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Article

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BEROC working paper series

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Reference: Kharitonchik, Anatoly (2023). Optimal monetary policy framework in Belarus. In: BEROC working paper series 88 S. 1 - 60.
https://beroc.org/upload/medialibrary/3f0/3f0d64beec3757dbee9ca1fc97a65e2b.pdf.

This Version is available at:
http://hdl.handle.net/11159/703076

Optimal Monetary Policy Framework in Belarus

Anatoly Kharitonchik, 2023

BEROC Working Paper Series, WP no. 88

The study uses the example of Belarus to evaluate the effectiveness of monetary policy regimes that can serve as the basis for monetary policy strategies in emerging market countries. Based on the macroeconomic gap model for Belarus, simulations of the impact of strong shocks on the economy using different monetary policy regimes have been implemented. The values of the loss function for each regime have been calculated, which form the basis for assessing the comparative effectiveness of the regimes. The effects of strict capital flow restrictions and low central bank credibility on the stabilization capacity of regimes are examined. Given the existing sanctions and internal capital controls, the most preferable regime for Belarus is a flexible inflation targeting. The application of monetary targeting is challenging because of the extremely high volatility of interest rates it generates, which can have adverse consequences for financial and macroeconomic stability, as well as for building credibility in the National Bank. In the transformation of the Belarusian economy and political system towards the inclusivity of political and economic institutions, it is advisable to consider the possibility of applying a flexible price level targeting regime.

Keywords: monetary policy, monetary policy regime, inflation, price level, output gap, interest rate, targeting, credibility, capital flows, model, simulation, loss function.

JEL: C32, E31, E32, E52, E58.

1. Introduction

Monetary policy is a crucial tool for ensuring macroeconomic stability in a country. For its effective execution of the stabilization function, the central bank must have independence in setting goals and using monetary policy instruments. The monetary policy regime, which refers to the system of rules and procedures for conducting monetary policy, should align with the characteristics of the country's economic system.

In Belarus since the 1990s, monetary policy has been implemented under various regimes, and for most of the historical period, the ability of the National Bank to set goals and use monetary policy instruments without government intervention was limited. As a result, except for a brief period from the 2015 to mid-2020, monetary policy in Belarus tended to exacerbate negative shocks on the Belarusian economy rather than playing a stabilizing role (Kharitonchik, 2023b).

Since mid-2020, the National Bank has de facto lost operational independence. Monetary policy has become discretionary, focusing on stimulating economic activity. The National Bank approaches the inflationary consequences of this policy with a high degree of tolerance (Kharitonchik, 2023a).

The research results of D. Kruk (2023), based on surveys of macroeconomic experts, indicate the multifaceted weaknesses of monetary policy in Belarus, primarily associated with the mismatch of its institutional design with advanced standards and the presence of numerous archaic practices and remnants. Important recommendations from experts to strengthen the stabilizing role of monetary policy include ensuring the independence of the National Bank, eliminating voluntarism, and the need for a clear hierarchy of monetary policy goals (Kruk, 2023).

The prolonged use of discretionary monetary policy in Belarus may at some point conflict strongly with the need to ensure macroeconomic stability. The question of stability may take precedence over the issue of economic growth due to the extremely high uncertainty of the development of the Belarusian economy and its strong vulnerability to shocks. In the case of democratic reforms in Belarus or their absence (but, for example, an increase in negative developments in the Russian economy), the activation of monetary policy tools may be required to prevent massive macroeconomic destabilization, which could have long-term negative consequences for economic growth (Ramey & Ramey, 1995; Raju & Acharya, 2020).

This study aims to assess the effectiveness of monetary policy regimes that can be considered as the basis for a monetary policy strategy in Belarus. The evaluation proposes using a macroeconomic gap model, the specification and parameterization of which reflect key characteristics of the Belarusian economy and can be adapted for economies with emerging markets.

Simulations of the impact on the Belarusian economy of shocks to both domestic and external economic conditions have been conducted based on the model. Additionally, simulation experiments were carried out in which the economy faces a set of random disturbances. Within these simulations, loss functions for flexible inflation targeting, flexible average inflation targeting, flexible price level targeting, and monetary targeting are calculated and compared. Special attention is given to the influence of capital flows restrictions and central bank credibility on the effectiveness of these regimes.

Simulation results indicate that the most effective monetary policy strategy in Belarus could be flexible price level targeting. Monetary targeting may also be an effective regime for stabilizing inflation and price level; however, this effectiveness is achieved through extremely high interest rate volatility, which may have significant nonlinear negative effects on macroeconomic and financial stability, beyond the proposed macroeconomic model. Under strict capital flow constraints, the most stabilizing regimes are flexible inflation and price level targeting.

For Belarus, the use of inflation targeting appears to be the most preferable regime. Under existing sanction restrictions and internal and external capital control measures, inflation targeting may be the most effective monetary policy strategy in the face of strong shocks to the economy. In the transformation of the Belarusian economy and political system towards inclusive political and economic institutions, considering the possibility of using price level targeting may be prudent.

The contribution of this research to the scientific literature on the issue of monetary policy regimes consists of three components. First, it explores the effectiveness of monetary policy regimes for a country with an emerging market – Belarus – unlike existing research predominantly focused on the USA, Canada, and the Eurozone. In this context, not only inflation and price level targeting regimes, but also monetary targeting, which remains relevant for emerging market countries, are investigated. The second component involves the application of a macroeconomic gap model for a country with a small, non-commodity-dependent, highly state-interventionist economy, largely isolated from global capital markets, dependent on a single economic partner, and subject to strong sanctions. The third component studies the impact of strict capital flow constraints on the effectiveness of monetary policy regimes. We are not aware of scientific works exploring this problem.

The working material is structured as follows. The macroeconomic gap model for studying the effectiveness of monetary policy regimes is presented in Section 2. Section 3 discusses the results of simulations of the impact of domestic and external shocks on the Belarusian economy and evaluates the effectiveness of monetary policy regimes. An analysis of the robustness of the results is presented in Section 4. The conclusions are drawn in Section 5.

2. Macroeconomic model for assessing the prospects of monetary policy regimes in Belarus

2.1 Structure of the baseline macroeconomic model

The baseline model is a semi-structural macroeconomic gap model (Mæhle et al., 2021). The model combines the main ideas of the New Keynesian theory regarding market imperfections and the presence of nominal and real rigidities in the economy, and the New Neoclassical Macroeconomics and Real Business Cycle theory, which include rational expectations in DSGE models.

In contrast to econometric models, semi-structural gap models have a more robust theoretical foundation, primarily based on microeconomic principles. Unlike full structural models (DSGE), semi-structural model parameters do not impose strict structural constraints, and microeconomic variables are approximated by macroeconomic indicators. Given the limited statistical data for the Belarusian economy and the presence of multiple structural shifts, estimating structural parameters is significantly challenging.

Equations define the model specification and are categorized into structural and non-structural. Structural equations have economic interpretation and are based on the reduced-form equations of a full DSGE. Structural equations are presented in deviations (gaps) of macroeconomic variables from their equilibrium levels, where equilibrium denotes a level of an economic indicator that exerts neither upward nor downward pressure on inflation (inflation corresponds to inflation expectations).

The gap model for Belarus comprises eight blocks, four of which are typical for models of countries with a small open economy (Berg et al., 2006a; 2006b; Mæhle et al., 2021), and four are specific to Belarus (Kharitonchik, 2023b).

