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Overview of the Macedonian Policy Analysis Model (MAKPAM)

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Abstract

This paper describes the Macedonian Policy Analysis Model (MAKPAM), which is used at the National Bank of the Republic of Macedonia (NBRM) for medium term macroeconomic forecasting and policy analysis. The MAKPAM is a medium scale, New Keynesian gap model that incorporates the key characteristics of the Macedonian economy: a small open economy with a fixed exchange rate regime. This model outlines the transmission mechanism of the monetary policy in the Macedonian economy, and it helps to quantify the reaction of the economy to various shocks. Since 2008, the MAKPAM model has gradually become an important block of the macroeconomic forecasting system of the NBRM. The model is therefore an important analytic tool for supporting the monetary policy decision-making of the NBRM.

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Contents:

1 Introduction

The paper presents the key features of the Macedonian Policy Analysis Model (MAKPAM), which is the core model used by the National Bank of the Republic of Macedonia (NBRM) for policy analysis and forecasting.

The primary objective of the National Bank of the Republic of Macedonia is to maintain price stability. The main instrument that is used by the central bank in its efforts to achieve price stability is keeping the nominal exchange rate of the Macedonian denar against the euro stable. Due to relatively high de jure capital mobility, short term policy interest rates are set in order to prevent any arbitrage. In other words, the domestic policy rates are derived from the policy rates in the euro area and the risk premium. Therefore, the overall macroeconomic forecast is consistent with the behaviour of the NBRM supporting the maintenance of the fixed exchange rate regime. Consequently, in the last decade, the NBRM has invested in the development and adoption of a modern forecasting and policy analysis system, with considerable technical assistance by the International Monetary Fund (IMF). MAKPAM lies at the core of this framework. It is used by the central bank for two main purposes: to derive the future path for the policy rate consistent with the future interest rates in the euro area and the risk premium, and to provide a macroeconomic forecast, which serves as an important input into the monetary policy decision-making.

MAKPAM belongs to the class of New Keynesian gap models. Gap models are small structural models which provide a stylized framework of the aggregate economy, including the monetary policy transmission mechanism. Being based on the New Keynesian framework, which is dominant in the modern macroeconomics, MAKPAM reflects the importance of rational expectations, as well as nominal and real rigidities in the economy. Like all gap models, MAKPAM embodies the basic principle that the fundamental role of monetary policy is to provide an anchor for inflation expectations. Due to existing nominal and real rigidities in the economy, aggregate demand determines output in the short run; expectations matter for both inflation and output; and monetary policy supports the sustainability of the fixed exchange rate, and maintains arbitrage-free conditions on the foreign exchange market.

MAKPAM includes all the key features of standard gap models, which are primarily related to the incorporation of key theoretical economic concepts into the model: the IS curve, the Phillips curve, the interest rate parity with the corresponding specification of the risk premium. The model specification reflects the main country-specific features. In particular, the MAKPAM captures in detail the foreign exchange flows crucial for quantifying the country's risk premium, having a strong impact on policy decisions. In addition, the model has been extended with the real expenditure components of GDP, as well as corresponding deflators. This level of detail enables to provide the policymakers with sufficiently disaggregated analysis during regular forecasting rounds. Finally, the calibration of model parameters is fully in line with the stylized facts of the Macedonian economy and the perceived monetary policy transmission.

This paper is structured as follows: The following section gives an overview of the theoretical foundations and the typical structure of gap models. Section 3 provides the historical background to the development of MAKPAM. The structure of MAKPAM and its core equations are presented in Section 4. Section 5 discusses the transmission mechanism and forecasting properties of MAKPAM. The final section concludes.

2 Gap models - theoretical foundations and typical structure[1]

Gap models are small structural models which provide a stylized framework of the aggregate economy, including the monetary policy transmission mechanism. These models, known also as small macroeconomic models, are mostly used for policy analysis and macroeconomic projections by the central banks or researchers mainly in inflation targeting countries with a flexible exchange rate. The main purpose of these models is to describe in a relatively simple, yet consistent and plausible manner, how monetary policy affects the economy and by which means it achieves price stability as a final medium-term goal. The label 'gap models' refers to the fact that most variables in these models are defined in gap terms, i.e. in terms of deviations of actual variables from their trend (equilibrium) values. This ensures that these models focus on the cyclical movements in the economy (gaps), i.e. on the demand side of the economy. In these models, gaps close in the medium run, which means that in the medium run the economy converges to equilibrium. Consequently, these models reflect the generally accepted assumption that, in the long run, macroeconomic policies (i.e. monetary policy in this case) can not affect aggregate supply, which is determined by other, structural factors.

Theoretically, gap models are structural, New Keynesian models. Like most modern macroeconomic models, they are based on the new neo-classical synthesis (Goodfriend and King, 1997; Woodford, 2009), which represents a combination of the real business cycle (RBC) methodology with the Keynesian theory. More precisely, the theory of RBC provides the methodology of inter-temporal optimization by rational economic agents. In addition, gap models also include nominal rigidities that are commonly found in Keynesian models, most notably monopolistic competition and sticky prices and wages. However, unlike the typical Dynamic Stochastic General Equilibrium (DSGE) models, gap models are not explicitly derived from micro-foundations. Instead, they use a relatively simple structure that incorporates the key building blocks of New Keynesian models[2]. The simple gap model typically consists of an aggregate demand (or IS) curve, a price-setting (or Phillips) curve, an exchange rate equation and a policy reaction function. These classes of models embody the basic principle that the fundamental role of monetary policy is to provide an anchor for inflation expectations. They embody the key policy dilemma policymakers regularly focus on: due to the existence of nominal and real rigidities, aggregate demand determines output in the

[1] The discussion in this section is based to a considerable extent on Berg et al. (2006a) and Berg et al. (2006b).
[2] For a description of standard New Keynesian models, see Clarida et al. (1999) or Woodford (2003).

short run; economic agents' expectations matter for both inflation and output; and monetary policy is expressed in terms of a rule for setting the nominal interest rate for the case of inflation targeting regimes (Berg et al., 2006a), or on the arbitrage condition for the fixed exchange rate regime.

Parameters in most of these models are not estimated, but are calibrated instead. The most common methodology used when bringing the model close to data is calibration, using an eclectic approach. This means that the choice of coefficients should be reasonable from the standpoint of economic theory, should be in line with econometric evidence, and should be based on a good understanding of the transmission mechanism. Although individual parameters might be calibrated separately, the crucial test of the calibration is related to the overall dynamic and forecasting properties of the model. The calibration, therefore, is an iterative process. A good model calibration assures adequate overall dynamic properties of the model in terms of forecasting performance and a realistic representation of the aggregate economy. This approach has proven to be superior to the pure econometric estimation, as in most cases problems such as lack of data, short time series and relatively frequent structural changes render econometric estimates unreliable.

The main strength of these models is that they represent well the institutional paradigm regarding the functioning of the domestic economy within an economically consistent framework. Most importantly, since these models are based on a model-consistent expectation formation of economic agents, they are suitable tools for carrying out policy analysis. In addition, forecasts based on gap models can be explicit about policy reactions, the source of shocks, and risks resulting from different assumptions about the functioning of the economy. All these aspects reflect the ability of this class of models to help policymakers to structure their thinking and discussions during efficiently designed forecasting exercises by using a simple, aggregate and consistent macroeconomic framework. Consequently, gap models have been or are still used in central banks, for instance as a core policy analysis and forecasting model by the Czech National Bank (Coats et al., 2003) and the National Bank of Serbia (Đukić et al., 2010), or as part of a suite of models of the Bank of England (Bank of England, 1999). In addition, various authors have used gap models to analyse the transmission mechanism in various countries, e.g. Israel (Argov et al., 2007), Chile (Corbo and Tessada, 2003) and Venezuela (Arreaza et al., 2003).

The following part of this section describes the most common features of gap models and lays out the basic economic intuition, without going into details due to model versatility[3]. The core part of the paper, however, is focused on the presentation of the current fixed exchange rate version of the gap model for the Macedonian economy, which will be elaborated and discussed in more detail in the following sections.

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[3] For a detailed description and comparison of various gap models, see Berg et al. (2006a) and Berg et al. (2006b).

2.1 The typical structure of gap models

Typically, small open economy (SOE) gap models designed for capturing an economy operating within a floating exchange rate consist of four key equations: (1) an aggregate demand or IS curve; (2) a price-setting or Phillips curve; (3) an uncovered interest parity condition; and (4) a policy rule[4]. As noted above, gap models define real variables in terms of gaps, or deviations of actual variables from equilibrium values (e.g. output gap as the deviation of observed real output from its equilibrium). An implicit assumption in gap models is that equilibrium values in the economy are determined by supply-side factors and hence are not affected by monetary policy. Therefore, these models are not designed to explain equilibrium values *per se*, but they focus instead on how the economy adjusts in order to eliminate deviations from equilibrium (i.e. how gaps close). Equilibrium values in gap models are typically determined by applying various types of filtering techniques to actual data in order to extract trend or equilibrium values (e.g. linear trends, Hodrick-Prescott filtering or Kalman filtering). More sophisticated gap models typically use the Kalman filter, which utilises the model structure, its estimated (or calibrated) parameters and standard deviations to decompose observed real variables into a cyclical component and a trend (equilibrium) component.

