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QUARTERLY PROJECTION MODEL OF THE NATIONAL BANK OF KAZAKHSTAN

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Quarterly Projection Model of the National Bank of Kazakhstan

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Abstract

The study describes the latest structure, key equations, shock transmission mechanisms, and selected parameters of the National Bank's core forecasting model for the medium term projection. The Quarterly Projection Model used by the National Bank of Kazakhstan is a semi-structural model based on the principles of New Keynesian business cycle theory. It takes into account the specific features of the Kazakh economy and describes the transmission of the National Bank's monetary policy to macroeconomic conditions. The model comprises three main blocks of the economy described by behavioral equations, as well as an external sector represented by autoregression processes.

Keywords: *quarterly projection model, New Keynesian macroeconomic theory, Phillips curve, aggregate demand curve, Taylor rule, uncovered interest rate parity, Kazakhstan's monetary policy.*

JEL classification: *E32, E37, E47, E52, E58*

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Introduction

The Quarterly Projection Model (QPM) of the National Bank of Kazakhstan is a semi-structural macroeconomic model of a small open economy designed for forecasting and monetary policy analysis. The model is based on the key tenets of New Keynesian macroeconomic theory and describes the relationships among the main macroeconomic variables. Unlike large structural general equilibrium models, the QPM combines theoretically grounded economic relationships with the specific features of the economy in question, which provides a balance between economic interpretability and practical applicability in regular forecasting at the NBK. Thus, the QPM reflects the main transmission channels of Kazakhstan's monetary policy and takes into account the key structural features of the economy, including the significant role of fiscal policy and the oil sector.

The QPM framework was developed by the Bank of Canada in the early 1990s [(Black, Richard; Laxton, Douglas; Rose, David; Tetlow, Robert, 1994), (Coletti Donald; Hunt Benjamin; Rose David; Tetlow Robert, 1996)]. The development of the QPM marked the transition to the second generation of central bank macroeconomic models. It differed fundamentally from the traditional econometric systems that dominated in the 1970s and 1980s and was a semi-structural tool.

In parallel with the Bank of Canada's work, a major contribution to the evolution of forecasting systems was made by the Reserve Bank of New Zealand. As a pioneer in the practical implementation of inflation targeting, the Reserve Bank began developing its own model, the Forecasting and Policy System, in the mid-1990s (Aaron Drew; Ben Hunt, 1998).

In 2006, IMF economists published the now classic paper “A Practical Model-Based Approach to Monetary Policy Analysis” (Berg, A., Karam, P. D. & Laxton, D., 2006). In this work, the authors formalised the so-called “canonical” QPM structure consisting of four interrelated blocks: the IS curve (aggregate demand), the Phillips curve (aggregate supply), the interest rate parity condition and the monetary policy rule (Taylor rule). The proposed structure became the methodological basis for developing and adapting QPMs in the central banks of various countries.

One of the most successful examples of QPM implementation is the experience of the Czech National Bank. After moving to an inflation targeting regime in 1998, the Bank initially used short-term statistical models, but as early as 2002 it introduced the semi-structural quarterly projection model QPM-Gap (Coats, W., D. Laxton, and D. Rose, 2003), which became the basis of its forecasting and monetary policy analysis system. The semi-structural QPM-Gap model described the main channels of the monetary policy transmission mechanism and included blocks for aggregate demand, inflation, the exchange rate, the interest rate and inflation expectations. In 2008 the model was replaced by the more structural DSGE model QPM-g3, but the transition was gradual, with both models used in parallel and their forecasting properties carefully reviewed. The Czech National Bank's experience is regarded as one of the successful

examples of building a modern decision-support system under an inflation targeting regime.

At the Central Bank of the Russian Federation, the development of a semi-structural quarterly projection model (QPM) adapted to the specific features of the Russian economy began in 2007 (Orlov, 2021). The model pays particular attention to the fiscal impulse, the dynamics of individual components of the consumer basket, relative prices, the term structure of interest rates, elements of non-rational expectations, and the impact of world oil prices. As the modelling toolkit developed, various modifications of the QPM were designed, including the extension of the Quarterly Projection Model with a Labour Market (Orlov A., Sharufutdinov A., 2024) and a version of the Quarterly Projection Model developed by the Research and Forecasting Department (Nelyubina, 2024). At present, QPM-class models are used by the Bank of Russia alongside dynamic stochastic general equilibrium (DSGE) models for medium-term macroeconomic forecasting and monetary policy analysis.

As at the Bank of Russia, in many central banks the semi-structural QPM-class models are used together with dynamic stochastic general equilibrium (DSGE) models, which combines the advantages of timely forecasting and structural analysis.

Some central banks continue to use semi-structural models as their core model, such as the central banks of Hungary (Szilágyi; Baksa; Benes; Horváth; Köber; D. Soós, 2013), Chile (Francisco Arroyo Marioli , Francisco Bullano , Jorge Fornero , Roberto Zúñiga, 2020), Peru, Georgia (Salome Tvalodze, Shalva Mkhatrishvili, Tamar Mdivnishvili, Davit, 2016), Armenia and a number of other countries.

At the National Bank of the Republic of Kazakhstan, the quarterly projection model has been used since 2016 as part of the Forecasting and Policy Analysis System (FPAS). The development and implementation of the FPAS, including the QPM, were carried out with methodological support from International Monetary Fund (IMF) experts. The evolution of the National Bank's monetary policy during the transition from a fixed exchange rate regime to an inflation targeting regime is discussed in (Chernyavskiy D.; Mukanov N., 2017), while a description of the initial structure of the quarterly projection model can be found in (Chernyavskiy, 2017).

To date, the QPM at the National Bank of Kazakhstan continues to be developed and improved; it is used in preparing the baseline macroeconomic forecast, analysing alternative scenarios for the economy, assessing the impact of domestic and external shocks, and formulating recommendations on the level of the base rate. The use of the QPM ensures the internal consistency of forecast estimates, improves the quality of risk analysis and allowing to quantify the consequences of different monetary policy options.

The QPM is built using variables expressed as gaps. A gap is a percentage deviation of the actual value of an indicator from its potential (equilibrium) level. The potential level (trend) reflects the long-run path of the variable determined by fundamental factors. In the model, trend components are described by autoregressive processes converging to their long-run equilibrium values (steady state). Since potential

values are unobserved variables, they are estimated using a multivariate Kalman filter. Trend components are characterised by high persistence, smooth dynamics and low variance of random shocks.