The aggregate demand block describes the dynamics of the output gap ($\hat{y}_t$), which is the deviation of the real GDP (y_t) from its potential (equilibrium) level ($\bar{y}_t$). The output gap approximates the state of the economic cycle and is modeled according to equation (1):

$$\hat{y}_t = a_1\hat{y}_{t-1} + a_2E_t\hat{y}_{t+1} - a_3mci_{t-1} + a_4\hat{y}_t^* + a_5r\widehat{wag}e_{t-1} + a_6fi_t + \varepsilon_t^{\hat{y}}. \quad (1)$$

The key factors driving the output gap are monetary conditions (mci_t), fiscal impulse (fi_t), the gap in real wages ($r\widehat{wag}e_t$), and external demand ($\hat{y}_t^*$). Since some economic agents may make decisions based on rational expectations, the equation (1) includes the variable of expected output gap($E_t\hat{y}_{t+1}$). The inertia component ($\hat{y}_{t-1}$) is incorporated into equation (1) due to the prolonged influence of economic factors on the output gap. The demand shock ($\varepsilon_t^{\hat{y}}$) approximates the impact of factors not directly considered in the model on the output gap.

The fiscal policy and wage block determines the dynamics of consolidated budget expenditures in Belarus and wages.

The deviation of real non-interest budget expenditures[1] (rfx_t) from its equilibrium level ($\overline{rfx}$) defines the gap in budget expenditures ($\widehat{rf}x_t$). The growth of equilibrium budget expenditures and their gap are modeled as first-order autoregressive processes with exogenously determined steady state and zero mean, respectively. Due to the prolonged impact of budgetary policy on economic activity, the values of the budget expenditures gap are averaged over two quarters and used as an indicator of the fiscal impulse (fi_t).

Wages are included in the model due to the significant role of administrative influence on their size and changes in the Belarusian economy (Miksjuk et al., 2015). The assumption is made that nominal wages ($wage_t$) are rigid, their growth ($\Delta wage_t$) is modeled similar to the Phillips curve specification proposed in the work of Musil et al. (2018):

$$\Delta wage_t = aa_1E_t\Delta wage_{t+1} + (1 - aa_1) * \Delta wage_{t-1} + aa_2\hat{y}_t - aa_3\, r\widehat{wag}e_{t-1} + \varepsilon_t^{\Delta wage}. \quad (2)$$

The dynamics of wages depend on the cyclical position of the economy, approximated by the output gap. The nominal wage dynamics have a negative correlation with the gap in real wages ($\widehat{rwage}_t$): it accelerates if real wages ($rwage_t$) are below their equilibrium level ($\overline{rwage}_t$) and decelerates otherwise. Equation (2) also includes components of rational expectations ($E_t\Delta wage_{t+1}$) and persistence ($\Delta wage_{t-1}$) as explanatory factors.

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[1] The real expenditures of the consolidated budget of the public administration sector in Belarus are calculated by adjusting nominal expenditures for the GDP deflator.

Factors not directly accounted for in equation (2) are approximated by the shock of nominal wage growth ($\varepsilon_t^{\Delta wage}$).

The inflation block is represented by modified New Keynesian Phillips curves. The inflation rate (π_t) is measured by the annualized growth of the composite consumer price index, which serves as the target for the monetary policy of the National Bank of Belarus.

Inflation is divided into the core (${\pi_{core}}_t$) and non-core (${\pi_{noncore}}_t$) components. Core inflation characterizes the change in prices not subject to direct administrative regulation. It's worth noting that goods and services included in core inflation may be subject to regulatory influence through various other instruments, such as established monthly price growth limits or maximum markups for trade and importers.[2] Non-core inflation characterizes the change in administratively regulated prices and prices for fruit and vegetable products.

The connection between core and non-core inflation is established through the relative price (rp_t), which represents the ratio of the core consumer price index (${p_{core}}_t$) to the composite index (p_t). The relative price is decomposed into equilibrium ($\overline{rp}_t$) and gap ($\widehat{rp}_t$) components, and the change in the equilibrium component ($\Delta\overline{rp}_t$) is modeled as an autoregressive process with exogenously determined sustainable rate ($\Delta\overline{rp}_{ss}$).

Modeling core inflation (3) is based on the assumption of price stickiness in the short term, i.e., incomplete simultaneous transformation of costs into prices.

$$ {\pi_{core}}_t = b_1 E_t {\pi_{core}}_{t+1} + (1 - b_1 - b_2) * {\pi_{core}}_{t-1} + b_2 {\pi_{imp}}_t + b_3 rmc_t + \varepsilon_t^{\pi core}. \quad (3) $$

The dynamics of core inflation are determined by inflation expectations, which are partially rational ($E_t {\pi_{core}}_{t+1}$) and partially adaptive (${\pi_{core}}_{t-1}$), imported inflation (${\pi_{imp}}_t$), real marginal costs (rmc_t), and an inflationary shock ($\varepsilon_t^{\pi core}$), which approximates unaccounted inflationary factors in the model.

Real marginal costs (rmc_t) approximate additional costs to produce an additional unit of output and represent a combination of output gap, real wages gap, and the real effective exchange rate of the Belarusian ruble gap ($\hat{z}_t$), adjusted for the gap in relative prices (4).

$$ rmc_t = k_1 \hat{y}_t + k_2 r\widehat{wage}_t + (1 - k_1 - k_2) * (\hat{z}_t - \widehat{rp}_t). \quad (4) $$

[2] See: Resolution of the Council of Ministers of the Republic of Belarus dated October 19, 2022, No. 713 "On the System of Price Regulation".

To model non-core inflation, the specification proposed in Musil et al. (2018) is utilized. According to equation (5) the dynamics of non-core inflation is linked to rational ($E_t\pi_{noncore_{t+1}}$) and adaptive expectations ($\pi_{noncore_{t-1}}$), the gap in relative oil prices ($\widehat{rp\_oil_t}$), and the gap in the real effective exchange rate (REER), adjusted for relative prices.

$$\pi_{noncore_t} = bb_1 E_t \pi_{noncore_{t+1}} + (1 - bb_1) * \pi_{noncore_{t-1}} + bb_2 \widehat{rp_{oil}}_t + bb_3 * (\hat{z}_t + \frac{weight}{1-weight} * * \widehat{rp}_t) + \varepsilon_t^{\pi_{noncore}}. \quad (5)$$

The external trade block determines the dynamics of Belarus's trade in goods and services. The specification for trade operations follows the approach presented in Mæhle et al. (2021). The direct recording of foreign trade transactions distinguishes the current model from those presented for Belarus in the scientific literature (Demidenko, 2008; Demidenko et al., 2016; Musil et al., 2018; Bezborodova & Vlček, 2018; Mironchik et al., 2018; Kharitonchik, 2020).

The physical volumes of exports (x_t) and imports of goods and services (m_t) are decomposed into equilibrium components ($\bar{x}_t$ and $\bar{m}_t$) and gaps ($\hat{x}_t$ and $\widehat{m}_t$). The exports gap ($\hat{x}_t$) is modeled as a function of external demand, approximated by the foreign output gap ($\hat{y}_t^*$), and the REER gap ($\hat{z}_t$), characterizing the price competitiveness of Belarusian exporters, considering the persistence of the exports gap (6).

$$\hat{x}_t = c_1 \hat{x}_{t-1} + c_2 \hat{y}_t^* + c_3 \hat{z}_{t-1} + \varepsilon_t^{\hat{x}}. \quad (6)$$

The imports gap ($\widehat{m}_t$) is modeled as a function of the output gap ($\hat{y}_t$), which approximates the demand for imports, and the REER gap ($\hat{z}_t$), considering the persistence of the imports gap (7).

$$\widehat{m}_t = d_1 \widehat{m}_{t-1} + d_2 \hat{y}_t - d_3 \hat{z}_{t-1} + \varepsilon_t^{\widehat{m}}. \quad (7)$$

In addition to the physical volumes of exports and imports, trade balance is also influenced by their prices. The model considers terms of trade, which represent the ratio of export prices to import prices. Terms of trade (tot_t) are decomposed into an equilibrium component ($\overline{tot}_t$) and a gap ($\widehat{tot}_t$). The gap in terms of trade and the growth of their equilibrium component ($\Delta\overline{tot}_t$) are modeled as first-order autoregressive processes with zero mean and exogenously determined steady state, respectively.