The aggregate demand equation (IS curve)

The aggregate demand equation links the output gap[5] (y_{gap}), to its main macroeconomic determinants. In line with economic theory, aggregate demand depends on future and lagged aggregate demand and the real interest rate expressed in gap terms (r_gap). The lagged real exchange rate gap (q_{gap}) and foreign effective demand gap (yf_{gap}) are also often included in order to capture the open economy context. All variables of the aggregate demand equation are expressed in gap form, i.e. as deviations from their respective equilibria.

$$y_{gap_t} = \beta_1 \cdot y_{gap_{t+1}} + \beta_2 \cdot y_{gap_{t-1}} + \left(\beta_3 \cdot q_{gap_{t-1}} - \beta_4 \cdot r_{gap_{t-1}}\right) + \beta_5 \cdot yf_{gap_{t-1}} + \varepsilon_t^{y_{gap}} \qquad (1)$$

The aggregate demand equation stipulates that, assuming short-run price rigidity, a (positive) shock to the policy rate leads to an increase of the real interest rate gap, which in turn leads to a fall in private consumption and private investment, as households save more and companies find borrowing more expensive. Consequently, the interest rate increase results in a fall in aggregate

[4] Besides these key equations that represent the essential features of the economy, gap models have additional behavioural equations, identities and definitions.
[5] The equilibrium (or potential) output in gap models may deviate from the traditional understanding of potential output as the one that results from a full use of production factors. Instead, equilibrium output in gap models is defined as the level of output that can be produced in current circumstances without generating inflationary or deflationary pressures.

demand (lower output gap). This contractionary effect is additionally strengthened by the exchange rate, as the increase of the policy rate also leads to real exchange rate appreciation (negative real exchange rate gap) through the uncovered interest parity condition (see below). The real appreciation, in turn, results in lower exports due to deteriorating price competitiveness and higher imports reflecting lower import prices. These factors contribute further to the fall in aggregate demand.

The inflation equation (Phillips curve)

The standard Phillips-curve specification states that inflation depends on inflation expectations, the output gap (y_{gap}), the real exchange rate gap (q_{gap}) and imported prices ($\pi^{oil}, \pi^{foreign}$).

$$\pi_t = \delta_1 \cdot \pi_{t+1} + \delta_2 \cdot \pi_{t-1} + +\delta_3 \cdot \pi_t^{oil} + \delta_4 \cdot \pi_t^{foreign} + \delta_5 \cdot y_{gap_{t-1}} + \delta_6 \cdot q_{gap_{t-1}} + \varepsilon_t^{\pi} \quad (2)$$

This equation embodies several important ideas related to economic theory and monetary policy transmission. First, in line with the New Keynesian nature of gap models, inflation depends on the real marginal costs of companies, which are approximated in this equation by the output gap (domestic cost pressures) and the real exchange rate gap (cost of imported products). Second, current inflation depends on model-consistent forward-looking inflation expectations, which is in accordance with the modern macroeconomic theory. Related to this, economic agents form their inflationary expectations both using adaptive expectations (π_{t-1}) and forward-looking expectations (π_{t+1}). The direct effect of imported to domestic inflation is captured by the oil prices and foreign inflation (usually an effective foreign inflation indicator). The coefficient on forward-looking expectations should be positive, reflecting the idea that the central bank can not consistently surprise people with higher than expected inflation. Third, the coefficients on forward-looking and past inflation rates should sum to one, implying that the Phillips curve is vertical in the long-run. Therefore, the model is based on the neutrality of monetary policy in the long run. In equilibrium, when the economy operates on its potential level (the output gap is zero) and the real exchange rate gap is zero, the inflation rate converges to the inflation target. In other words, the monetary policy reaction function stabilizes inflation around the inflation target. Monetary policy controls inflation through affecting the output gap (cost pressures from the domestic economy) and the real exchange rate gap (external competitiveness). Therefore, the stronger is the credit channel in terms of influencing domestic demand, the more powerful monetary policy can be in terms of controlling inflation.

One of the key coefficients determining inflation inertia in the economy is the size of the δ_1 coefficient. If inflation expectations are entirely forward looking (δ_1=1), then inflation is equal to the sum of future output and exchange rate gaps. In this case, a small but persistent increase in interest rates would have a large and immediate effect on current inflation, which is associated with a central bank that has very high credibility. On the other hand, if expectations are largely backward-looking, (δ_2 is close to 1), current inflation is a function of past values of the gaps, and only an accumulation of many periods of interest rate adjustments can move current inflation toward the desired path.

The exchange rate equation (uncovered interest parity condition)

The third key equation in SOE gap models is the exchange rate equation, which is usually represented by the uncovered interest rate parity (UIP) condition. This equation embodies one of the key behavioural relationships in a small open economy operating within an inflation targeting regime, characterized by high capital mobility and (usually) a flexible exchange rate[6]. The UIP condition states that, with full capital mobility, today's exchange rate (e_t) depends on the expected future exchange rate (e_{t+1}), the deviation of the domestic from the foreign interest rate ($i_t - i_t^*$) and the risk premium ($prem_t$). According to the UIP, when a shock hits the economy, the nominal exchange rate follows such path in the future that will eliminate any arbitrage potentially arising from the expected trajectory of the interest rate differential and risk premium. In practice, however, the UIP might not be a good description of reality in countries where there are restrictions on free capital flows or risk premium shocks are frequent and large.[7]

$$e_t = e_{t+1} + (i_t - i_t^*) - prem_t + \varepsilon_t^e \quad (3)$$

SOE gap models satisfy the UIP expressed in real terms. This equation links changes in the steady-state trajectory of the real exchange rate with the long-term values of the domestic and foreign real interest rates.

The monetary policy rule

This equation describes the monetary policy reaction function, or how the central bank sets its policy in order to achieve its targeted inflation rate. The specification captures the so called Taylor rule (Taylor 1993), according to which the central bank reacts to the deviations of inflation from the target and the deviations of output from its equilibrium. However, in practice, in the presence of

[6] See Beneš et al. (2008) for a micro-founded modification of the interest rate parity condition that can be used in New Keynesian gap models when inflation targeting is combined with exchange rate interventions.

[7] Under the assumption of very low capital mobility and a fixed exchange rate, the central bank can follow, at least to some extent, some autonomous monetary policy. The assumption of very low capital mobility, therefore, allows the domestic interest rate to deviate from the UIP condition.

monetary policy transmission lags, most central banks follow so-called inflation forecast targeting (Svensson, 1997), meaning that the monetary policy reaction function includes forecasted instead of currently observed inflation.

$$i_t = \gamma_1 * i_{t-1} + (1-\gamma_1) \cdot (r_t^{eq} + \pi_t + \gamma_2 \cdot (\pi_{t+4} - \pi_t^{target}) + \gamma_3 \cdot y_{gap_t}) + \varepsilon_t^i \quad (4)$$

In most cases, central bank's nominal interest rate (i_t) depends on the deviation of expected inflation four quarters ahead from the inflation target $(\pi_{t+4} - \pi_t^{target})$. In models relying on rational expectations, the forecasted, model-consistent inflation incorporates all relevant information regarding the future path of inflation. Following this type of monetary rule, combined with transparent communication strategy of the central bank, yields good results in terms of stabilizing inflation expectations, and thus enhances the central bank credibility. Monetary policy also reacts to the output gap (y_{gap_t}) as current deviations of actual output from potential are one of the key factors affecting future inflation. Even in the cases when forecasted inflation is below the target, it is possible that observed demand pressures lead to acceleration of inflation above target in the future (Beneš et al., 2008). Interest rate smoothing, captured by the lagged policy rate (i_{t-1}), is crucial for a realistic description of central bank's behaviour, since policymakers usually do not react with drastic interest rate changes to each deviation of inflation from target or of output from equilibrium, but instead implement some interest rate smoothing. In practical terms, monetary policy is also affected by the central bank's estimate of the equilibrium real interest rate (r_t^{eq})[8].

Another important issue for the monetary policy is setting the monetary policy horizon as it reflects the lags in monetary policy transmission. The monetary policy horizon is captured by the lead of the expected inflation term in the policy rule. Typically, the policy rule is focused on the policy rate in the current period as a function of inflation deviations from target four quarters ahead. However, since these models are forward looking in various aspects, the monetary policy horizon is in fact longer than four quarters (Coats et al., 2003).

This type of policy rule is typical for countries with floating exchange rate regime. However, it is possible to modify the policy rule in a way that can capture the objective of controlling the exchange rate. Central banks that try to control the exchange rate find it difficult to simultaneously control the money market rate as well. Therefore, the money market rate becomes partially determined by the UIP condition (Equation 5).

$$i_t = g_1(\Delta e_{t+1} + i_t^* + prem_t) + (1-g_1)(\gamma_1 * i_{t-1} + (1-\gamma_1) \cdot \left(r_t^{eq} + \pi_t + \gamma_2 \cdot (\pi_{t+4} - \pi_t^{target}) + \gamma_3 \cdot y_{gap_t}\right)) + \varepsilon_t^i \quad (5)$$

[8] The level of the policy rate depends on the equilibrium real interest rate and the inflation target in the long run.

The coefficient g_1 reflects the degree of control that the central bank retains over the domestic money market: if $g1 = 0$, then the bank has retained full control and the Taylor rule applies; if $g1 = 1$, the bank has lost control over money market rates and only tries to control the exchange rate[9].