The model parameters are determined by calibration. According to (Berg, A., Karam, P. D. & Laxton, D., 2006), the calibration of model parameters is an iterative process in which parameter values are determined on the basis of economic theory, empirical research and expert judgement. For Kazakhstan's economy this approach is particularly relevant, since it takes into account limited statistical data, structural changes in the economy and features of the monetary policy transmission mechanism that cannot always be captured only by historical data. After the initial values of parameters are chosen, the properties of the model are analysed and, where necessary, the parameters are adjusted until their results are consistent with the main regularities how the economy functions. This approach ensures the economic interpretability of the model, the robustness of forecasts and the consistency of the long-run equilibrium with the features of Kazakhstan's economy.

At the same time, the QPM is a linear model whose parameters are calibrated in line with the regime in which the economy and monetary policy operate. Consequently, the current version of the QPM is adapted to the conditions of an inflation targeting regime with a floating exchange rate and the assumption of a developing capital market.

1. Structure of the QPM

The basic structure of the QPM comprises three endogenous blocks – the Phillips curve, the aggregate demand and the monetary policy. In addition, exogenous parts are built into the model – the fiscal and oil sectors, as well as the external foreign sector.

In equations, the variables z_t are transformed and expressed in log levels multiplied by 100 ($100*\log Z_t$), and interest rates are expressed in annual terms.

1.1 Inflation Block

Inflation dynamics in the QPM are described by a hybrid New Keynesian Phillips curve, according to which current inflation is determined both by the inflation expectations of economic agents and by its own inertia. In addition, price dynamics are affected by producers' real marginal costs, which depend on the degree of utilisation of factors of production. They are expressed through the output gap, as well as by external factors, including the dynamics of the real exchange rate and relative prices. Thus, inflation is shaped by both forward-looking expectations and accumulated inflation pressures in the economy.

The Phillips curve block is split into food and non-food inflation components (1). The non-food inflation equation combines the services and non-food components.

$$PI = \omega * PI_F + (1 - \omega) * PI_{NF} + \varepsilon_{PI}, (1)$$

where PI is core inflation (q/q), PI_F is food inflation (q/q), PI_{NF} is non-food inflation (q/q), excluding prices of fuels and lubricants and regulated housing and utility services, ω is a weight of the food part in the core inflation, and ε_{PI} is the weight-change shock.

$$PI_F = a_{1_{F_1}} * PI_{F_{exp}} + \left(1 - a_{1_{F_1}}\right) * PI_F\{-1\} + a_{1_{F_2}} * \left[a_{1_{F_3}} * Y_{gap}\{-2\} + a_{1_{F_4}} * REER^F_{GAP}\{-2\}\right] + \varepsilon_{PI_F}, \quad (2)$$

where $PI_{F_{exp}}$ is food inflation expected one quarter ahead, $PI_F\{-1\}$ is food inflation in the previous quarter, Y_{gap} is the output gap, $REER^F_{GAP}$ is the real effective exchange rate (REER) gap for food, and ε_{PI_F} is a supply shock on food markets.

$$PI_{NF} = a_{1_{NF_1}} * PI_{NF_{exp}} + \left(1 - a_{1_{NF_1}}\right) * PI_{NF}\{-1\} + a_{1_{NF_2}} * \left[a_{1_{NF_3}} * Y_{gap}\{-1\} + a_{1_{NF_4}} * REER^{NF}_{GAP}\{-1\}\right] + \varepsilon_{PI_{NF}}, \quad (3)$$

where $PI_{NF_{exp}}$ is non-food inflation expected one quarter ahead, $PI_{NF}\{-1\}$ is non-food inflation in the previous quarter, Y_{gap} is the output gap, $REER^{NF}_{GAP}$ is the REER gap for non-food inflation, and $\varepsilon_{PI_{NF}}$ is a supply shock on non-food and services markets.

The non-food REER is calculated as a function of the nominal exchange rate of the US dollar against the tenge and the relative level of non-food prices in Kazakhstan and abroad. The domestic price index is represented by Kazakhstan's non-food inflation, and the foreign one by foreign inflation expressed in US dollars and weighted by the shares of Russia, China and the European Union in Kazakhstan's foreign trade turnover. Expressing the foreign prices in dollars ensures comparability with the nominal USD/KZT exchange rate and allows to correctly reflecting changes in the price competitiveness of Kazakhstan's non-food goods on external markets. In turn, the food real effective exchange rate is determined on the basis of the nominal exchange rate of the US dollar against the tenge, taking into account the relative dynamics of domestic and foreign food prices. Food inflation in Kazakhstan is used as the domestic price indicator, while the foreign price index is approximated by the dynamics of the Food and Agriculture Organization (FAO) Cereals Price Index expressed in US dollars. The use of the FAO cereal price index reflects the high dependence of domestic food prices on conditions in the world cereals market, given the significant role of grain both in the structure of Kazakhstan's exports and in the formation of prices for a wide range of food products. This approach takes into account the impact of changes in world food prices on the price competitiveness of domestic products and ensures that the calculations are consistent with the use of the nominal USD/KZT exchange rate.

Thus, the Phillips curves equation shows that in long-run equilibrium, when the output gap and the real effective exchange rate gap are zero and there are no supply shocks, actual inflation is determined by a weighted average of expected future and past inflations. Once the inflation target is reached and inflation expectations are firmly anchored, inflation stabilises at the target.

It should be noted that the choice of core inflation as the target variable was driven by the need to separate out those components of inflation whose dynamics are

determined mainly by exogenous factors and are influenced by monetary policy only to a very limited extent. In particular, these are the prices of regulated housing and utility services and of fuels and lubricants, whose dynamics are largely determined by administrative decisions and government regulation mechanisms. At the same time, the strategic objective of the National Bank of the Republic of Kazakhstan remains to ensure low and stable headline inflation. In forecasting, the price dynamics of regulated housing and utility services and of fuels and lubricants are modelled as exogenous and are set outside the QPM.