The deviation of the foreign trade balance in goods and services from its equilibrium level ($\widehat{bop}_t$) is approximated by the gap in the physical volumes of net exports, adjusted for the gap in terms of trade (8).

$$\widehat{bop}_t = \widehat{tot}_t + \hat{x}_t - \hat{m}_t. \tag{8}$$

The exchange rate block determines the dynamics of the effective exchange rate of the Belarusian ruble (9).

The nominal effective exchange rate of the Belarusian ruble (NEER; s_t) is modeled as a combination of the rate obtained from a modified version of the uncovered interest rate parity condition (s_t^{uip}) and the rate corresponding to the state of external trade, taking into account the mechanism of currency interventions by the National Bank (s_t^{bop}).

$$s_t = (1 - h_1) * s_t^{uip} + h_1 s_t^{bop} + \varepsilon_t^s. \tag{9}$$

The specification of equation (9) differs from the canonical one and those presented earlier in models for Belarus due to the consideration of the state of external trade. The inclusion of the external trade factor is associated with the deepening isolation of Belarus's financial sector and the potential difficulty of arbitrage in financial markets after February 2022, when key sectors of the Belarusian industry and the financial sector were subjected to sanctions by the United States, the European Union, the United Kingdom, and several other countries.

The exchange rate (s_t^{uip}), derived from a modified version of the uncovered interest rate parity condition (10), is determined by expectations of the exchange rate in the upcoming period ($E_t s_{t+1}$) and the differential between nominal interest rates in the money market in Belarus (i_t) and abroad (i_t^*), adjusted for the risk premium for investments in assets denominated in Belarusian rubles ($prem_t$).[3]

$$s_t^{uip} = E_t s_{t+1} + \frac{i_t^* - i_t + prem_t}{4}. \tag{10}$$

The exchange rate (s_t^{bop}), corresponding to the state of external trade (11), is determined by the deviation of the trade balance from its equilibrium level, considering the smoothing of exchange rate dynamics by the National Bank through currency interventions. The latter is approximated by adding the trend change in the NEER ($\Delta\bar{s}_t$) to equation (11), calculated as the sum of the

[3] Expectations of the NEER have two components: rational (s_{t+1}) and adaptive (s_{t+1}^{nf}). The inclusion of adaptive expectations allows for the inertia of exchange rate dynamics observed in historical data, as well as the influence of National Bank interventions on exchange rate formation. It is assumed that adaptive expectations are formed through a naïve forecast. This means that economic agents have an idea of the trend change in the exchange rate and use these estimates to extrapolate the level of the exchange rate.

inflation targets differential in Belarus (π_t^T) and trading partner countries (π_{ss}^*), and the equilibrium change in the real effective exchange rate of the Belarusian ruble ($\Delta\bar{z}_t$).

$$s_t^{bop} = s_{t-1} + \frac{\Delta\bar{s}_t}{4} - h_2\widehat{bop}_t. \quad (11)$$

The reaction function of monetary policy in the baseline model is represented by a modified Taylor rule for flexible inflation targeting (12). The National Bank of Belarus declares the use of a monetary targeting regime in Belarus. However, the results of the study by A. Kharitonchik (2023b) show that monetary targeting was applied in 2015 – the first half of 2016. From mid-2016 to mid-2020, the National Bank used the interbank market rate as the operational target for monetary policy, and its dynamics during this period were quite accurately described by the Taylor rule for flexible inflation targeting. From mid-2020, the National Bank has implemented discretionary monetary policy, but since the beginning of 2024, measures have been announced for a gradual restoration of rules in the implementation of monetary policy.[4]

$$i_t = mm_1 i_{t-1} + (1 - mm_1) * (\bar{r}_t + E_t\pi_{t+4}^4 + mm_2 * (E_t\pi_{t+3}^4 - \pi_{t+3}^T) + mm_3\hat{y}_t) + \varepsilon_t^i. \quad (12)$$

The overnight ruble interbank market loans interest rate (i_t) is calculated by adding to the neutral interest rate ($\bar{r}_t + E_t\pi_{t+4}^4$) a premium determined based on the expected deviation of inflation from the target ($E_t\pi_{t+3}^4 - \pi_{t+3}^T$) and the position of the economy in the business cycle, approximated by the output gap ($\hat{y}_t$). The lagged component (i_{t-1}) ensures the smoothing of the rate dynamics, reflecting the central banks' tendency to avoid excessive volatility in rates when applying an inflation targeting regime in practice. The shock (ε_t^i) takes into account the central bank's discretionary actions.

The block of interest rates on the credit and deposit market determines the behavior of interest rates on new time deposits and new market loans for organizations and the population in Belarusian rubles. Accounting for these rates allows for a more comprehensive approximation of the monetary conditions compared to gap models presented in the literature for Belarus.

The model assumes that changes in the interbank market loans rate (IBL) are transmitted to the loans interest rates following a pattern identified in the research of A. Kharitonchik (2019): The response of the average interest rate on ruble-denominated market loans to the population and organizations (i_l_t) to changes in the IBL rate in Belarus is incomplete and reaches its maximum value within two quarters after the shock. The average

[4] See: https://www.nbrb.by/press/15849.

rate on new ruble time deposits for individuals and organizations (i_d_t) is modeled similarly based on econometric analysis results (Kharitonchik, 2022).

Ultimately, monetary conditions (mci_t) approximate the impact of monetary and exchange rate policy measures on economic activity through two primary channels of the transmission mechanism: the interest rate and the exchange rate (13):

$$mci_t = m_1 * (m_2\hat{r}_t + m_3\widehat{r\_l}_t + (1 - m_2 - m_3) * \widehat{r\_d}_t) - (1 - m_1) * \hat{z}_t. \tag{13}$$

Monetary conditions are a weighted combination of interest rate and REER components. The interest rate component characterizes the state of the interest rate policy of the National Bank and banks. It is calculated as the weighted average of the gaps in real interest rates on assets in Belarusian rubles: the overnight ruble interbank market ($\hat{r}_t$), new market loans ($\widehat{r\_l}_t$) and new time deposits ($\widehat{r\_d}_t$). The REER gap ($\hat{z}_t$) approximates the intra-temporal substitution between imported and non-imported goods and the price competitiveness of Belarusian producers.

The external sector block describes the dynamics of output gap, inflation, money market interest rates, and exchange rates in Belarus's trading partner countries, as well as oil prices. External variables for the output gap ($\hat{y}_t^*$), inflation (π_t^*), and nominal interest rate (i_t^*) are effective, meaning they are weighted averages considering the significance of the economic partner. Belarus's economic partners in the model include Russia, the EU (Eurozone for inflation and interest rate), China, and the USA, approximating the rest of the world.

Equations governing the dynamics of external sector variables for individual countries are not structural but presented as autoregressive processes with exogenously determined steady states. The estimation of unobservable components in external variables is carried out using univariate filters with expert judgments, and the transformed data are directly introduced into the model.[5]

2.2 Calibration of parameters of the baseline macroeconomic model

The model parameters were calibrated to account for stylized facts of the Belarusian economy, considering changes in its functioning after 2022, such as increased financial sector isolation, shifts in trade flows towards Russia, and changes in monetary and exchange rate policies (Table 1).[6] As noted in Mæhle et al. (2021), parameters in gap models developed with the support of the IMF are typically calibrated rather than estimated.