3 MAKPAM - historical perspective

Until 2004, the National Bank of the Republic of Macedonia (NBRM) based the analysis of the macroeconomic sectors and policies, as well as the preparation of the short-term projections for the individual sectors on the so-called financial programming framework. Financial programming is a standard tool for macroeconomic analysis developed by the IMF that encompasses all sectors in the economy (real, external, fiscal and monetary). The framework is designed to impose macroeconomic consistency in terms of fulfilling key macroeconomic accounting identities (aiming at converging towards internal and external balance). However, it fails to model the transmission mechanism of the monetary policy and gives no answer to the key question facing monetary authorities: what interest rate path is consistent with the monetary policy objective. Furthermore, the framework mostly relies on the analysis of historic data, rather than on a transmission mechanism based on forward-looking expectations of the economic agents. In order to overcome some of these drawbacks of the financial programming framework, the NBRM initiated the development of the Macedonian Policy Analysis Model (MAKPAM). It was aimed at broadening the projection framework and responding to the key issues within the monetary policy domain. The goal, therefore, was to develop a structural model that captures the transmission mechanism of the monetary policy in the Macedonian economy, and enables policy analysis and forecasting in the presence of unexpected domestic or external shocks.

The need for a development of a more advanced framework was especially apparent at the end of 2004 and it emanated from a relatively turbulent macroeconomic environment (imbalances in the external sector, a volatile public consumption and foreign exchange market speculations). These factors, together with the challenges from the capital liberalization process, motivated a discussion related to the re-assessment of the monetary strategy, as well as the need to build the institutional capacity regarding different monetary strategies. This was also in line with the recommendations of the IMF Mission presented in the Ex-post Assessment Report at the end of 2004 (IMF, 2004). The successful realization of these activities required additional resources and the development of a more sophisticated analytical framework. Since then, the NBRM has worked actively on the gradual establishment of a comprehensive process of macroeconomic modelling, with significant help and support by the IMF.[10] The final result is the contemporary macroeconomic model MAKPAM and a well

[9] Application of this rule also requires changes in the UIP equation. See also Beneš et al. (2008).

[10] In the beginning, these activities were realized with the help of experts from other central banks within the technical assistance by FSVC (Financial Services Volunteer Corps). However, most of this process was completed

organized process of macroeconomic forecasting and monetary policy decision-making. Consequently, the overall Forecasting and Policy Analysis System (FPAS) in the NBRM is fairly similar to the one in the central banks of more developed economies. Since the process of developing and implementing MAKPAM was relatively long, spanning over several years, it is useful to first describe the key stages in its development, and then to present its current structure and key features.

3.1 The first stage of MAKPAM development

The initial steps related to the development of MAKPAM focused on the development of the basic forecasting database and the pilot version of the model and resulted in the first version of the model. This was a standard small-size New Keynesian gap model, which included a Phillips curve for inflation, an IS curve, an equation for the foreign exchange rate and the monetary policy rule. As noted in the previous section, this structure is typical for countries that apply inflation targeting within a flexible exchange rate regime. Therefore, it was also necessary to adjust MAKPAM so that it reflects the characteristics of the Macedonian economy, primarily the fixed exchange rate regime. The key assumptions in this version of the model referred to the possibility for a relatively high autonomy of monetary policy in terms of setting short-term interest rates, which relied on the perceived low sensitivity of households and firms to the interest rate differential (to foreign interest rates) when deciding on buying or selling foreign currency[11].

The first version of the MAKPAM contained the three main characteristics typical for all small gap models, as explained in the previous section. First, the model was specified in gap form, with gaps defined as deviations of variables from their equilibrium values, which are obtained by the Kalman filter as one of the most sophisticated methods for determining these values. Second, the MAKPAM's first version was featuring forward-looking, model-consistent inflation expectations. Third, MAKPAM parameters were calibrated[12], and not econometrically estimated. In this version of MAKPAM, monetary policy affects inflation through two transmission channels. First, the NBRM influences output through the interest rate, thus affecting the movement of the real economic activity, which is captured through the IS curve. Then, the aggregate economic activity affects inflation through the Phillips curve. The second channel is related to the real exchange rate. More precisely, changes in inflation will also be reflected in real exchange rate movements, which in turn affect output through the IS curve, thus reinforcing the effects of interest rates. The first version of the model had a fairly standard Taylor rule, according to which the central bank will increase the

within the IMF technical assistance. Namely, through several technical missions starting from 2007, the IMF has helped the building of the monetary policy model, as well as the establishment of the entire Forecasting and Policy Analysis System (FPAS) infrastructure.

[11] In other words, this version of the model assumed low de facto capital mobility.

[12] See previous section for a brief discussion of calibration. For further details on calibration, see Berg et al. (2006b).

interest rate if the projected inflation is higher than the desirable inflation rate and/or if the economy is above its potential in the current period, with some inertia in the rule. The need for a forward looking monetary policy arises from the time lags, i.e. the time needed for monetary policy actions to affect the real economy. In MAKPAM, the reference interest rate is the nominal interest rate on central bank bills.

In the following period the model was further developed and tested. It was refined and brought to data through iterative calibration rounds. The entire forecasting process was simulated within the NBRM as part of the preparation for the introduction of the new FPAS. The most important extension in this period was related to the gradual building of a new satellite model as a complementary part of the forecasting process. The satellite model served as a tool for the decomposition of the real GDP forecast into expenditure components. Finally, since 2008 MAKPAM has been actively used alongside the financial programming framework in the process of forecasting in the NBRM.

3.2 The second stage of MAKPAM development

In 2009, a significant modification of the core macroeconomic model was undertaken. This reflected particular features of the monetary decision-making, which were highlighted by the global financial crisis. The main signs of the crisis emerged in terms of falling prices and a substantial fall of the exports, together with the decline in private transfers[13]. As a consequence, there was also a considerable fall in the level of foreign exchange reserves in late 2008 and particularly in the first half of 2009.

In the MAKPAM version that was used at that time, the NBRM stabilized the economy by reacting to the divergence of inflation from the target and/or deviations of output from its potential. However, this model was established and tested in a relatively favourable macroeconomic environment, which was characterized by stable foreign reserves growth and space for autonomous setting of the interest rate by the NBRM without jeopardizing the accumulation of the foreign reserves. The emergence of the global crisis eliminated the inflationary pressures, but created a considerable disturbance in the balance of payments, resulting in a fall of foreign reserves. In such conditions, despite the reduced inflation pressures, the pressure on foreign exchange reserves required a more restrictive monetary policy to support the sustainability of the fixed exchange rate regime. The model that derived the systematic behaviour of the central bank from a standard Taylor-type rule was not fully suited to the dramatically changed external environment. Since the sustainability of the fixed exchange rate regime is closely related to the maintenance of a certain level of foreign reserves, the model was transformed into a standard model featuring a fixed exchange

[13] The fall in private transfers (mainly incorporating the foreign currency cash purchased on the currency exchange market) primarily took place at the beginning of the crisis period.

rate, in which the policy rate follows foreign interest rates and the risk premium. The risk premium, in turn, was defined as a function of the main determinants of the NBRM foreign exchange reserves.

The Taylor-type policy rule was therefore replaced by an arbitrage condition stating that domestic and foreign interest rates can differ only if the risk premium is non-zero. To put it differently, the domestic interest rates are equal to the foreign interest rates plus the risk premium. The risk premium was specified as a sum of a fixed, exogenous component (related to long-term non-economic fundamentals) and an endogenous component, which is linked to the foreign reserves gap. The foreign reserves gap is thus a function of the main determinants of the expected net foreign asset position of the Macedonian economy: the real exports, imports, foreign direct investments and private transfers (all in gap form) and corresponding prices. Related to this, these balance of payment components are also modelled through behavioural equations. These model changes increased the explanatory strength of the forecasting framework and improved its performance. What is more important, the change in the interest rate equation brought the model closer to the manner in which the monetary policy with fixed exchange rate is conducted, which also resulted in improved model performance.

3.3 The third stage of MAKPAM development

The third and the final stage of the MAKPAM development process was focused on merging the core, structural model with the satellite model into one integrated framework. In practical terms this involved extending the core MAKPAM model with all real expenditure items of the national accounts. The model change called for an entire recalibration of the multivariate Kalman filter. The latest version of the model is presented and discussed in detail in the following two sections.

4 Model structure and core equations

As discussed previously, MAKPAM belongs to the generation of small open economy gap models featuring a fixed exchange rate regime. It is a medium-size, log-linearized model, with each variable being expressed as deviation from its long-term trend value. The MAKPAM is structured in a way to reflect the key characteristics of the Macedonian economy. Three distinct features make MAKPAM different from standard gap models. First, MAKPAM incorporates the fixed exchange rate that has been in use since 1995 in Macedonia. By doing so, it deviates from the standard practice of building these models for countries with flexible exchange rates. Second, MAKPAM is a model consistent with a fixed exchange rate regime with imperfect capital mobility. This is reflected in the policy rule, which states that domestic interest rates are equal to the foreign interest rate plus a risk premium. In other words, the central bank's room for monetary policy is constrained by foreign interest rates and the risk premium. Third, the model reflects the fact that Macedonia is a small economy that is heavily dependent upon foreign trade and is a price-taker in the world economy. Therefore, variables like foreign effective demand, foreign effective prices and commodity prices are important for both explaining past developments and forecasting. Related to this, the model incorporates a relatively detailed structure of foreign trade, with both exports and imports expressed as sums of two components: energy and metals and others (i.e. non-energy).