1.2 IS Curve

The dynamics of domestic demand in the QPM are described by a New Keynesian IS curve, which captures the relationship between output, the real interest rate and other factors affecting aggregate demand. In the model, GDP gap is determined by the following equation (4):

$$Y_{GAP} = sh_{DD} * DD_{GAP} + sh_G * G_{GAP} + sh_X * X_{GAP} - sh_M * M_{GAP} + \varepsilon_{Y_{GAP}}, \quad (4)$$

where DD_{GAP} is the domestic demand gap, G_{GAP} is the government consumption gap, X_{GAP} is the export gap, M_{GAP} is the import gap, and $\varepsilon_{Y_{GAP}}$ is the combined weight-change shock. The components of the GDP gap are weighted by the nominal share of each component (sh).

In the QPM, domestic demand is an aggregate indicator combining household consumption and gross fixed capital formation. Its dynamics are highly inertial, since economic agents' decisions on consumption and partly also on investment change gradually. For this reason, one of the key drivers of domestic demand is its own past dynamics.

Domestic demand is also substantially affected by the fiscal impulse, which reflects the spending of the government and quasi-fiscal sectors. Growth in such spending supports aggregate demand and contributes to higher consumption and investment activity (see Section 1.4 for more detail).

A distinctive feature of Kazakhstan's QPM is the inclusion of the oil price gap in the domestic demand equation as an important determinant of economic growth dynamics. A positive oil price gap reflects a period when the actual oil price exceeds its long-run level, which is usually accompanied by improved external conditions, rising incomes in the economy and stronger confidence among households and businesses. As a result, this has a positive effect on domestic demand.

Alongside this, the real interest rate gap plays an important role. A real interest rate above its neutral level corresponds to tighter monetary conditions, raises the cost of borrowing and encourages saving, which restrains consumption and investment activity that are excessive in terms of their impact on inflation, ensuring a gradual adjustment in the behaviour of economic agents.

$$DD_{GAP} = b_1 * DD_{GAP}\{-1\} - b_2 * RIR_{GAP} + b_3 * PO_{GAP}\{-1\} + b_4 * FiscalImpulse + \varepsilon_{DD_{GAP}}, (5)$$

where $DD_{GAP}\{-1\}$ is the inertia of the domestic demand gap, RIR_{GAP} is the real interest rate gap, PO_{GAP} is the oil price gap, $FiscalImpulse$ is the fiscal impulse, and $\varepsilon_{DD_{GAP}}$ is a domestic demand shock.

The dynamics of government spending are inertial and depend on its own past value. In addition, government consumption responds to the deviation of world oil prices from their long-run level, reflecting the dependence of budget expenditure on commodity market conditions. The model also takes into account the gap in transfers from the National Fund, which characterises discretionary changes in fiscal policy. Thus, government consumption is determined by the following equation:

$$G_{GAP} = \alpha_1 * G_{GAP}\{-1\} + \alpha_2 * [e_1 * PO_{GAP} + (1 - e_1) * PO_{GAP}\{-1\}] + \alpha_3 * TR_{GAP} + \varepsilon_{G_{GAP}}, (6)$$

where $G_{GAP}\{-1\}$ is the inertia of the government consumption gap, TR_{GAP} is the gap in transfers from the National Fund of the Republic of Kazakhstan, and $\varepsilon_{G_{GAP}}$ is a government consumption shock.

The export equation consists of oil (EX_{GAP}^{Oil}) and non-oil exports ($EX_{GAP}^{Non-oil}$), as well as a total export shock:

$$X_{GAP} = sh_{OX} * EX_{GAP}^{Oil} + (1 - sh_{OX}) * EX_{GAP}^{Non-oil} + \varepsilon_{EX}, (7)$$

The dynamics of non-oil exports are shaped by external demand and by the real effective exchange rate, which determines the competitiveness of domestic producers. Non-oil exports are thus given by the following equation:

$$EX_{GAP}^{Non-oil} = \delta_1 * EX_{GAP}^{Non-oil}\{-1\} + \delta_2 * REER_{GAP}^{NF}\{-1\} + \delta_3 * REER_{GAP}^{F}\{-1\} + \delta_4 * YNO_{GAP}^{*} + \varepsilon_{EX_{GAP}^{Non-oil}}, (8)$$

where $EX_{GAP}^{Non-oil}\{-1\}$ is the inertia of non-oil exports, YNO_{GAP}^{*} is the effective foreign non-oil output gap, and $\varepsilon_{EX_{GAP}^{Non-oil}}$ is the non-oil export shock.

YNO_{GAP}^{*} characterises external demand, which is approximated by the business cycle phases of the main trading partners – China, the European Union and the Russian Federation. The country weights are determined by their shares in non-oil exports.

The dynamics of oil exports differ somewhat from those of non-oil exports, and they are determined by an autoregressive process. In forecasting practice, the benchmark for the future path of oil exports is the assumption on oil production in subsequent periods.

The import equation is a function of domestic demand, reflecting the importance of imports in household consumption and investment. In addition, the equation takes into account the effect of the exchange rate channel. A change in the real exchange rate affects the relative cost of imported goods and services compared to domestic ones. A weaker exchange rate raises the cost of imports in national currency, reducing demand for imported goods and encouraging their substitution with domestically produced

goods. Conversely, a stronger exchange rate makes imported products cheaper, increasing their competitiveness and stimulating higher imports.

$$M_{GAP} = x_1 * [\theta_1 * DD_{GAP}\{-1\} + (1-\theta_1) * DD_{GAP}\{-2\}] - x_2 * REER_{GAP}^{NF}\{-3\} + \varepsilon_{Im_{GAP}}, (9)$$

1.3 Monetary Policy Block

The monetary policy block consists of the exchange rate equations and the monetary policy rule.

Exchange rate equation

In the standard version of the QPM, which assumes full capital mobility and developed financial markets, exchange rate dynamics are determined by the differential between domestic and foreign interest rates and by a country risk premium. A wider interest rate differential encourages foreign capital inflows and an appreciation of the national currency, while a narrower one leads to capital outflows and a weaker exchange rate. In turn, a higher risk premium reflects an increase in the riskiness of investing in domestic assets as perceived by investors (both foreign and domestic), reduces the attractiveness of those assets, encourages capital outflows and puts depreciation pressure on the exchange rate. A lower risk premium, by contrast, stimulates capital inflows and supports the appreciation of the national currency.