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[5] The complete structure of the model is presented in Appendix A.

[6] The values of model parameters are presented in Appendix A.

During calibration, recommendations for emerging market countries (Berg et al., 2006a; 2006b), values from other studies, and expert judgments were considered. The calibration was based on the period from 2013 onwards, as this period vividly revealed structural imbalances in the Belarusian economy and witnessed changes in monetary policy and exchange rate regimes.

Table 1: Values of key model parameters

Parameter	Value	Parameter	Value
Output gap		**Core inflation**	
a_1	0.55	b_1	0.35
a_2	0.05	b_2	0.09
a_3	0.20	b_3	0.20
a_4	0.35	**Real marginal costs**	
a_5	0.10	k_1	0.45
a_6	0.15	k_2	0.25
Wages		**Non-core inflation**	
aa_1	0.55	bb_1	0.60
aa_2	0.40	bb_2	0.05
aa_3	0.25	bb_3	0.10
Exports		**Imports**	
c_1	0.45	d_1	0.40
c_2	0.45	d_2	1.00
c_3	0.25	d_3	0.10
Exchange rate		**Monetary policy reaction function**	
h_1	0.30	mm_1	0.60
h_2	0.90	mm_3	0.55
Monetary conditions		mm_2	0.30
m_1	0.50		
m_2	0.15		
m_3	0.35		

Source: author's calculations.

To assess the realism of parameters calibration, the methods proposed in Mæhle et al. (2021) were employed, including: 1) economic consistency demonstrated by impulse response functions; 2) ability of the model to explain historical dynamics of macroeconomic variables (based on Kalman smoothing); 3) accuracy of forecasting on historical data (in-sample simulations); 4) parameters calibration verification via Bayesian estimation. In latter case, the correctness of the calibration of coefficients in equations determining the dynamic properties of the model was examined.[7] The impulse response functions to basic macroeconomic shocks, presented in Appendix B, align with economic intuition and account for changes in the operating conditions of the Belarusian economy after February 2022. The accuracy of forecasting key macroeconomic indicators for Belarus on historical data within the developed model is higher compared to random walk models (Appendix C).

2.3 Monetary policy reaction functions in alternative regimes

The baseline model specification assumes the implementation of a flexible inflation targeting regime by the National Bank: the central bank responds with the interest rate to the expected deviation of inflation from the target and smoothens fluctuations in the economic cycle (14). Such a strategy does not include historical dependence: the National Bank does not seek to compensate for previous deviations of inflation from the target.

$$i_t = mm_1 i_{t-1} + (1 - mm_1) * (\bar{r}_t + E_t\pi^4_{t+4} + mm_2 * (E_t\pi^4_{t+3} - E_t\pi^T_{t+3}) + mm_3\hat{y}_t) + \varepsilon^i_t. \quad (14)$$

Flexible price level targeting implies stabilizing the price level (p_t) near the target level of prices (p^T_t), as opposed to stabilizing inflation near the target level in the inflation targeting regime. The monetary policy reaction function takes the form of (15) and assumes that the central bank seeks to compensate for previous deviations of inflation from the target to return the price level to the targeted trajectory.

$$i_t = mm_1 i_{t-1} + (1 - mm_1) * (\bar{r}_t + E_t\pi^4_{t+4} + mm_2 * (E_t p_{t+3} - E_t p^T_{t+3}) + mm_3\hat{y}_t) + \varepsilon^i_t. \quad (15)$$

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[7] Parameters characterizing the impact of economic policy on the economy and determining the dynamics of the central bank interest rate and exchange rate were estimated for the period from the first quarter of 2017 to the fourth quarter of 2021. Other parameters were estimated for the period from the first quarter of 2013 to the fourth quarter of 2021. The differences in the estimation periods are related to the change in monetary and exchange rate regimes in 2015, as well as adjustments to the implementation of fiscal policy and wages policy in Belarus in 2015–2016. Since the Belarusian economy faced a powerful sanction shock in the first quarter of 2022, the estimation period is limited to the fourth quarter of 2021. Economic indicators of Belarus and its economic partners with quarterly periodicity were used as initial data for the estimation. A Kalman filter was used to estimate unobservable components for the period from the first quarter of 2003 to the fourth quarter of 2021. The estimation of unobservable variables before 2015 is challenging given the current model specification because Belarus applied a fixed exchange rate regime until that year. Therefore, expert judgments were incorporated into the Kalman filtering process: the REER gap in the first quarter of 2005 was assumed to be zero, and in the first quarter of 2011, it was assumed to be minus five percent. The relative price gap was assumed to be zero in the second quarter of 2005 and the second quarter of 2019.

The price-level target corresponds to the dynamics of prices that increase at a constant rate π_t^T, corresponding to a sustainable inflation rate (16).

$$p_t^T = p_{t-1}^T + \frac{\pi_t^T}{4}. \tag{16}$$

Flexible average inflation targeting has limited historical dependence. The central bank aims to compensate for the deviation of inflation from the target over N years to return the average inflation over N years to the target level (17). At the end of N years, the observation remains outside the averaging period and becomes irrelevant – past deviations from the target are partially compensated. As a result, the monetary policy reaction function takes the form (18).

$$\bar{\pi}_t^4 = \sum_{j=-4N+1}^{0} \pi_{t+j}^4. \tag{17}$$

$$i_t = mm_1 i_{t-1} + (1 - mm_1) * (\bar{r}_t + E_t\pi_{t+4}^4 + mm_2 * (E_t\bar{\pi}_{t+3}^4 - E_t\bar{\pi}_{t+3}^T) + mm_3\hat{y}_t) + \varepsilon_t^i. \tag{18}$$

Within the simulations, two specifications of the average inflation targeting regime are applied, differing in the number of periods for averaging: two and three years, respectively. A two-year averaging period was used in the study by Bussetti et al. (2021) for the Eurozone, and a three-year period in the study by Wagner et al. (2022) for Canada. In the simulations, the parameters in the reaction functions (14, 15, 18) remain the same for all monetary policy regimes.

Monetary targeting regime assumes that the central bank, to achieve the inflation target, seeks to maintain the money supply at the intermediate target level. The interest rate on the money market becomes endogenous and settles at a level that balances the money supply and demand given the intermediate money supply target.

Nominal money (nm_t) is an observable variable – a broad aggregate of the money supply. Real money (rm_t) is calculated by adjusting the nominal money by the consumer price index (p_t).

The economy's demand for real money balances (19–20) is represented by the real money demand function based on real GDP (y_t), the equilibrium velocity of money ($\bar{v}_t$) and the deviation of the nominal interest rate from its neutral level (nominal interest rate gap; $\hat{\imath}_t$).

$$\widehat{rm}_t = rm_t - (y_t - md_1\hat{\imath}_t - \bar{v}_t). \tag{19}$$

$$\Delta rm_t = \Delta y_t - md_1\Delta\hat{\imath}_t - \Delta\bar{v}_t - md_2\widehat{rm}_{t-1} + \varepsilon_t^{\Delta rm}. \tag{20}$$

The variable of real GDP approximates the scale of transactions in the economy. The demand for money increases with an increase in real GDP and decreases with a decrease in real GDP, with a coefficient equal to 1.00 in both cases.