The need for building a comprehensive Forecasting and Policy Analysis System (FPAS) in the central bank has also greatly affected the development of the model, as discussed above. The current version of MAKPAM has, in total, 292 equations including behavioural equations, identities and definitions. In essence, the equations in MAKPAM can be structured in three main building blocks: the price block, the real economy block and the monetary policy and financial block. This section contains description on each of these blocks in more details.

4.1 The price block

The inflation process is modelled through New Keynesian, forward looking, Phillips curve. In line with the theory, Equation 6 defines the consumer price inflation (π_t, consumer price inflation without administered prices) as a function of expected inflation (π_{t+1}), lagged inflation (π_{t-1}) and the real marginal cost (rmc). Lagged inflation shows up in Phillips curves due to indexation (mostly reflecting the indexation of wages). If $\alpha_1^{\pi t+1}$ is equal to 1, all economic agents form fully forward-looking, model-consistent expectations and there are no price rigidities in the economy.

$$\pi_t = \alpha_1^{\pi t+1} \cdot \pi_{t+1} + \left(1 - \alpha_1^{\pi t+1}\right) \cdot \pi_{t-1} + \alpha_1^{rmc} \cdot rmc + \varepsilon_t^{\pi t} \tag{6}$$

Given that we have two types of foreign prices in the model (energy imported prices (p_t^E) and non-energy imported prices (p_t^{NE})), we also have two real exchange rates: the real exchange rates of energy (${q^E}_t$) and the real exchange rate of non-energy prices (${q^{NE}}_t$) (Equation 7 and 8). They are equal to the sum between the nominal exchange rate (e_t) and the relative prices (foreign over domestic prices, captured by the GDP deflator (p_t^{PY})). The real exchange rates are defined in line with the Purchasing Power Parity condition, which is common for small open economies.

$${q^{NE}}_t = e_t + p_t^{NE} - p_t^{PY} \tag{7}$$

$${q^E}_t = e_t + p_t^E - p_t^{PY} \tag{8}$$

Real marginal costs are model-specific, and in our case they are described in Equation 9. Real marginal costs are equal to the weighted sum of the output gap, $ygap$(domestic inflation pressures) and imported prices (imported inflation pressures).

$$rmc = (1 - \beta^{CE} - \beta^{CNE}) \cdot y_{gap} + \beta^{CE} \cdot q^{E}{}_{gap_t} + \beta^{CNE} \cdot q^{NE}{}_{gap_t} \tag{9}$$

where:

$$q^{E}{}_{gap_t} = (p_t^E + e_t) - p_t^Y - q^{E}{}_{eq_t} \tag{10}$$

$$q^{NE}{}_{gap_t} = (p_t^{NE} + e_t) - p_t^Y - q^{NE}{}_{eq_t} \tag{11}$$

The connection between imported inflation and domestic prices is modelled through relative indicators i.e. imported prices (energy and non-energy prices) as opposed to domestic prices. The term q_{gap}^{E} refers to the energy and metals real exchange rate gap, i.e. the deviation from its equilibrium of the ratio between imported energy prices (p_t^E), corrected for the changes in the nominal exchange rate (e_t), and domestic prices, approximated through the GDP deflator (p_t^Y). Similarly, the term q_{gap}^{NE} refers to the non-energy real exchange rate gap, i.e. the deviation from its equilibrium of the ratio between imported non-energy prices (p_t^{NE}), corrected for the changes in the nominal exchange rate (e_t), and the GDP deflator[14]. The coefficients β^{CE} and β^{CNE} are calibrated to the share of imported energy respectively non-energy prices in the consumer price index (CPI), whereas the term $(1 - \beta^{CE} - \beta^{CNE})$ represents the share of domestic value added prices in the CPI basket.

Equation 12 gives the total consumer price inflation (π_t^{cpi}) as equal to π_t plus changes in administered prices (π_t^{adm}).

$$\pi_t^{cpi} = \pi_t + \pi_t^{adm} \tag{12}$$

Besides CPI inflation, the model contains definitions for all expenditure side deflators. Namely, all the deflators are expressed as a weighted sum of the change in the price of the domestic valued added and the change in imported prices of energy and non-energy products. The GDP deflator is a weighted sum of all expenditure components' deflators.

[14] The respective ratios are equivalent to using the energy and non-energy real exchange rates (Equations 7 and 8), i.e. the gaps could alternatively be represented as deviations of the real exchange rates from their respective equilibria.

4.2 The real economy block

The real economy block consists of several behavioural equations to describe the evolution of the real expenditure side components of GDP. In addition, as discussed above, the model also incorporates consistent prices (i.e. equations modelling deflators), so that the national accounts identity holds in nominal terms.

Equation 13 is the national accounts identity in a log-linear form. The output gap (y_{gap_t}) is a weighted sum of households consumption gap (c_{gap_t}), government consumption gap (g_{gap_t}), investment gap (j_{gap_t}), exports gap (x_{gap_t}) and imports gap (m_{gap_t}), with weights δ calculated on the basis of respective shares between 2011 and 2014.

$$y_{gap_t} = \delta_1^c \cdot c_{gap_t} + \delta_1^g \cdot g_{gap_t} + \delta_1^j \cdot j_{gap_t} + \delta_1^x \cdot x_{gap_t} - \delta_1^m \cdot m_{gap_t} \tag{13}$$

Behavioural process for each of the real expenditure components are presented in equations 14 to 21.

Household consumption is modelled within a set of behavioural equations. The main idea behind modelling consumption in the model is that the real disposable income is the main source of consumption spending, but households also smooth their consumption by bank borrowing/saving. Consequently, total household consumption is modelled as a function of real disposable income and the real interest rate gap, which is used as a proxy for households' incentives to change their financial borrowing/saving in Equation 14.

$$c_{gap_t} = \delta_2^{clag} \cdot \ c_{gap_{t-1}} + \delta_2^{rdi} \cdot rdi_{gap_t} - \delta_2^r \cdot r_{gap_t} + \varepsilon_t^{c_{gap}} \tag{14}$$

The real disposable income is defined as a sum of the real wage bill, real pensions and real private transfers in Equation 15, with GDP shares of the later three components used for normalisation.

$$rdi_{gap_t} = (\delta_3^{rwb} \cdot rwb_{gap_t} + \ \delta_3^{pt} \cdot pt_{gap_t} + \delta_3^{pn} \cdot pn_{gap_t})/(\delta_3^{rwb} + \ \delta_3^{pt} + \delta_3^{pn}) \tag{15}$$

The three components of real disposable income have their own separate behavioural equations. Namely, real wages are a function of their own lagged value, the deviation of inflation from its steady-state value and labour productivity; pensions depend on inertia and the movements in the economy (represented by the output gap and inflation) and private transfers depend upon inertia, domestic conditions (real interest rate gap, domestic demand gap[15] and the deviation of inflation from its steady-state value) and foreign conditions (approximated through the foreign demand gap).

The **real government consumption gap** depends on its lagged value ($g_{gap_{t-1}}$), the output gap (y_{gap_t}) and the government consumption shock ($\varepsilon_t^{g_{gap}}$). Moreover, **the government consumption** is assumed to be countercyclical i.e. the coefficient $\delta_4^{y_{gap}}$ in front of the output gap is negative.

$$g_{gap_t} = \delta_4^{g_{gap}} \cdot g_{gap_{t-1}} - \delta_4^{y_{gap}} \cdot y_{gap_t} + \varepsilon_t^{g_{gap}} \tag{16}$$

The **real investment gap** is a function of its lagged value ($j_{gap_{t-1}}$), lagged household consumption gap ($c_{gap_{t-1}}$), non-energy exports gap (xne_{gap_t}), the lagged real interest rate ($r_{gap_{t-1}}$), the lagged FDI gap ($fdi_{gap_{t-1}}$) and the corresponding shock to investment gap ($\varepsilon_t^{j_{gap}}$).

$$\begin{aligned} j_{gap_t} = \delta_5^{j_{gap}} \cdot j_{gap_{t-1}} + \delta_5^{c_{gap}} \cdot c_{gap_{t-1}} + \delta_5^{xne} \cdot xne_{gap_t} - \delta_5^{r_{gap}} \cdot r_{gap_{t-1}} \\ + \delta_5^{fdi_{gap}} \cdot fdi_{gap_{t-1}} + \varepsilon_t^{j_{gap}} \end{aligned} \tag{17}$$

The **real exports of goods and services** are modelled via a standard export demand function where the volume of exports depends upon the competition, approximated through the real exchange rate, and the foreign demand.

$$xne_{gap_t} = \delta_6^{xne_{gap}} \cdot xne_{gap_{t-1}} + \delta_6^{q_{gap}} \cdot q_{gap_{t-2}} + \delta_6^{yf_{gap}} \cdot yf_{gap_{t-1}} + \varepsilon_t^{xne_{gap}} \tag{18}$$

$$xe_{gap_t} = \delta_7^{xe_{gap}} \cdot xe_{gap_{t-1}} + \delta_7^{qe_{gap}} \cdot qe_{gap_{t-1}} + \delta_7^{yf_{gap}} \cdot yf_{gap_{t-1}} + \varepsilon_t^{xe_{gap}} \tag{19}$$

There are two export equations – one for the exports of non-energy products (xne_{gap_t}) and one for exports of energy and metal products (xe_{gap_t}). Equation 18 describes exports of non-energy products as function of its own lagged value ($xne_{gap_{t-1}}$), the real non-energy price's exchange rate gap lagged by two quarters ($q_{gap_{t-2}}$), which approximates price competitiveness, and the lagged foreign demand gap ($yf_{gap_{t-1}}$). According to Equation 19, exports of energy products depend upon its own lagged value ($xe_{gap_{t-1}}$), the real energy price's exchange rate gap lagged by one quarter

[15] Domestic demand gap is a weighted sum of the households' consumption gap, government consumption gap and investment gap.