For emerging economies, including Kazakhstan, this mechanism is supplemented by features of the structure of the economy. In particular, it is assumed that exchange rate dynamics are determined by two main channels: the financial channel, which reflects the effect of the interest rate differential and the risk premium, and the external trade channel, which is associated with changes in the terms of trade – above all the dynamics of world commodity prices – and with export and import volumes, which together determine foreign exchange inflows and the supply of foreign currency on the domestic market. Thus, for Kazakhstan the exchange rate is assumed to be affected through two channels:

$$\Delta S = (1 - capmob) * \Delta S_1 + capmob * \Delta S_2 + \varepsilon_{\Delta S}, (10)$$

where $capmob$ *is a* capital mobility parameter and $\varepsilon_{\Delta S}$ is the shock of the deviation of actual capital mobility ($capmob$) from that in the model.

Equation (11) describes the trade channel (BoP channel) and includes ΔS_{EQ} – the equilibrium change in the nominal exchange rate – and BoP_{GAP} – the trade balance gap adjusted for the terms of trade ($BoP_{GAP} = TOT_{GAP} + X_{GAP} - M_{GAP}$).

$$\Delta S_1 = \Delta S_{EQ} - \rho_1 * BoP_{GAP}, (11)$$

Equation (12) reflects the effect of the uncovered interest parity channel, or the financial channel (UIP channel).

$$\Delta S_2 = \rho_2 * \Delta S_2\{1\} + (1-\rho_2) * \Delta S\{-1\} - (IR - IR^* - prem_{SS}) - \rho_3 * BoP_{GAP} - \rho_4 TR_{GAP}, (12)$$

where $\Delta S_2\{1\}$ is the change in the nominal exchange rate expected one quarter ahead through the UIP channel, IR is the NBK's domestic interest rate, IR^* is the foreign nominal interest rate, represented by the US Federal Reserve rate, $prem_{SS}$ is the risk

premium, and TR_{GAP} is the gap in transfers from the National Fund of the Republic of Kazakhstan. In addition, the financial channel of Kazakhstan's QPM takes into account the gap in transfers from the National Fund. Other things being equal, an increase in transfers is accompanied by the conversion of foreign currency into tenge, which increases the supply of foreign currency on the domestic foreign exchange market and puts short-term appreciation pressure on the exchange rate. In the medium term, however, larger transfers stimulate domestic demand, which is accompanied by growth in imports and in demand for foreign currency. As a result, the initial effect through the foreign exchange market gradually gives way to depreciation pressure on the nominal exchange rate.

Monetary policy rule

In Kazakhstan's QPM, the monetary policy rule is represented by two equations: monetary policy responds not only to the expected deviation of inflation from the target and to the output gap, but the central bank also reacts to a depreciation (appreciation) of the nominal exchange rate above (below) its equilibrium level. The two parts of the monetary policy rule are weighted by the capital mobility coefficient (*capmob*), which accounts for the imperfect capital mobility characteristic of Kazakhstan's economy.

$$IR = (1 - capmob) * IR_1 + capmob * IR_2 + \varepsilon_{IR}, (13)$$

where IR is the NBK's nominal interest rate and ε_{IR} is the monetary policy shock.

The capital mobility coefficient characterises the level of development and openness of financial markets, the degree of economic agents' confidence in the effectiveness of monetary policy and the central bank's ability to anchor inflation expectations. At the same time, this coefficient reflects the relative importance of the exchange rate and the interest rate in the process of macroeconomic adjustment: in economies with high dollarisation and a significant role of exchange rate fluctuations in price setting, the exchange rate has a stronger influence on the expectations of economic agents, whereas as financial markets develop and confidence in the inflation targeting regime strengthens, the role of the interest rate channel of monetary policy transmission increases. In this regard, the gradual increase in the capital mobility coefficient in the QPM from 0.1 at the initial stage of introducing the inflation targeting regime to 0.4 at present reflects the structural and fundamental changes that have taken place in Kazakhstan's economy, including lower dollarisation, the country's greater involvement in global financial flows, and the increased transparency and effectiveness of the communication policy of the NBK, which have helped to strengthen confidence in monetary policy and enhanced the role of the interest rate transmission channel. The first part of the monetary policy rule is a response to the deviation of the change in the exchange rate from its equilibrium change.

$$IR_1 = \beta_1 * IR\{-1\} + (1 - \beta_1) * \left(RIR_{EQ} + PI_{TAR}\right) + \mu * (\Delta S - \Delta S_{EQ}), (14)$$

where $IR\{-1\}$ is the NBK's nominal interest rate in the previous quarter, RIR_{EQ} is the real neutral interest rate, and PI_{TAR} is the inflation target.

In the QPM, the equilibrium rate of change of the nominal exchange rate is defined as the difference between tinflation target in Kazakhstan and inflation in trading partner countries, taking into account the long-run dynamics of the real effective exchange rate. The real effective exchange rates are weighted by the shares of the components in the consumer basket. The equilibrium REERs themselves are represented by autoregressive processes converging to their long-run equilibria.

This formulation is consistent with the concept of relative purchasing power parity in the long run and ensures that the economy's external price competitiveness is preserved.

The second part of the monetary policy rule in the QPM is a modified Taylor rule (15) describing the response of the National Bank of Kazakhstan to changes in macroeconomic conditions. In line with the inflation targeting regime, the central bank is guided by the forecast of annual core inflation (excluding prices of fuels and lubricants and regulated housing and utility services) four quarters ahead. In addition, base rate decisions take the output gap into account: a positive gap calls for tighter monetary policy, while a negative one allows to be eased. The rule also includes an interest rate inertia component, reflecting the need to change the rate gradually, avoiding sharp swings in monetary conditions and ensuring the predictability of policy and financial stability.

$$IR_2 = \beta_1 * IR\{-1\} + (1-\beta_1) * \left(RIR_{EQ} + PI_{TAR}\right) + \varphi * (PI_4\{4\} - PI_{TAR}) + \epsilon Y_{GAP}, \quad (15)$$

where $PI_4\{4\}$ is expected annual core inflation one year ahead.

In the QPM, the equilibrium real interest rate is modelled as an unobserved variable with a high degree of persistence and depends on its own previous value and the long-run growth rate of potential output. This takes into account gradual changes in the structural factors of the economy that affect the neutral level of the interest rate. Formally, the equilibrium real interest rate is defined as follows:

$$RIR_{EQ} = \sigma_1 * RIR_{EQ}\{-1\} + (1-\sigma_1) * Y_{EQ} + \varepsilon_{RIR_{EQ}}, \quad (16)$$

Thus, in long-run equilibrium, when the output gap is zero, inflation is at the target level and the nominal exchange rate is at its equilibrium value, the nominal interest rate of the National Bank of Kazakhstan is set at the level of the neutral nominal rate, which is defined as the sum of the equilibrium real interest rate and the inflation target.