The equilibrium velocity of money characterizes stable changes in money demand, which may be related to technological innovations and/or prolonged and inertial changes in the degree the National Bank credibility. The velocity of money has a negative correlation with money demand with a value equal to 1.00.

The nominal interest rate gap acts as a factor explaining the fluctuations in the cyclical component of the velocity of money and can approximate the speculative motive for holding money and/or short-term fluctuations in the National Bank credibility. A negative correlation between the nominal interest rate gap and money demand is assumed. Parameter md_1 characterizes the semi-elasticity of money demand to the interest rate, and its value is calibrated at 0.105 according to the results of the study by I. Pelipas & I. Tochitskaya (2023).

At any given point in time, the observed demand for money may deviate from the "desired" (or long-term) level determined by the factors mentioned above. Therefore, the equation (20) includes the variable $\widehat{rm}_{t-1}$. Temporary deviations of money demand from the long-term level are caused by short-term liquidity shocks, which are approximated by the shock $\varepsilon_t^{\Delta rm}$ in equation (20). The speed of adjustment of money demand to the long-term level is determined by the parameter md_2, assumed to be 0.60 (Musil et al., 2018).

It is assumed that the dynamics of money supply correspond to the intermediate target of the National Bank (Δnm_t^T). The intermediate target is set according to equation (21) as a function of changes in potential GDP ($\Delta \bar{y}_t$) and the equilibrium velocity of money ($\Delta \bar{v}_t$), the inflation target (π_t^T), and a shock $\left(\varepsilon_t^{\Delta nm^T}\right)$, where the discretionary actions of the National Bank are approximated. This specification of the intermediate money supply target assumes that monetary policy will automatically loosen or tighten when the economic system deviates from the equilibria.

$$\Delta nm_t^T = \pi_t^T + \Delta \bar{y}_t - \Delta \bar{v}_t + \varepsilon_t^{\Delta nm^T}. \tag{21}$$

Monetary targeting assumes that the National Bank supports the money supply at an intermediate target level. As a result, the interest rate on the money market i_t^{MT}, which balances the demand and supply of money at the intermediate target level, is determined by equation (22).

$$\Delta nm_t^T = \pi_t + \Delta y_t - md_1 * ((i_t^{MT} - \bar{\iota}_t) - \hat{\iota}_{t-1}) - \Delta\bar{v}_t - md_2\widehat{rm}_{t-1} + \varepsilon_t^{\Delta rm}. \quad (22)$$

2.4 *Modeling the National Bank credibility and capital flow restrictions*

Central bank credibility plays a crucial role in anchoring inflation expectations. With low level of credibility, the significance of rational expectations may decrease, and inflation expectations become more adaptive (Argov et al., 2007; Alichi et al., 2009). To account for this assumption, inflation expectations $E_t\pi_{core_{t+1}}$ are modeled as a function of both rational expectations ($\pi_{core_{t+1}}$) and adaptive expectations ($\pi_{core_{t-1}}$) according to equation (23).

$$E_t\pi_{core_{t+1}} = cr_t\pi_{core_{t+1}} + (1 - cr_t) * \pi_{core_{t-1}}. \quad (23)$$

The weight on rational expectations is determined by the variable cr_t, which approximates the degree of credibility in the central bank and takes values from zero (no credibility) to one (full credibility).

Central bank credibility (24) is influenced by the signaling variable sig_t. The signaling variable is modeled according to equation (25) as the deviation of the actual value of the targeted monetary policy indicator from its targeted level ($\pi_t^{4,dev}$).[8]

The process of building trust in the central bank is prolonged. Therefore, the value of the parameter a_1^{cr} is calibrated to be 0.95. In Belarus, inflation has often exceeded the targeted benchmarks throughout most of its history. Hence, it is assumed that deviations of the targeted monetary policy indicator below the target will not lead to a reduction in trust in monetary policy (26–27).

$$cr_t = a_1^{cr}cr_{t-1} + (1 - a_1^{cr}) * sig_t + \varepsilon_t^{cr}. \quad (24)$$

$$sig_t = e^{-(\pi_{t-1}^{4,dev})^2}. \quad (25)$$

$$\pi_t^{4,dev^{un}} = \pi_t^4 - \pi_t^T. \quad (26)$$

$$\pi_t^{4,dev} = \max\{0, \pi_t^{4,dev^{un}}\}. \quad (27)$$

In the **absence of free capital flows**, the exchange rate becomes insensitive to changes in interest rates. The value of the national currency, under total capital flows

[8] Equation (26) is presented for inflation targeting and monetary targeting regimes. In the price level and average inflation targeting regimes, the target indicator is the price level and average inflation over N years, respectively.

restrictions, will be determined by the state of foreign trade and the mechanism of currency interventions by the central bank. Therefore, modeling scenarios of complete capital restrictions involve increasing the value of the parameter h_1 in equation (9) from 0.30 to 1.00. The parameters in the reaction functions of the central bank remain unchanged because, under capital flows restrictions, the central bank still has the ability to implement independent monetary policy.

3. Efficiency of Monetary Policy Regimes in Scenario Simulations

3.1 Design of simulations

For the evaluation of the effectiveness of monetary policy regimes, simulations are implemented for two types of strong macroeconomic shocks in scenarios deemed realistic.

In the first case, a scenario of a sharp deterioration in domestic economic conditions is simulated. The calibration for this scenario is based on the actual dynamics of Belarus's macroeconomic indicators in the first and second quarters of 2022, when the Belarusian economy faced a powerful negative sanctions shock. In the initial simulation period, negative gaps are introduced in output, physical volumes of exports and imports amounting to 6.7%, 13.5%, and 21.9%, respectively. The Belarusian ruble weakens by 8.9% in terms of the nominal effective exchange rate, and there is an increase in the annualized quarterly core inflation by 21.9 percentage points.

The second scenario envisions a sharp deterioration in economic conditions in Russia, to which the dependence of the Belarusian economy has increased in 2022-2023. The calibration for this scenario is based on the dynamics of Russia's macroeconomic indicators in the fourth quarter of 2014 to the second quarter of 2015 when the Russian economy experienced a sharp decline in output, coupled with the devaluation of the national currency and a spike in inflation. The simulation incorporates the formation of a negative output gap in Russia of 2.3% in the first period, expanding by 0.8 percentage points in the second period. Additionally, there is an increase in the annualized quarterly inflation rate in Russia by 10 percentage points in the first period and an additional 8.4 percentage points in the second period. The MBK rate in Russia is raised by 4.1 percentage points in the first period and an additional 4.4 percentage points in the second period. Furthermore, there is an increase in the risk premium for investments in assets denominated in Belarusian rubles by 5.3 percentage points in the first period.

Both scenarios for each monetary policy regime are simulated three times: within the framework of the baseline model specification, for the model specification with capital flows restrictions, and for the model specification with low central bank credibility. In the latter case, the value of the variable cr_t during the shock period is set to minus one. In all simulations, the economic system is in a steady state until the shock occurs, and the shock itself is unexpected – economic agents have no information about the shock until its occurrence.

3.2 Criterion for the effectiveness of monetary policy regimes

As a criterion for the effectiveness of alternative monetary policy strategies, a quadratic loss function (28) is employed:

$$L_t = 0.5(\pi_t^4 - \pi_t^T)^2 + 0.5(p_t - p_t^T)^2 + \lambda \hat{y}_t^{\,2} + \gamma(i_t - i_{t-1})^2. \quad (28)$$

The quadratic functional form aligns with the academic literature (Woodford, 2003; Svensson, 2020) and assumes that the central bank perceives large deviations in macroeconomic variables as much costlier compared to their small volatility.