($qe_{gap_{t-1}}$) and the lagged foreign demand gap ($yf_{gap_{t-1}}$). The terms $\varepsilon_t^{xne_{gap}}$ and $\varepsilon_t^{xe_{gap}}$ represent the coresponding shocks.

The **import demand functions** for energy and non-energy goods assume that all expenditure components have a constant import content, given by equations 20 and 21. In other words, energy and non-energy imports are a sum of imports that are used for various expenditure components.

$$mne_{gap_t} = \sum_{zne} \delta_8^{zne} \cdot zne + \varepsilon_t^{mne_{gap}} \tag{20}$$

where $zne \in \{c_{gap_t}, g_{gap_t}, j_{gap_t}, x_{gap_t}\}$

$$me_{gap_t} = \sum_{ze} \delta_9^{ze} \cdot ze + \varepsilon_t^{me_{gap}} \tag{21}$$

where $ze \in \{c_{gap_t}, g_{gap_t}, j_{gap_t}, x_{gap_t}\}$

In equations 20 and 21, mne_{gap_t} denotes the imports of non-energy products, and me_{gap_t} denotes the imports of energy products. Coefficients δ_8^{zne} and δ_9^{ze} are the import shares of the corresponding expenditure components. zne respectively ze denote the gaps of the corresponding expenditure components ($c_{gap_t}, g_{gap_t}, j_{gap_t}, x_{gap_t}$) and $\varepsilon_t^{mne_{gap}}$ and $\varepsilon_t^{me_{gap}}$ are the corresponding shock terms.

4.3 Monetary policy and financial block

The behaviour of the central bank is described by a policy reaction function which reflects the central bank's commitment to maintain the fixed exchange rate regime. The policy rule in the model takes into account the dependence between the sustainability of the fixed exchange rate regime and the level of the foreign exchange reserves. This is done by linking the interest rate to foreign interest rates and the risk premium, which in turn is approximated by the main factors driving the changes in the foreign exchange reserves, in a consistent manner.

Equations 22 to 27 describe the monetary policy framework of the model.

Equation 22 is the uncovered interest rate parity where the nominal interest rate in the domestic economy (i_t) is equal to the foreign interest rate (i_{star_t}) and the risk premium ($risk_{premium}$). In other words, the policy interest rate in normal times (i.e. ε_t^i=0) will be higher, the higher is the foreign interest rate and the higher is the risk premium.

$$i_t = i_{star_t} + risk_{premium} + \varepsilon_t^i \tag{22}$$

The risk premium consists of two parts – exogenous risk premium (${risk_{prem}}^{SS}$), which is fixed and reflects long-term, fundamental differences between Macedonia and the euro-area, and endogenous risk premium (${risk_{prem}}^{flow\_gap}$).

$$risk_{premium} = {risk_{prem}}^{SS} + {risk_{prem}}^{flow\_gap} \quad (23)$$

The endogenous risk premium is defined as a function of key components of foreign exchange flows (exports of goods and services, imports of goods and services, private transfers and foreign direct investment). Linking the risk premium and consequently the policy interest rate to factors determining the change in net foreign assets reflects the commitment of the central bank to maintain the peg (e.g. restrict policy in case of massive foreign exchange outflows) through changing the domestic policy rate not only on the basis of changes in foreign policy rates, but also on the basis of risk perceptions of foreign and domestic agents (who monitor foreign reserves as a fast and visible indicator of the state of the Macedonian economy and thus as a key indicator in forming their risk perceptions).

Equation 24 links the endogenous risk premium (${risk_{prem}}^{flow\_gap}$) to the sum of the balance of payment variables (${flow_{gap}}_t$) one year ahead, whereas equation 25 describes the $flow_{gap}$ as a sum of the nominal exports gap (nx_{gap},), nominal imports gap (nm_{gap}), foreign direct investment gap (fdi_{gap}) and private transfers gap (pt_{gap}).

$${risk_{prem}}^{flow_{gap}} = -\lambda_1^{flow_{gap}} \cdot ({flow_{gap}}_t + {flow_{gap}}_{t+1} + {flow_{gap}}_{t+2} + {flow_{gap}}_{t+3})/4 \quad (24)$$

$${flow_{gap}}_t = f(nx_{gap}, nm_{gap}, fdi_{gap}, pt_{gap}) \quad (25)$$

The coefficient $\lambda_1^{flow\_gap}$ in Equation 24 is negative, meaning that higher foreign inflows will lead to a decline in the risk premium. Namely, favourable developments in the expected future net foreign asset position of Macedonia will result in a downward revision of the perceived risk by economic agents (smaller ${risk_{prem}}^{flow\_gap}$).

Equation 26 specifies the real interest rate (r_t) as the nominal interest rate (i_t) minus inflation expectations ($E(\pi_t)$).

$$r_t = i_t - E(\pi_t) \quad (26)$$

where $E(\pi_t) = \lambda_2^r \cdot \pi_{t+4} + (1 - \lambda_2^r) \cdot \pi_{t-1}$

Finally, the nominal exchange rate denar/euro (e_t) is given by Equation 27.

$$e_t = e_{t-1} + \varepsilon_t^e \quad (27)$$

where ε_t^e is the corresponding shock to the exchange rate, equal to zero in normal times. Consequently, Equation 27 also ensures that the nominal exchange rate in the model is fixed.

5 Transmission mechanism and model performance

The initial version of MAKPAM was similar to standard small macroeconomic (gap) models, as discussed above. However, in its current version MAKPAM is a fairly advanced modelling and forecasting framework. In a sense, the current, rather complex version of the model reflects two main aspects: the characteristics of the economy and the needs of a comprehensive policy analysis and forecasting system. This is also reflected in the transmission mechanism and the model performance, which are discussed in this section.

The extensions to MAKPAM (discussed previously) have resulted in a relatively complex structure of the model, but its key features can be captured in a single schematic presentation (Figure 1). The aim of this figure is to show the main building blocks of the model, including all the main equations that were discussed in the previous section. In terms of the national accounts, the model includes all the components of domestic demand. Related to this, the model also includes key components of real disposable income (real wage bill, pensions, private transfers), which is part of household consumption. In addition, exports are divided into two components: energy (and metal) exports and non-energy exports. All components of domestic demand and exports have a constant share of import content. Therefore, energy and non-energy imports are a sum of imports that are used in the production of various expenditure components. Further, the model also captures the two groups of factors that affect domestic inflation. First, foreign prices (foreign effective inflation and prices of primary commodities) affect prices of energy and non-energy imports. Import prices then influence GDP expenditure component deflators, as well as domestic CPI inflation. Second, domestic inflation is also affected by domestic demand, thus capturing demand pressures on prices. Finally, the model also captures the interest rate and financial block. The four balance of payment components (exports, imports, FDI, transfers) affect net foreign exchange flows, which in turn determine the endogenous risk premium. This factor, together with the exogenous risk premium and foreign interest rates further determine the domestic policy interest rate. Finally, monetary policy is directly transmitted in the economy via the effects of the policy rate on the components of domestic demand.