1.4 Exogenous Blocks

The exogenous blocks in the QPM comprise the external sector, the oil sector and fiscal policy indicators. In the current specification, the dynamics of the exogenous variables are given mainly by autoregressive processes with varying degrees of persistence and reversion to long-run equilibrium values.

The external sector includes the foreign non-oil output gap (YNO^*_{GAP}), foreign aggregate inflation (PI^*), foreign aggregate food inflation (PI^*_F), foreign nominal interest rate (IR^*) and oil price gap (PO_{GAP}).

$$YNO^*_{GAP} = 0.85 * YNO^*_{GAP}\{-1\} + \varepsilon_{YNO^*_{GAP}}, (17)$$

$$PI^* = 0.85 * PI^*\{-1\} + (1 - 0.85) * PI^*_{SS} + \varepsilon_{PI^*}, (18)$$

$$PI^*_F = 0.85 * PI^*_F\{-1\} + (1 - 0.85) * PI^*_{FSS} + \varepsilon_{PI^*_F}, (19)$$

$$IR^* = 0.85 * IR^*\{-1\} + (1 - 0.85) * IR^*_{SS} + \varepsilon_{IR^*}, (20)$$

$$PO_{GAP} = 0.7 * PO_{GAP}\{-1\} + \epsilon PO_{GAP}, \ (21)$$

$$PO = PO_{GAP} + PO_{EQ}, (22)$$

$$PO_{EQ} = \ PO_{EQ}\{-1\} + PIO_{EQ}/4, (23)$$

$$PIO_{EQ} = 0.9 * PIO_{EQ}\{-1\} + (1 - 0.9) * PIO_{\underset{SS}{EQ}} + \varepsilon_{PIO_{EQ}}, (24)$$

The oil sector represents the volumes of real exports of oil and gas condensate; in the model it is given by an autoregressive process:

$$EX^{Oil}_{GAP} = \delta_5 * EX^{Oil}_{GAP}\{-1\} + \varepsilon_{EX^{Oil}_{GAP}}, (25)$$

Fiscal impulse

The fiscal policy indicator is an aggregate measure that takes into account the non-oil budget deficit and quasi-fiscal operations, adjusted for the the business cycle position (discussed in more detail below), as well as the transfers gap.

$$Fiscalimpulse = \delta_6 * Fiscalimpulse\{-1\} + \varepsilon_{Fimpulse}, (26)$$

$$TR_{GAP} = \delta_7 * TR_{GAP}\{-1\} + \varepsilon_{TR_{GAP}}, (27)$$

The fiscal impulse is an indicator characterising the stimulating or restraining nature of fiscal policy. Its calculation is based on estimating the change in the structural (primary cyclically adjusted) non-oil budget deficit.

To calculate it, at the first stage all components of the state budget are seasonally adjusted. Oil revenues – namely transfers from the National Fund of the Republic of Kazakhstan and the export customs duty on oil – are then excluded from total budget revenues. This moves to an estimate of non-oil revenues. Next, budget revenues are cyclically adjusted using the output gap, which gives their potential level, cleansed of the influence of the phases of the economic cycle.

On the expenditure side, interest payments on public debt are excluded, since they reflect decisions of past periods and do not show the current stance of fiscal policy. This yields primary expenditure.

The structural deficit is the difference between potential non-oil revenues and primary expenditure. The fiscal stance is defined as the structural deficit taken with the opposite sign. This representation is used for more intuitive interpretation.

Thus, the fiscal impulse is the change in the fiscal stance between two periods and is used to assess the direction of current budget policy. A positive fiscal impulse implies that the deficit in the current period exceeded the deficit of the base period, i.e. budget policy is becoming more stimulative: the government is increasing spending and/or lowering the tax burden relative to the base period. As a result, aggregate

demand in the economy rises, which may contribute to faster economic activity and generate inflationary pressures.

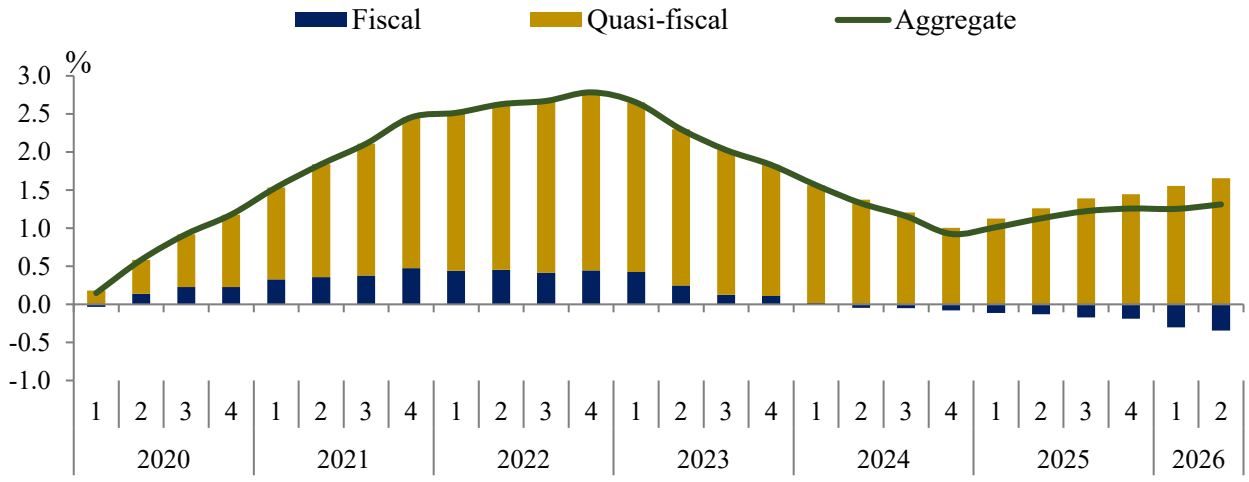
A negative fiscal impulse, by contrast, indicates that fiscal policy is restraining relative to the base period. It occurs when the fiscal stance contracts, which may be associated with lower government spending and/or higher taxes (a larger withdrawal of money from the economy). Such a policy is aimed at reducing inflationary pressure, narrowing the budget deficit and ensuring the sustainability of public finances.

