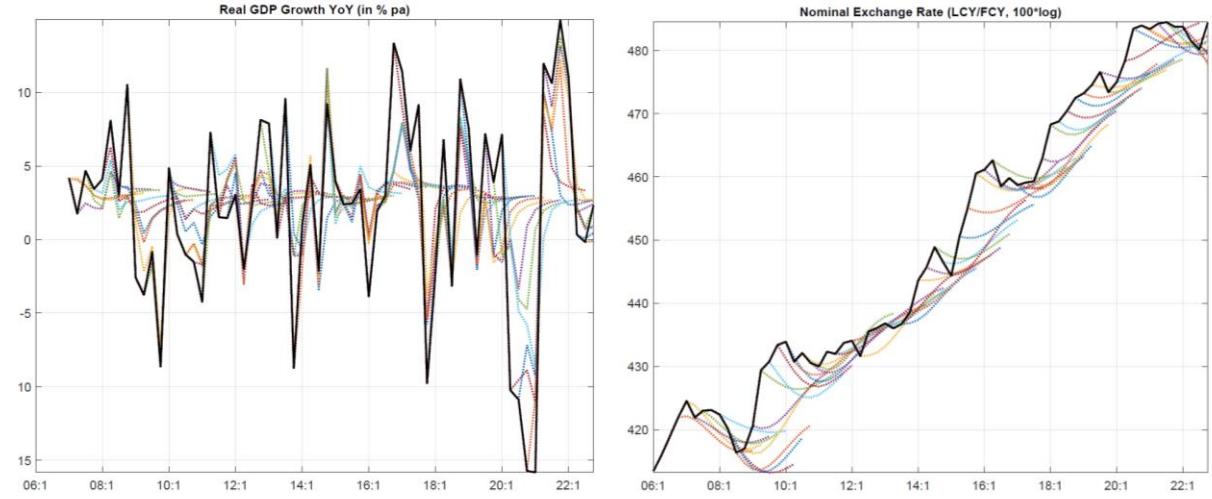
<u>Source</u>: author via Matlab

In-sample forecast

In-sample forecasts allow us to assess the quality of the model's predictions. The following graphs show the results of these in-sample forecasts for inflation, output gap and exchange rate. It appears to indicate that this model generates a relatively good quality forecasts.

Figure 12: In-sample forecasts





Source: author via Matlab

Conclusion

This study presents the evolution of the QPM focused on conducting monetary policy for the case of Madagascar. Initially, we applied the data of this country to the basic model developed by Berg, Karam, and Laxton (2006). Recognizing the areas for improvement that could be made to the canonical model, we subsequently proposed a strengthened version, including the addition of blocks on sectors of the economy not previously accounted for, the decomposition of the CPI, the addition and improvement of data quality, and the re-estimation of parameters.

From this version, considered as more adapted to the Malagasy economy, we have been able to obtain more precise and detailed analysis on the transmission mechanism of monetary policy and the dynamics of inflation in Madagascar. The quality indicators of the forecasts appear to be superior compared to those of the previous version. The implementation of this new model should improve the conduct of monetary policy.

The QPM model is an indispensable tool for a central bank aspiring to conduct forward-looking monetary policy, such as interest rate targeting or inflation targeting. However, it should remain a tool for analysis and decision-making support. The transition to inflation targeting should be the subject of further study to identify especially, the prerequisites gaps related to such a monetary policy regime, including the development of financial markets, the level of central bank independence, fiscal discipline, etc.

Despite the improvement made to the basic version of the QPM, the extended version presented here could be enhanced. Indeed, this model seems to omit other features of the Malagasy economy, such as the existence of many rigidities in different markets, the failure to take into account the financial sector, the non-consideration of the informal sector predominance, etc. Approaches for assigning values to parameters may also be subject to criticism. Data gaps, in terms of quality and time availability, remain the Achilles tendon of researches on the case of Madagascar. We must recognize that some data issues would necessarily have impacted the quality of the analyzes and forecasts carried out with this model.

References

Andrle M., Berg A., Armando Morales R., Portillo R., and Vlcek J. (2013): *"Forecasting and Monetary Policy Analysis in Low-Income Countries: Food and non-Food Inflation in Kenya"*, IMF WP/13/61.

Berg A., Karam P., and Laxton D. (2006a): "*A Practical Model-Based Approach to Monetary Policy Analysis—Overview*", IMF WP/06/80.

Berg A., Karam P., and Laxton D. (2006b): "*A Practical Model-Based Approach to Monetary Policy Analysis—A How-to Guide*", IMF WP/06/81.

Bokan N., and Ravnik R. (2018): "*Quarterly Projection Model for Croatia*", Croatia National Bank, Surveys S-34.

Carabenciov I., Ermolaev I., Freedman C., Juillard M., Kamenik O., Korshunov D., and Laxton D. (2008): "*A Small Quarterly Projection Model of the US Economy*", IMF Working Paper WP/08/278.

de Resende C., Fall A., and Sy D. (2022): "*A Quarterly Projection Model for the WAEMU*", IMF WP/22/215.

Randriamianjaharison F.J. and Rivomanantsoa J.G. (2020) "Construction d'un Indicateur des Conditions Monétaires pour Banky Foiben'i Madagasikara », Bulletin de BFM Mars 2020.