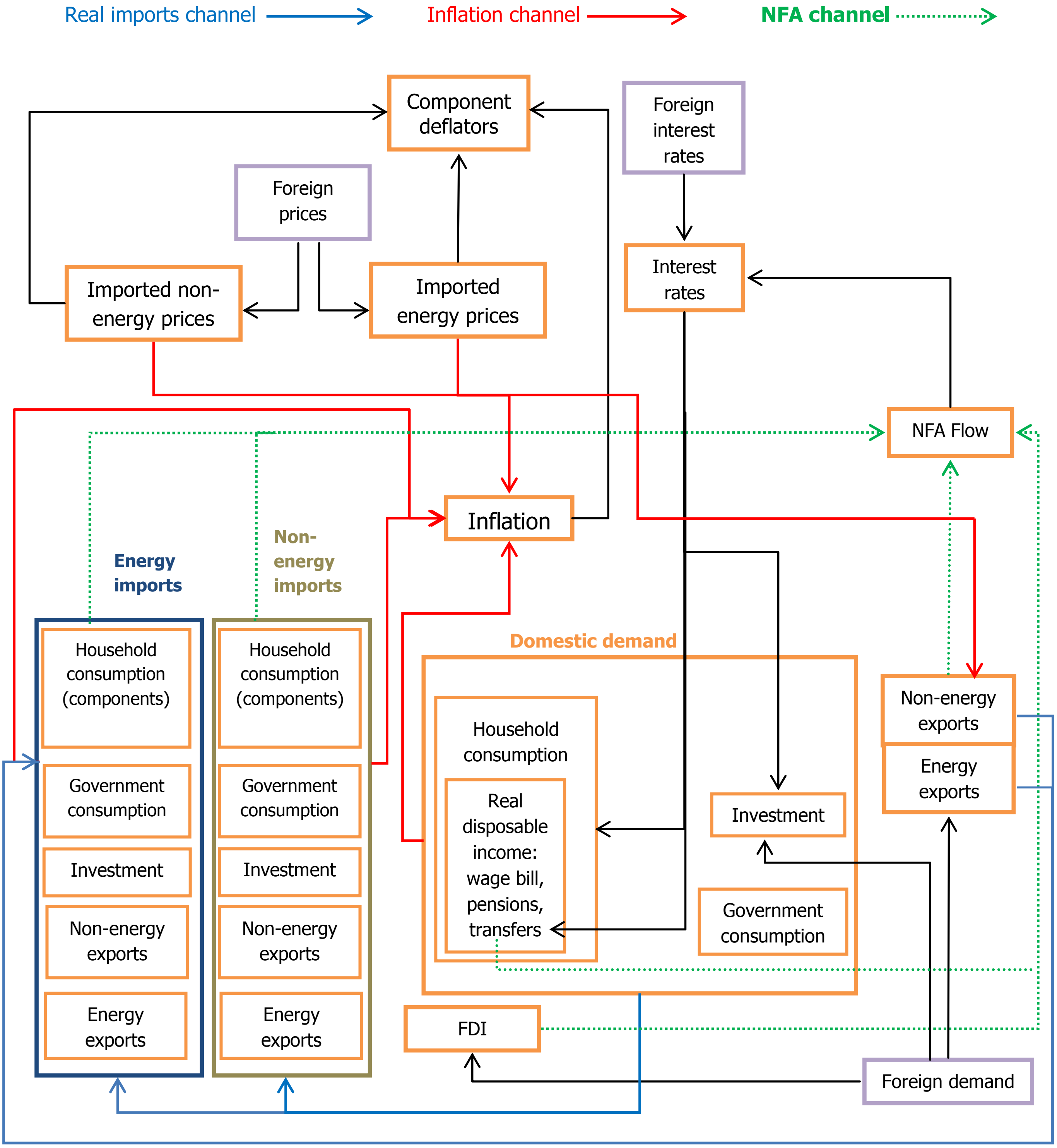


Figure 1. MAKPAM structure and transmission mechanism

After the presentation of the model, the key equations, and the transmission mechanism, we discuss how well the model reflects key principles of macroeconomic theory and empirical features of the Macedonian economy. This is done in two ways: with impulse responses and with in-sample forecasting.

Impulse response analysis shows how key macroeconomic variables respond to various shocks hitting the economy. It relies only on the equations and coefficients in the model, and not actual data. Therefore, it also serves as a cross-check of the calibration of coefficients. Impulse responses are carried out under the assumption that the model is initially in equilibrium, and is then hit by a shock. Shocks appear one at a time, for a single period. Certainly, in reality this does not hold, but the aim of the impulse response analysis is to simplify the matters in order to better describe and analyse the features of the model. Besides the effects of various shocks on the economy, this analysis also shows the dynamic response of the economy to the shock and the speed by which it returns to equilibrium (assuming no further shocks). In order to present the transmission mechanism, we present the responses to two shocks: a shock to the gap of foreign effective demand and a shock to the nominal policy rate.

Figure 2 shows how the economy responds to a positive shock to the gap of foreign effective demand of 1 percentage point. First, the shock itself dies out within about two years. The foreign demand shock to the real economy is transmitted through several channels. Most notably, the shock implies a higher foreign demand for domestically produced goods, so real exports increase. In turn, domestic companies respond by increasing their investments in order to be able to meet the higher demand for exports. Due to their import content, higher exports and higher investments also increase real imports. However, the rise in imports compared with that of domestic demand and exports is smaller, so the shock has an overall positive effect on the domestic output gap. This is entirely in line with expectations, since a small open economy like Macedonia is highly dependent on foreign demand (and prices). Further, the foreign demand shock also has an effect on household consumption and prices. Most notably, private transfers are initially higher due to higher foreign demand growth, but they soon fall as the domestic economy improves, so Macedonians working abroad have lower incentives to send money home. Real wages are initially lower because of the higher inflation, but they rise afterwards, as employment increases with some delay, in line with higher domestic demand. Although after a temporary fall household consumption is quite volatile due to the divergent movements of its components, it is higher overall in the wake of the foreign demand shock. Further, as a result of higher domestic demand, domestic prices also increase. This contributes to an appreciation of the real exchange rate gap, which in turn reduces the pressure from the import prices on domestic prices and stabilises inflation. Finally, higher foreign demand has a positive effect on foreign exchange flows, mainly as a result of higher exports and FDI. Consequently, the central bank is able to lower its policy rate, which further reinforces the positive effect of the foreign demand shock on the economy.

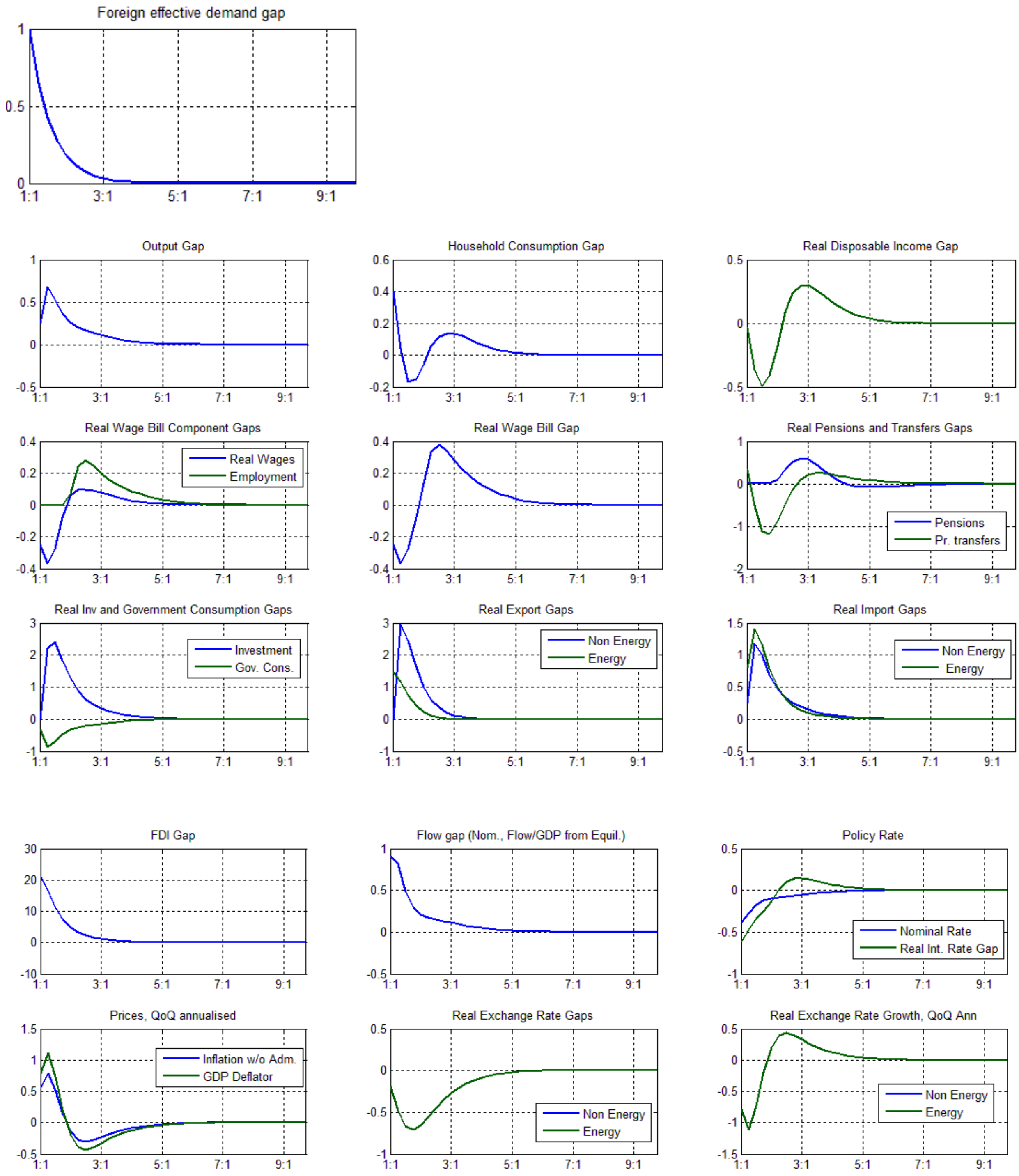


Figure 2. Impulse responses to a shock in foreign effective demand

The second shock quantifies the effect of a more restrictive monetary policy, through increasing the nominal policy rate by one percentage point (Figure 3). The higher nominal policy rate is directly reflected in a higher real interest rate gap, which affects the real economy. The biggest effect can be seen in the fall of real investments, as companies refrain from investing due to higher borrowing costs. Real disposable income is higher, mostly as a reflection of rising private transfers, which in turn reflect higher remittances to support lower domestic demand, but also to take advantage of higher domestic saving rates. However, overall consumption falls as households consume less due to higher costs of borrowing from commercial banks and the higher attractiveness of saving. Overall, due to their import share, the fall of consumption and investments also results in lower imports. Further, lower investments and lower household consumption are reflected in lower economic growth, so the output gap is also negative in the wake of a restrictive monetary policy shock. This has a positive effect on private transfers, as Macedonian workers abroad send more remittances back home. Further, the lower aggregate demand (negative output gap) also results in lower prices. However, the size of this effect is relatively small, indicating that the ultimate effect of monetary policy on prices is quite weak. This is entirely in line with *a priori* expectations, bearing in mind that Macedonia is a small open economy with a fixed exchange rate, which implies a weaker monetary policy transmission through the interest rate channel. Further, the lower economic growth also results in lower FDI flows. However, overall net foreign exchange flows are higher, which is a reflection of lower imports paired with higher private transfers. This reaction thus captures an important historical feature, when more restrictive monetary policy was often used to stabilize the pressures on the balance of payments, i.e. to maintain or increase foreign exchange reserves.