For analytical purposes, the fiscal impulse is calculated relative to 2019, which is used as the base period because it was marked by a stable macroeconomic environment preceding the crisis and a comparatively moderate level of government stimulus. In addition, to capture the delayed effect of the funds allocated, exponential smoothing over twelve quarters is applied.

Besides the state budget itself, the government also finances the economy through the *quasi-government channel*, whose role has increased markedly in recent years. Its impact on economic activity is assessed on the basis of the volume of financing provided by Baiterek National Investment Holding JSC, which acts as a source of funds for the economy. The allocation of such funds by Baiterek is captured through the seasonally adjusted change in total financing of the economy, adjusted for the business cycle, which includes indirect support instruments in the form of guarantees and insurance. This type of indirect financing has a multiplicative effect, allowing banks and enterprises to launch additional projects, which also strengthens the credit impulse in the economy.

Similarly, the quasi-fiscal impulse is calculated relative to the base year 2019 with exponential smoothing over 12 quarters.

Figure 1. Aggregate impulse, relative to 2019, % of GDP



Source: authors' calculations

The aggregate impulse of the government is formed as the sum of the fiscal and quasi-fiscal impulses and reflects the overall impact of government policy on economic

activity. The analysis show that the best relationship with inflation dynamics and real GDP growth is achieved with weights of 30% for the fiscal impulse and 70% for the quasi-fiscal impulse (Figure 1).

Recently, in overall government policy there has been a shift of the stimulus from the fiscal channel towards the quasi-fiscal sector. This approach allows to support economic activity while complying with fiscal rules and deficit targets.

2. Transmission Mechanism

Impulse response functions are used to assess the performance of the model and to analyse the transmission of economic shocks. Impulse responses capture the dynamic reaction of the model's endogenous variables to a unit shock. Analysing them allows to assess the direction, magnitude and duration of the effect of a shock, and to check whether the model's behaviour is consistent with the theoretical understanding of monetary policy mechanisms.

The impulse responses of the main macroeconomic variables to the most important (1%) shocks characterising the functioning of Kazakhstan's QPM are presented below (Figure 2).

Demand shock

A domestic demand shock *(RES_DD_GAP)* leads to a positive output gap, reflecting actual output exceeding potential. The rise in aggregate domestic demand intensifies inflationary pressure, which is accompanied by higher inflation. The nominal exchange rate weakens owing to higher demand for imports and foreign currency. This in turn leads to a weakening of the food and non-food real effective exchange rates, reinforcing inflationary pressure through the imported inflation channel. In response to the rise in forecast inflation, the National Bank of Kazakhstan raises the base rate, tightening monetary conditions. The higher real interest rate restrains domestic demand, as a result of which the output gap gradually closes and the exchange rate returns to its equilibrium value.

Oil price shock

A positive shock to world oil prices (RES_PO_GAP) initially leads to improved terms of trade, higher export revenues and larger foreign exchange inflows. This in turn brings about an appreciation of the nominal and real effective exchange rates. This has a disinflationary effect by making imported goods cheaper, as a result of which inflation declines, accompanied by a lower nominal interest rate.

At the same time, higher export revenues combined with a negative real interest rate gap stimulate aggregate demand, which leads to a positive output gap. As the oil price shock fades and imports increase owing to the strong exchange rate, economic growth approaches its potential rate.

Fiscal impulse shock

A fiscal impulse shock *(RES_FIMPULSE)* increases aggregate demand, which leads to a positive output gap. The positive output gap intensifies pro-inflationary pressures in the economy abd inflation accelerates. Economic activity returns to equilibrium faster than inflation returns to its target, reflecting the delayed and inertial nature of price changes. At the same time, the real effective exchange rate weakens owing to stronger domestic demand and higher imports. As the shock spreads through the economy and inflationary pressure builds, the National Bank raises the base rate. Tighter monetary conditions lead to a higher real interest rate, restrain domestic demand and contribute to the gradual closing of the output gap. As a result, the exchange rate and real interest rates gradually return to their long-run equilibrium values.