The challenge in comparing the effectiveness of monetary policy regimes lies in the fact that the loss functions for each are specific due to different target variables (таблица 2). Therefore, the use of an ad-hoc loss function (Busetti et al., 2021), assuming the inclusion of variations in inflation and output, appears debatable. To overcome this issue in this study, the loss function takes into account not only the inflation indicator but also the price level. As a result, the optimal monetary policy involves minimizing losses, approximated by a weighted sum of squared variations in the price dynamics indicator (the average between deviations of year-on-year inflation (π_t^4) and the price level (p_t) from their stable values), the output indicator's variation (deviation of GDP from the equilibrium level – output gap ($\hat{y}_t$)) and the nominal money market interest rate's variation (change in the interest rate (i_t) compared to its value in the previous period).

Using the average of deviations in year-on-year inflation and the price level from their stable values as the price dynamics indicator allows for accounting for differences in the loss functions specific to monetary policy regimes. It also considers the fact that for economic agents, additional costs are associated with both prolonged changes in the overall price level in the economy and their short-term fluctuations. Year-on-year inflation serves as the ultimate target in the inflation targeting and monetary targeting regimes, while the price level is targeted in the price level targeting regime. The average inflation targeting regime assumes limited historical dependence, making it an intermediate case between inflation targeting and price level targeting.

Table 2: Loss functions specific to monetary policy regimes

Monetary policy regime	Loss function specification
Flexible inflation targeting and monetary targeting	$L_t^{FIT/MT} = (\pi_t^4 - \pi_t^T)^2 + \lambda \hat{y}_t^{\,2} + \gamma(i_t - i_{t-1})^2$
Flexible average inflation targeting	$L_t^{AIT} = (\bar{\pi}_t^4 - \bar{\pi}_t^T)^2 + \lambda \hat{y}_t^{\,2} + \gamma(i_t - i_{t-1})^2$
Flexible price level targeting	$L_t^{PLT} = (p_t - p_t^T)^2 + \lambda \hat{y}_t^{\,2} + \gamma(i_t - i_{t-1})^2$

Source: author's development.

Including the interest rate in the loss function aims to account for the adverse consequences of rate volatility for economic agents, especially the potential negative effects of abrupt and substantial changes on financial and macroeconomic stability (Woodford, 2003; Alstadheim, Røisland, 2017; Dorich et al., 2021; Wagner et. al., 2022). In the studies of Dorich et al. (2021) and Wagner et. al. (2022) for Canada, the parameter γ is calibrated to 0.50, in Alichi et al. (2015) for the United States, it is also 0.50, and in Evjen et al. (2012) for Norway, it is 0.25. The significance of interest rate volatility for emerging market economies appears ambiguous. On the one hand, the γ parameter might be lower compared to developed countries due to economic agents adapting to higher historical interest rate variability. On the other hand, the resilience of emerging market economies to shocks may be much weaker compared to developed countries, potentially causing negative nonlinear effects of increased rate volatility on macroeconomic and financial stability. Additionally, the level of central bank credibility in emerging market countries may be lower compared to developed countries, and high interest rate volatility may not contribute to strengthening its signaling function and gaining trust in the central bank. Taking these considerations into account, this study applied a set of $\gamma = [0.25; 0.50; 0.75]$ when calculating loss functions. In accordance with Busetti et al. (2021), the parameter λ, determining the significance of the output gap in the loss function, is set to 0.50.

The resulting indicator is the average value of the loss function over twelve consecutive periods from the shock impact. This corresponds to a three-year time horizon, which is relevant for monetary policy. Monetary policy does not have a direct impact on long-term economic growth and other equilibrium macroeconomic variables, the dynamics of which are determined by structural factors. Therefore, considering time horizons beyond the medium term is less relevant for assessing the effectiveness of monetary policy regimes.

3.3 Results of simulation of a scenario of worsening domestic economic conditions

Table 3 presents the standard deviations of the output gap $\sigma(\hat{y})$, year-on-year inflation $\sigma(\pi^4)$, price level $\sigma(p)$, and changes in the nominal interest rate $\sigma(\Delta i)$, as well as the resulting values of the loss function (L) within the simulation of the scenario of a sharp deterioration in domestic economic conditions based on the baseline model specification for different monetary policy regimes.[9]

Table 3: Simulation results of a scenario of worsening domestic economic conditions: baseline model specification

Indicator	**Monetary policy regime**				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	2.8	2.9	2.8	3.2	3.5
$\sigma(\pi^4)$	5.0	5.1	5.2	5.3	4.4
$\sigma(p)$	8.5	7.7	8.1	6.5	5.3
$\sigma(\Delta i)$	1.2	0.8	0.7	1.1	12.1
$L(\gamma = 0.25)$	52.8	47.5	50.8	40.7	66.3
$L(\gamma = 0.50)$	53.2	47.7	50.9	41.0	103.0
$L(\gamma = 0.75)$	53.6	47.8	51.1	41.3	139.7

Source: author's calculations.

Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

The application of the flexible price level targeting ensures the lowest losses in the scenario of deteriorating domestic economic conditions. This is attributed to the much smaller deviation of the price level from the target level in this regime compared to the alternatives. The monetary targeting regime can achieve even lower volatility in prices and inflation compared to flexible price level targeting. However, this is achieved through extremely high interest rate volatility and, consequently, an increase in output volatility (Figure 1). Therefore, losses increase significantly when employing monetary targeting if the strong volatility of the interest rate has negative consequences for the economy.

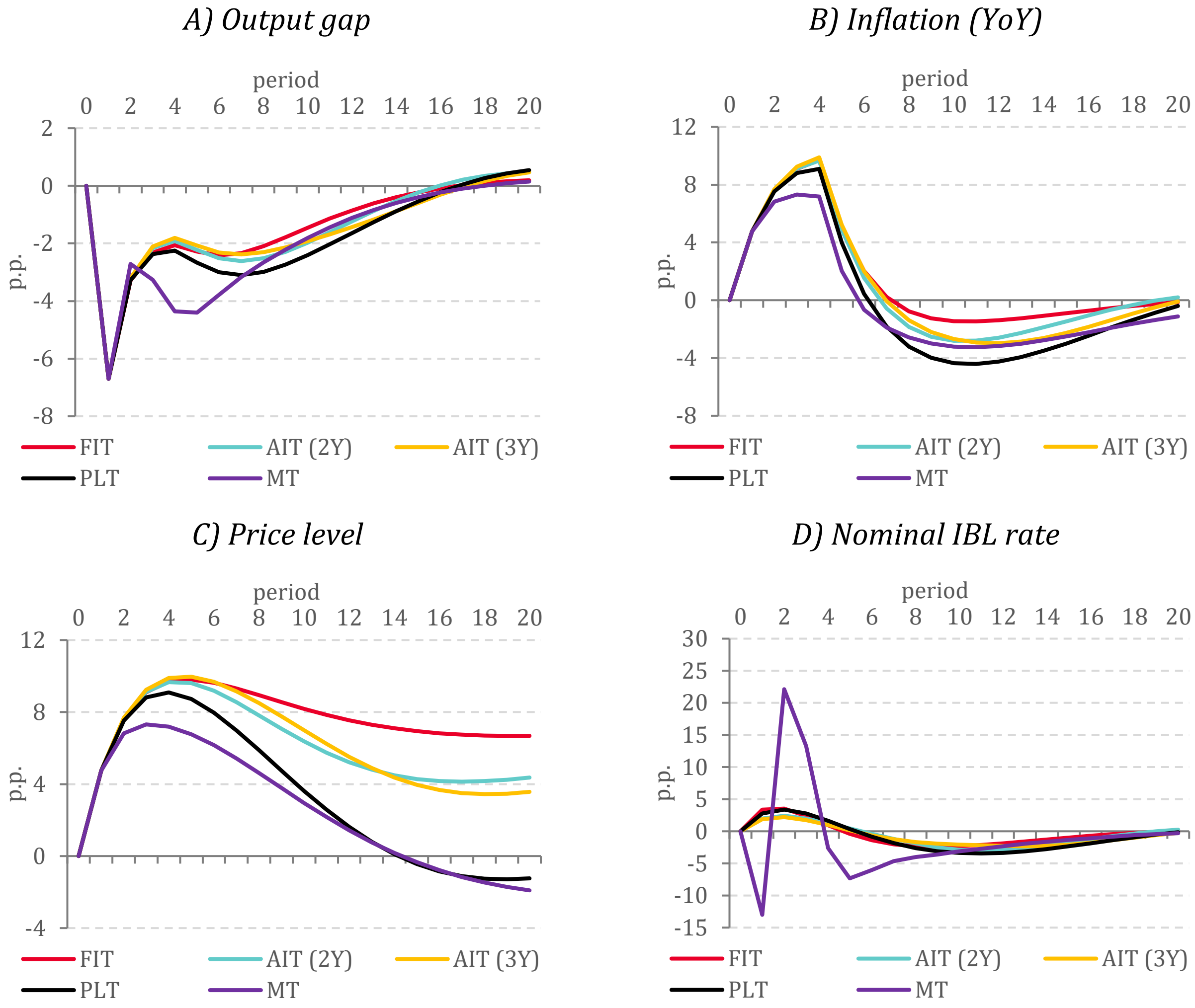
The flexible inflation targeting regime provides the lowest output volatility and lower inflation volatility compared to regimes of flexible average inflation