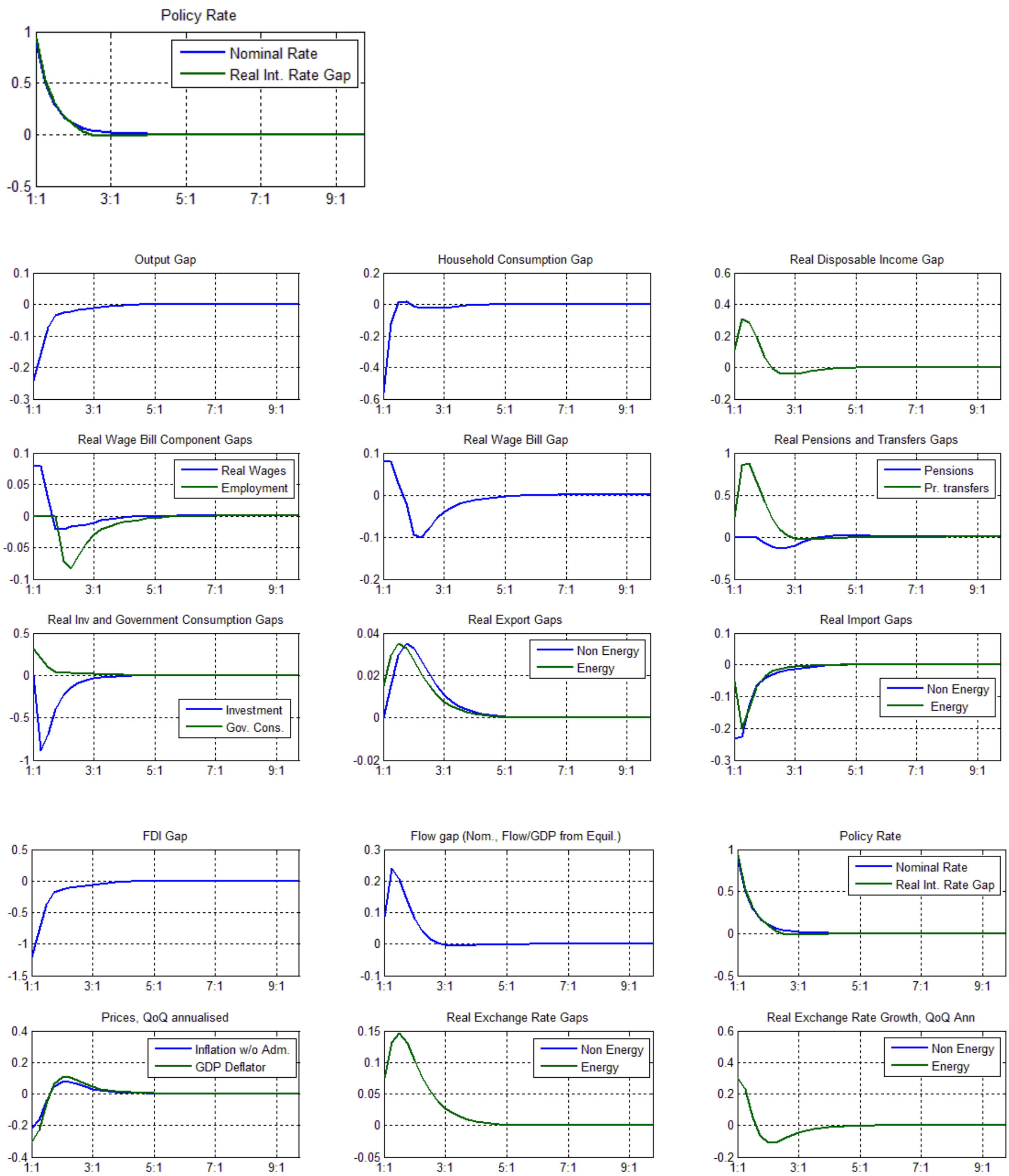


Figure 3. Impulse responses to a shock in the policy rate

The impulse response analysis indicates that the model is specified and calibrated in line with economic intuition. Most notably, all variables react to the shocks in a manner that is consistent with theoretical predictions and the characteristics of the Macedonian economy and the monetary policy transmission mechanism. In addition, shocks do not have a long-lasting effect, and the economy comes back to equilibrium with various speed of adjustment for different shocks (assuming no further shocks appear).

A more direct and precise check of the model performance could be achieved by analysing the results of in-sample forecasting (or in-sample simulations). In-sample forecasting refers to forecasting of key variables starting at various points in the past. It assumes that filtered trends for the whole horizon as well as the exogenous variables are all known *ex ante*. Therefore, the results of the in-sample analysis show how well the model is able to replicate the cyclical movement of the economy around the known trend[16]. The final result of the in-sample analysis consists of a large number of mechanical model simulations[17] (pseudo-forecasts). It enables a graphical comparison of model predictions at different points with actual outcomes (Figure 4). In this case, the blue line shows actual history, whereas red lines are 8-quarter ahead in-sample forecasts at various points in the past.

Figure 4 shows the results of the in-sample analysis for the key variables in MAKPAM (using historical data for the 2002Q1-2015Q1 period). In general, the model is able to capture well the dynamic behaviour of the economy for the model calibration, both for these and other variables (which are not shown in Figure 4). The results confirm a relatively good fit for inflation, as the in-sample forecast is generally close to actual outcomes and it captures turning points quite well. However, there is a slight undershooting of inflation compared with the actual outcome for the 2009–10 period and the model somewhat overestimates inflation pressures for the last few quarters. Further, the model captures surprisingly well the dynamics of the output gap, despite the fact that detailed models (such as this version of the model, with separate GDP expenditure components) often generate significantly worse in-sample simulation results than their more aggregate counterparts. In particular, the dynamics of the output gap are captured well with the exception of the 2009 recession and the overshooting in 2012-2013. The in-sample fit for the year-on-year GDP rate is also generally good, again with the exception of the undershooting in the 2009 recession and the overshooting in 2012-2013.

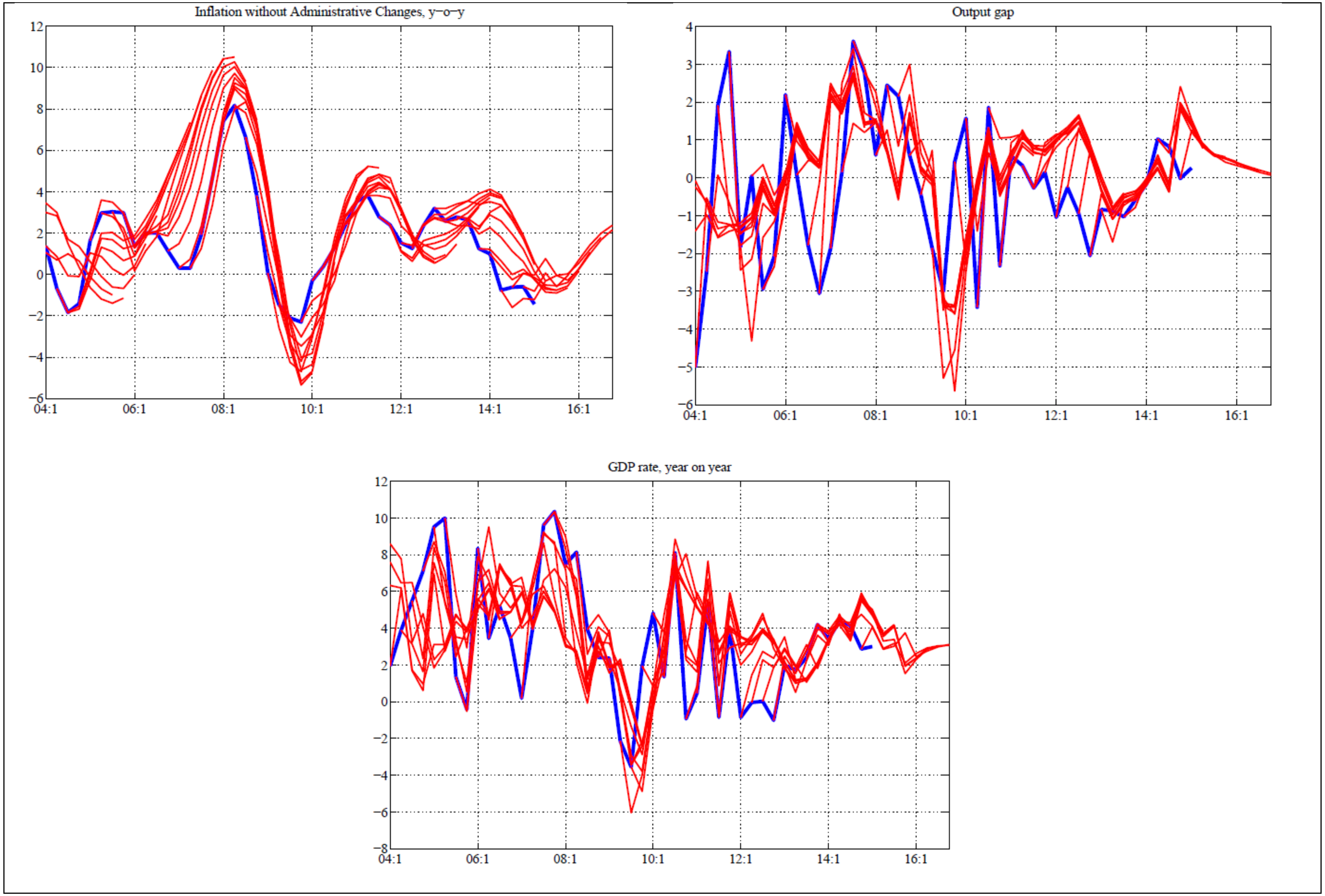
The results of the in-sample simulations are generally acceptable for the financial and interest rate block of the model as well. For instance, the model captures quite well the dynamics of the flow gap, which is in fact a reflection of respective in-sample simulations for the key components of the balance of payments (not shown). In-sample simulations of the flow gap capture the direction of changes quite accurately, but leave out the excessive volatility of foreign exchange flows, particularly the relatively large swings in 2009. Finally, in-sample simulations for the policy interest rate indicate mixed goodness of fit. On the one hand, the deviations of the in-sample predictions from the actual interest rates after 2010 are relatively small and they are more volatile than the actual smooth path