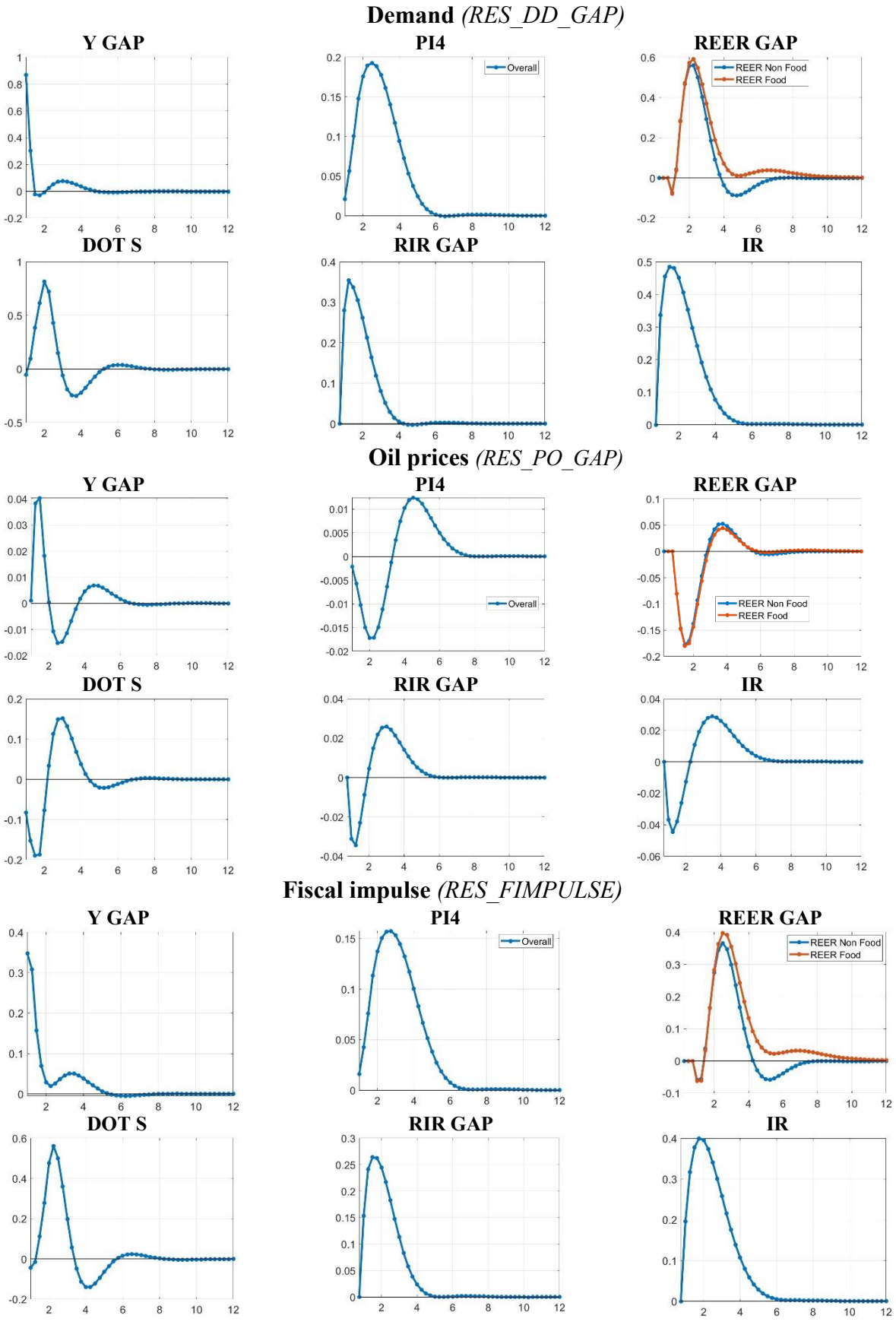
Monetary policy shock

A monetary policy shock *(RES_IR)* leads to a higher real interest rate and tighter monetary conditions. The higher cost of borrowing restrains domestic demand, resulting in a negative output gap. At the same time, the nominal and real effective exchange rates appreciate owing to the wider interest rate differential and capital inflows, which has an additional disinflationary effect through the lower cost of imported goods. As a result, inflationary pressure eases and inflation gradually declines. The maximum response of the interest rates is observed immediately after the shock, while the largest decline in output and inflation occurs with a lag of several quarters, reflecting the gradual transmission of the monetary policy impulse to the real sector of the economy. Owing to the disinflationary processes, the base rate is subsequently lowered. As a result, the real interest rate, the output gap, inflation and the exchange rate return to their long-run equilibria.

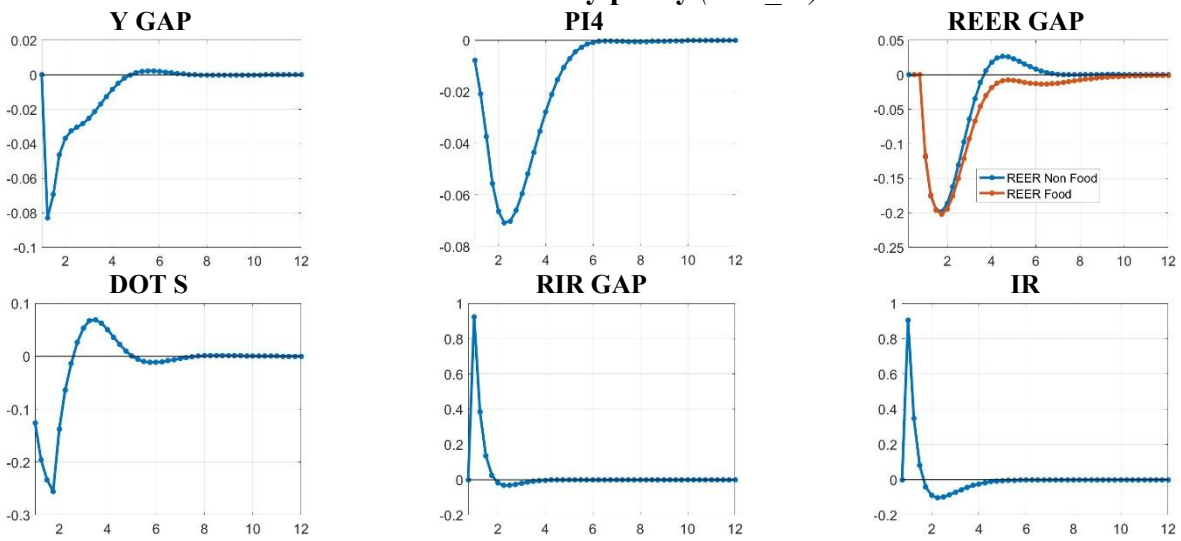
Nominal exchange rate shock

A nominal exchange rate shock *(RES_DOT_S)* is accompanied by a weakening of the nominal and real effective exchange rate. The higher cost of imported goods intensifies inflationary pressure and leads to faster inflation. At the same time, the price competitiveness of domestic producers improves, which has a stimulating effect on aggregate demand and leads to a positive output gap. In response to higher forecast inflation, pro-inflationary GDP dynamics and the weaker exchange rate, the National Bank of Kazakhstan raises the base rate, as a result of which the real interest rate rises. Tighter monetary conditions help the exchange rate to appreciate, restrain domestic demand and ensure the gradual return of inflation, the output gap and other macroeconomic variables to their long-run equilibria.

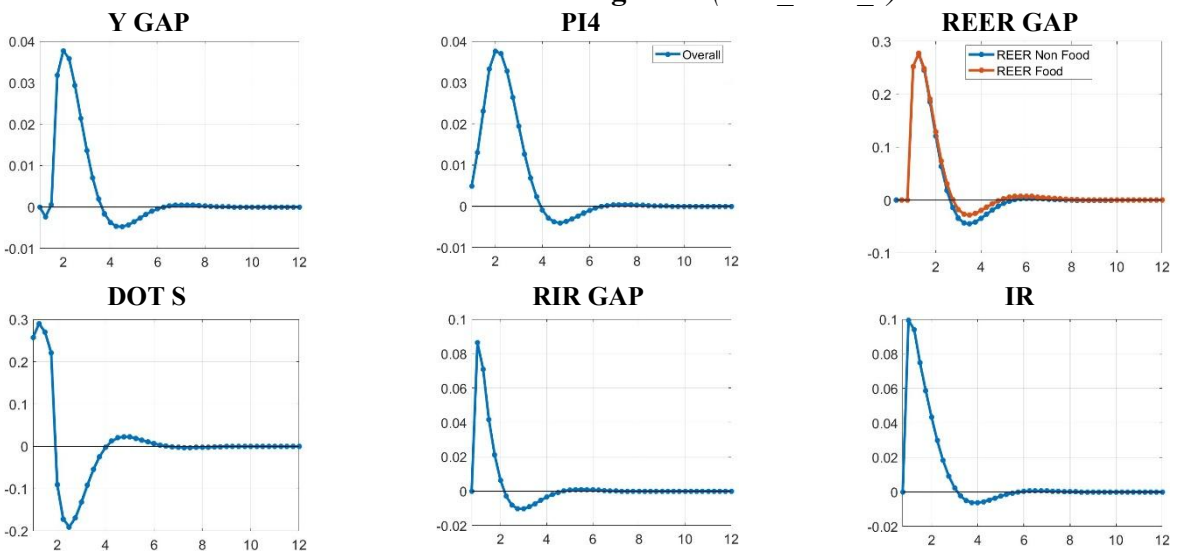
Figure 2. Impulse responses of macroeconomic variables to a 1% shock