[9] Standard deviations are calculated for the deviations of variables from their steady-state levels.

targeting and price level targeting (Figure 1). However, since there is no historical dependence in inflation targeting, deviations in the price level become constant and increase total losses.

The application of flexible average inflation targeting allows achieving the lowest interest rate volatility, but it lags behind the flexible price level targeting regime in the ability to return prices to an equilibrium trajectory. Additionally, averaging inflation over a two-year horizon results in lower losses compared to averaging over a three-year period.

Figure 1: Reaction of macroeconomic indicators to the shock of deterioration in domestic economic conditions: baseline model specification



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

In the absence of trust in the central bank during the shock impact period, losses significantly increase (Table 4). This is due to the increased inertia of inflation, requiring a more significant and prolonged increase in the central bank's interest rate to bring inflation (or the price level) back to the target level (Figure 2).

Table 4: Simulation results of a scenario of worsening domestic economic conditions: low National Bank credibility

Indicator	**Monetary policy regime**				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	4.8	5.0	4.8	6.2	5.6
$\sigma(\pi^4)$	7.1	7.2	7.4	7.2	5.8
$\sigma(p)$	14.0	13.6	14.2	11.4	10.2
$\sigma(\Delta i)$	2.4	1.9	1.7	2.5	14.3
$L(\gamma = 0.25)$	135.5	132.2	139.4	111.5	135.9
$L(\gamma = 0.50)$	137.0	133.1	140.2	113.0	187.1
$L(\gamma = 0.75)$	138.4	134.0	140.9	114.6	238.4

Source: author's calculations.

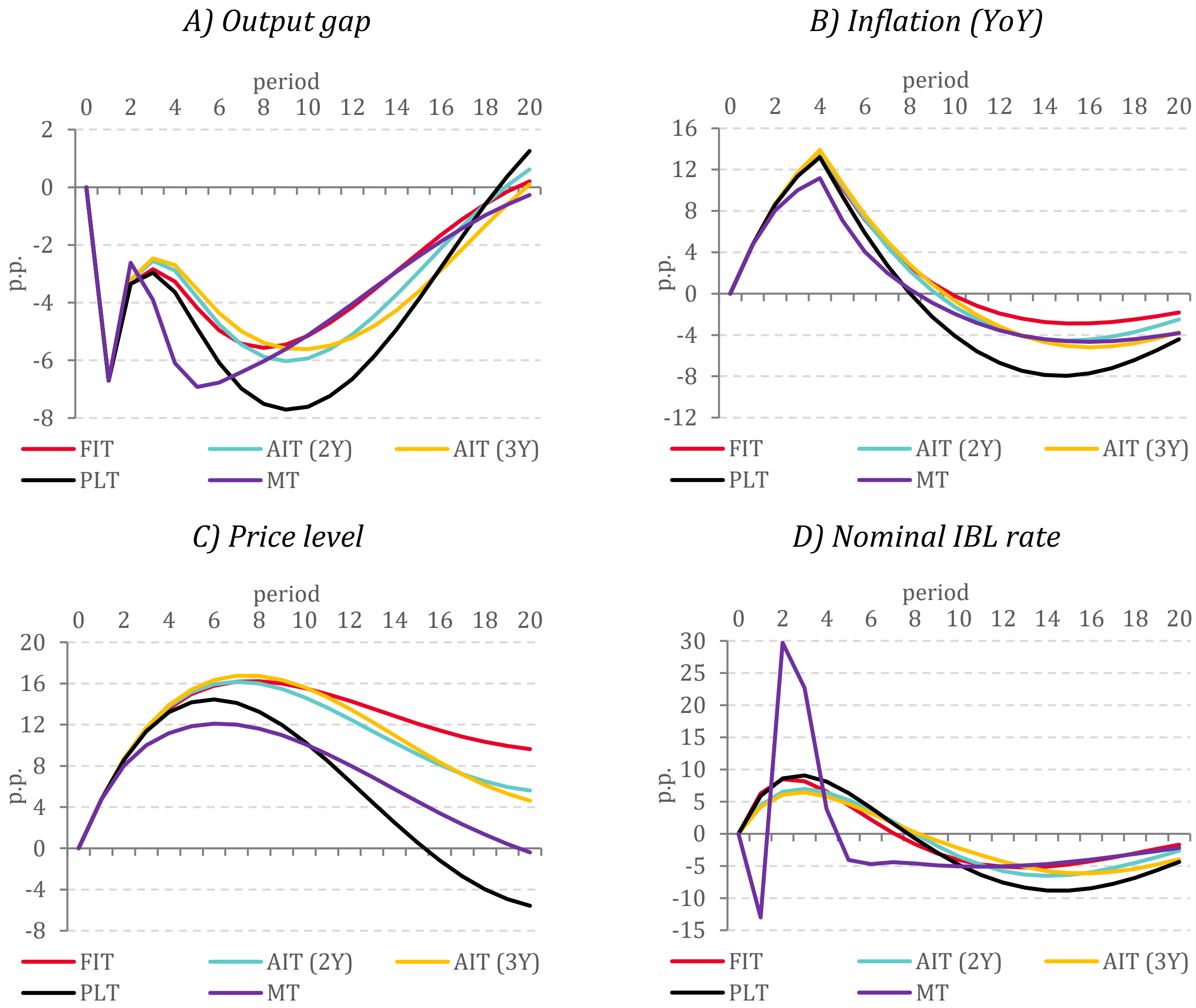
Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

The conclusions regarding the effectiveness of monetary policy regimes in the case of low central bank credibility generally remain consistent. The lowest losses are estimated for the flexible price level targeting strategy (Table 4). Monetary targeting can provide stabilization of inflation and the price level, but at the cost of extremely high interest rate volatility (Figure 2).

In the case of low trust in the central bank and the application of the flexible average inflation targeting regime, it is optimal to use a shorter period of inflation averaging. Losses in a two-year averaging period are lower compared to a three-year period. In the latter case, flexible average inflation targeting is less effective than flexible inflation targeting (Table 4).