[16] For instance, for the in-sample forecast starting in 2010 Q2, the model uses the actual data for all variables until 2010 Q1 as well as the actual trends and exogenous variables for the entire horizon. On the basis of these data and the model calibration, MAKPAM then forecasts the endogenous variables starting from 2010 Q2.

[17] They differ from real-life forecasting in that these simulations do not include any expert judgment reflecting off-model information.

of policy rates. On the other hand, there are divergent predictions before 2010. In particular, simulations indicate that the policy interest rate should have increased during the 2006-2008 period and should have been reduced sharply immediately after the burst of the global economic crises. In other words, the model indicates that the reaction of the monetary policy at that period was relatively delayed, both when tightening and relaxing the policy stance. However, these deviations could be explained by several important factors. For instance, the model assumes that the central bank bill rate is the only instrument of monetary policy, while in reality the NBRM uses various additional instruments as well. Additional instruments were particularly important when reacting to the first wave of the crisis[18]. In addition, in reality the policymakers had to adjust policy rates to the high uncertainty and the increased global risks, which are not included in the model but were prevalent in reality when the crisis hit. Finally, when analysing the real interest rate gap, which actually affects the economy, it can be noticed that deviations are relatively small most of the time. The only exceptions from this are the undershooting in 2009-2010 (related to in-sample predictions for lower nominal rates) and the undershooting in the recent quarters, which is a reflection of overshooting in predicted inflation (discussed previously).

[18] For instance, in order to discourage the demand for foreign currency, additional contractionary measures were adopted in May 2009 by increasing the reserve requirement rate for bank liabilities in foreign currency and liabilities with a foreign exchange clause (foreign currency-linked liabilities). During 2009 the central bank also adopted prudential measures for liquidity management.


Inflation without Administrative Changes, y−o−y
12
10
8
6
4
2
0
−2
−4
−6
04:1
06:1
08:1
10:1
12:1
14:1
16:1
Output gap
4
3
2
1
0
−1
−2
−3
−4
−5
−6
04:1
06:1
08:1
10:1
12:1
14:1
16:1
GDP rate, year on year
12
10
8
6
4
2
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04:1
06:1
08:1
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12:1
14:1
16:1

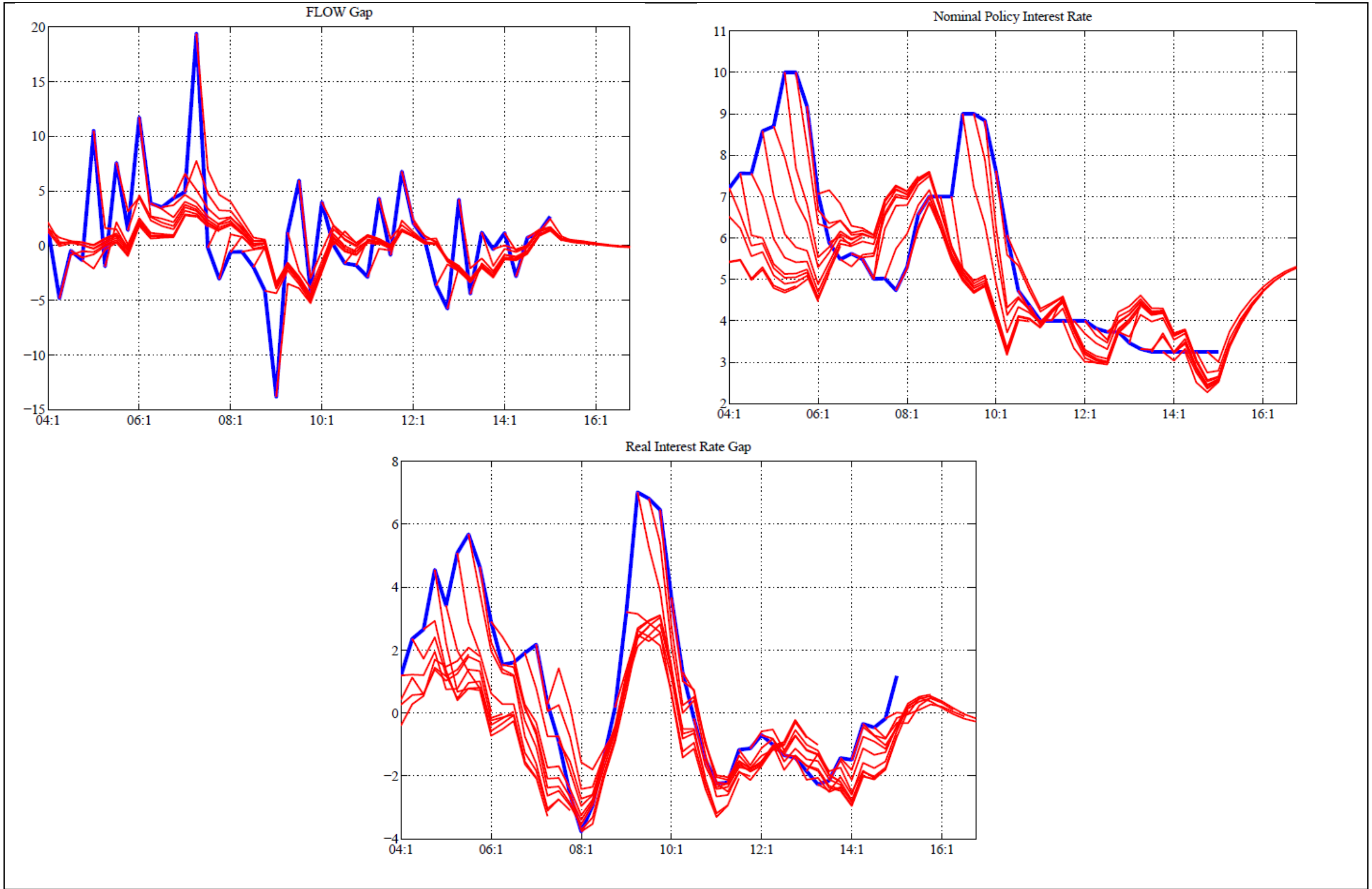

Figure 4. In-sample simulations

6 Conclusions

This paper provides a description of the MAKPAM model – a medium scale, New Keynesian gap model which is an integral part of the Forecasting and Policy Analysis System used at the National Bank of the Republic of Macedonia. The model is structured in a way that reflects the key characteristics of the Macedonian economy – a small open economy, with a fixed exchange rate regime and imperfect capital mobility. It is aimed at broadening the projection framework and responding to the key issues within the monetary policy domain. This model maps the key channels of the transmission mechanism of the monetary policy in the Macedonian economy, and it also helps the understanding and the quantification of the most probable manner in which the economy reacts to different economic events. Consequently, macroeconomic forecasts based on the MAKPAM model are an important block of the monetary policy decision-making process in the NBRM.

Going forward, the National Bank of the Republic of Macedonia will continue to improve the model in the future, in order to even better reflect the specifics of the Macedonian economy. The current stage of the development of the model shows that the NBRM already has a flexible analytical and forecasting framework that can adjust to the changes in the economy. This possibility elevates the capability of the central bank for monetary decision-making in different circumstances, which was the primary objective of this several-year project.

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