Monetary policy *(RES_IR)*



Nominal exchange rate *(RES_DOT_S)*



Conclusion

The Quarterly Projection Model is a core medium term model of the National Bank of Kazakhstan, which is used quarterly as part of forecasting rounds. The results of its modeling serve as the basis for the monetary policy decision-making process.

At the same time, the model is in the process of continuous development and improvement. Its operation and application are managed by the Medium-Term Forecasting Team (model operators), which regularly reviews the model and assesses the need for further improvements. Where necessary, the model is adjusted to reflect structural changes and new developments in the functioning of the economy of Kazakhstan, which allows it to maintain its relevance and analytical reliability.

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Appendix

Steady state parameters in the QPM

Parameter	Notation	Value	Unit
Inflation target	PI_{TAR}	5.0	y/y
Long-run oil price growth	$PIO_{EQ}{}_{SS}$	0	q/q annualised
Foreign long-run interest rate	IR^{*}_{SS}	2.0	%
Long-run domestic demand growth	ΔDD_{ss}	5.1	q/q annualised
Long-run export growth	ΔX_{ss}	1.5	q/q annualised
Long-run oil export growth	ΔX_O_{ss}	1.0	q/q annualised
Long-run non-oil export growth	$\Delta X_NO_{ss} = (\Delta X_{ss} - sh_{OX} * \Delta X_O_{ss})/(1\text{-}sh_{OX})$;		q/q
Long-run import growth	ΔM_{ss}	5.0	q/q annualised
Long-run government consumption growth	ΔG_{ss}	3.0	q/q annualised
Long-run growth of the change in transfers	ΔTR_{ss}	4.0	q/q annualised
Long-run potential growth	$\Delta Y^{SS}_{EQ} sh_{DD} = sh_{DD} * \Delta DD_{ss} + sh_G * \Delta G_{ss} + sh_X * \Delta X_{ss} - sh_M * \Delta M_{ss}$		q/q annualised
Real neutral interest rate	$RIR_{EQ} = sh_{DD} * \Delta DD_{ss} + sh_G * \Delta G_{ss} + sh_X * \Delta X_{ss} - sh_M * \Delta M_{ss}$		%
Risk premium	$prem_{SS} = RIR_{EQ} + PI_{TAR} - IR^{*}_{SS}$		%
Capital mobility	$capmob$	0.4	
Long-run change in the non-food real effective exchange rate	$\Delta REER^{NF}_{EQss}$	0	q/q annualised
Long-run change in the food real effective exchange rate	$\Delta REER^{F}_{EQss}$	0	q/q annualised

Values of the variables in the equations of the QPM

Variable	Definition	Value
IS curve		
sh_{DD}	Weight of domestic demand	**0.87**
sh_G	Weight of government consumption	**0.1**
sh_X	Weight of exports	**0.37**
sh_{OX}	Weight of oil exports	**0.54**
sh_M	Weight of imports	**p.dd_sh+p.g_sh+p.x_sh-1;**
Domestic demand		
b_1	Inertia of domestic demand	**0.8**
b_2	Effect of the real interest rate gap	**0.1**
b_3	Effect of the oil price gap	**0.04**
b_4	Effect of the fiscal impulse	**0.4**
Government consumption		
α_1	Inertia of government consumption	**0.75**
α_2	Effect of the oil price gap	**0.02**
e_1	Weighting of oil price lags	**0.5**
α_3	Effect of the transfers gap	**0.02**
Non-oil exports		
δ_1	Inertia of non-oil exports	**0.75**
δ_2	Effect of the non-food REER	**0.07**
δ_3	Effect of the food REER	**0.05**
δ_4	Effect of the external demand gap	**0.92**
Imports		
x_1	Effect of the domestic demand gap	**1.8**
θ_1	Weights of the domestic demand gap lags	**0.6**
x_2	Effect of the non-food REER	**0.3**
Phillips curve		
ω	Weight of food inflation	**0.411**
$a_{1_{F_1}}$	Persistence of food inflation	**0.65**
$a_{1_{F_2}}$	Effect of marginal costs	**0.02**
$a_{1_{F_3}}$	Effect of the output gap	**0.5**
$a_{1_{F_4}}$	Effect of the food REER	**1-$a_{1_{F_3}}$**
$a_{1_{NF_1}}$	Persistence of non-food inflation	**0.55**
$a_{1_{NF_2}}$	Effect of marginal costs	**0.02**
$a_{1_{NF_3}}$	Effect of the output gap	**0.5**
$a_{1_{NF_4}}$	Effect of the non-food REER	**1-$a_{1_{NF_3}}$**
Monetary policy block		
Exchange rate equation		
ρ_1	Effect of the terms-of-trade channel	**1.2**
ρ_2	Effect of the expected exchange rate	**0.5**
ρ_3	Effect of the terms-of-trade channel	**0.1**
ρ_4	Effect of the transfers channel	**0.2**
Monetary policy rule		
β_1	Interest rate inertia	**0.5**
μ	Response to the deviation of the exchange rate from equilibrium	**0.2**

φ	Response to the deviation of future inflation from the target	**3.0**
σ_1	Inertia of the equilibrium neutral rate	**0.85**
Exogenous blocks		
δ_5	Inertia of oil exports	**0.85**
δ_6	Inertia of the fiscal impulse	**0.55**
δ_7	Inertia of the transfers gap	**0.75**