Salas J. (2010): "*Bayesian Estimation of a Simple Macroeconomic Model for a Small Open and Partially Dollarized Economy*", Banco Central de Reserva del Peru DT. N° 2010-007.

Vlcek J., Pranovich M., Hitayezu P., Mwenese B., and Nyalihama C. (2020): "*Quarterly Projection Model for the National Bank of Rwanda*". IMF WP/20/295.

https://www.instat.mg/

https://www.banky-foibe.mg/

https://data.ecb.europa.eu/

https://tradingeconomics.com/

Appendices

Parameters of the canonical QPM

Parameters	Value	Rationale
Steady-states		
Potential output	2.8	Annualized quarterly growth during the observation period
Inflation target	5.0	Regional convergence criteria
Domestic real exchange rate	-1.4	Middle of interest rate corridor at that time deflated by inflation
Real exchange rate	0.0	Exchange rate stability objective
Foreign inflation target	2.0	Adopted in the main economic partners
Niveau du taux d'intérêt réel étranger	0.75	Weighted average in main partners over a given period
Coefficients		
b1: Output peristence	0.2	Satellite model
b2: Impact of monetary policy on real activity	0.4	Satellite model
b3: Impact of external demand on domestic production	0.7	Satellite model + expert judgment
b4: Weight of interest rate on the monetary conditions index	0.78	Related study[6]
a1: Inflation persistence	0.4	Satellite model
a2: Transmission of real marginal cost on inflation	0.3	Calibation
a3: Share of domestic cost in the total cost of firms	0.7	
g1: Monetary policy persistence	0.5	Neutral behavior of the Central Bank
g2: Monetary policy reaction to the deviation of inflation	0.7 ou 0.5	In the first case (0.7 and 0.3), the Monetary Authority's stated determination to react more to the deviation in inflation than to that of production. In the second case (0.5 and 0.5), equal distribution between responses to inflation and the output gap
g3: Monetary policy reaction to the output gap	0.3 ou 0.5	
e1: Weight of the « backward looking » component in the exchange rate	0.4	Satellite model
Rho_ : persistance de l'ajustement de la cible d'inflation à la cible de moyen terme	0.5	Standard in basic QPM
Standard deviation of shocks		
All standard deviations	0.8	Standard in basic QPM

<u>Source</u> : author and others

Parameters of Gaskam

Parameters	Description	Value	Rationale
a_{11}	Core inflation persistence	0.64	AR(1) estimation of CPI core serie[7]
a_{21}	Transmission of real marginal costs to core inflation	0.2	Calibration
a_{31}	Share of domestic cost in the total cost of firms	0.5	Expert judgment

[6] Randriamianjaharison and Rivomanantsoa (2020)

[7] Central Bank of Madagascar

	producing core goods and services		
a_{12}	Rice infaltion persistence	0.31	AR(1) estimation of CPI rice serie
a_{22}	Transmission of real marginal costs to rice inflation	0.3	Calibration
a_{32}	Share of rice imports	0.132	Volume of rice imports/(local production + imports)
a_{13}	Energy inflation persistence	0.33	AR(1) estimation of CPI energy serie
b_1	Output gap persistence	0.21	AR(1) estimation of output gap serie
b_2	Impact of monetary conditions on demand	0.1	Estimation of 2 variables model : *GDP and MCI*
b_3	Impact of discretionnary fiscal policy on demand	0.15	Estimation of 2 variables model : *GDP and Fiscal Impulse*
b_4	Impact of foreign demand on domestic demand	0.3	Estimation of 2 variables model : *domestic output gap and foreign output gap,* adjusted by an expert judgment
b_5	Weight of interest rate on the monetary conditions index	0.78	Related study[8]
w^{core}	Weight of core products/services in the consumption basket	0.744	Respective weights in the consumer price index[9]
w^{riz}	Weight of rice in the consumption basket	0.1785	
w^{erg}	Weight of energy in the consumption basket	0.0775	
e_1	Forward-looking component in the exchange rate	0.87	1 minus the weight of backward-looking component (estimated from an AR(1) on exchange rate serie)
e_2	Importance given by the central bank to smooth the exchange rate	0.2	Calibration
e_3	Impact of trade balance on exchange rate	0.46	Estimation of 2 variables model : *exchange rate and trade balance*
g_1	Monetary policy persistence	0.5	Neutral behavior of the central bank
g_2	Monetary policy reaction to the deviation of inflation	0.7 or 0.3	In the first case (0.7 and 0.3), the Monetary Authority's stated determination to react more to the deviation in inflation than to that of
g_3	Monetary policy reaction to the output gap	0.5 or 0.5	

[8] Randriamianjaharison and Rivomanantsoa (2020) op. cited
[9] Central Bank of Madagascar

			production. In the second case (0.5 and 0.5), equal distribution between responses to inflation and the output gap
ex	Elasticity of external demand to exports prices	0.1	Estimation of 2 variables model : *foreign GDP and exports prices index*
em	Elasticity of domestic demand to imports prices	0.28	Estimation of 2 variables model : *domestic GDP and imports prices index*

Source : author and others