Flexible inflation targeting, as in simulations for the baseline model specification, can provide the lowest output volatility in response to a sharp deterioration in domestic economic conditions and relatively low inflation volatility. However, the price level shift remains constant, increasing losses when this regime is applied.

Figure 2: Reaction of macroeconomic indicators to the shock of deterioration in domestic economic conditions: low National Bank credibility



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Under strict capital flows restrictions, the most effective response to a sharp deterioration in domestic economic conditions is the flexible inflation targeting regime (Table 5). Strict capital controls are de facto equivalent to the active use of currency interventions by the central bank to smooth excess volatility in the exchange rate due to fluctuations in external trade. As a result, the deviation of the price level from the equilibrium trajectory is less significant in this simulation compared to the baseline model specification. Consequently, the ability of inflation targeting to effectively stabilize output, inflation, and interest rates makes losses in this regime the lowest (Figure 3).

Table 5: Simulation results of a scenario of worsening domestic economic conditions: strict restrictions on capital flows

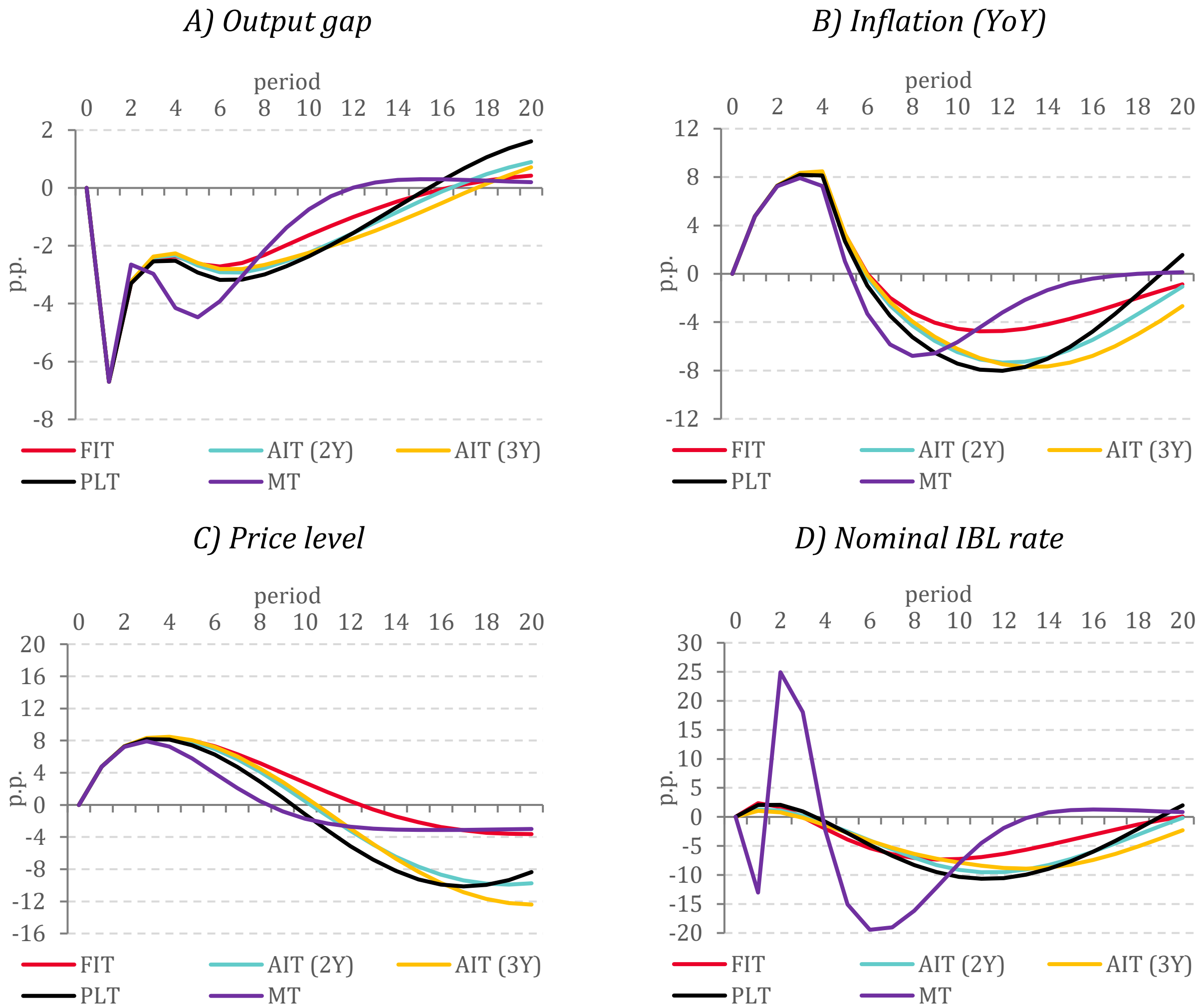
Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	2.9	3.1	3.1	3.2	3.3
$\sigma(\pi^4)$	5.2	6.0	5.9	6.3	5.7
$\sigma(p)$	6.0	5.7	5.8	5.6	4.7
$\sigma(\Delta i)$	1.3	1.1	1.0	1.4	13.9
$L(\gamma = 0.25)$	35.9	39.3	39.5	41.3	80.6
$L(\gamma = 0.50)$	36.3	39.6	39.7	41.8	128.8
$L(\gamma = 0.75)$	36.8	40.0	40.0	42.3	177.0

Source: author's calculations.

Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Overall, losses in response to a sharp deterioration in domestic economic conditions are significantly lower under strict capital flow restrictions. This can be explained by the lower volatility of the exchange rate and its faster stabilization after a sharp depreciation during the shock period. From a model perspective, strict capital flow restrictions can also be interpreted as the active use of currency interventions by the central bank to smooth exchange rate volatility. Simulation results indicate that during sharp exchange rate adjustments, the use of currency interventions may be justified to counteract the rapid increase in devaluation and inflation expectations, which could negatively impact financial stability. However, currency interventions should be employed only to smooth volatility and should not oppose the formation of exchange rate dynamics consistent with its equilibrium trajectory in the medium term.

Figure 3: Reaction of macroeconomic indicators to the shock of deterioration in domestic economic conditions: strict restrictions on capital flows



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

3.4 Results of simulation of a scenario of worsening external economic conditions

When facing a negative external shock to the Belarusian economy, the monetary targeting regime demonstrates the greatest stabilization capacity (Table 6). However, similar to the shock of deteriorating domestic economic conditions, the stabilization of inflation and the price level in the monetary targeting regime is achieved through extremely high volatility of the interest rate (Figure 4). The required variability of the interest rate may generate nonlinear negative effects for the economy that are beyond the scope of the proposed macroeconomic model. In the context of emerging market economies, such effects may include surges in inflationary and devaluation expectations, which could have adverse effects on financial and macroeconomic stability.

Table 6: Simulation results of a scenario of worsening external economic conditions: baseline model specification

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	0.4	0.4	0.5	0.4	0.4
$\sigma(\pi^4)$	2.1	2.3	2.5	1.9	1.1
$\sigma(p)$	4.4	4.8	5.1	3.5	1.5
$\sigma(\Delta i)$	0.7	0.6	0.6	0.7	1.7
$L(\gamma = 0.25)$	12.3	14.2	16.2	8.0	2.6
$L(\gamma = 0.50)$	12.5	14.3	16.3	8.1	3.3
$L(\gamma = 0.75)$	12.6	14.4	16.4	8.3	4.1

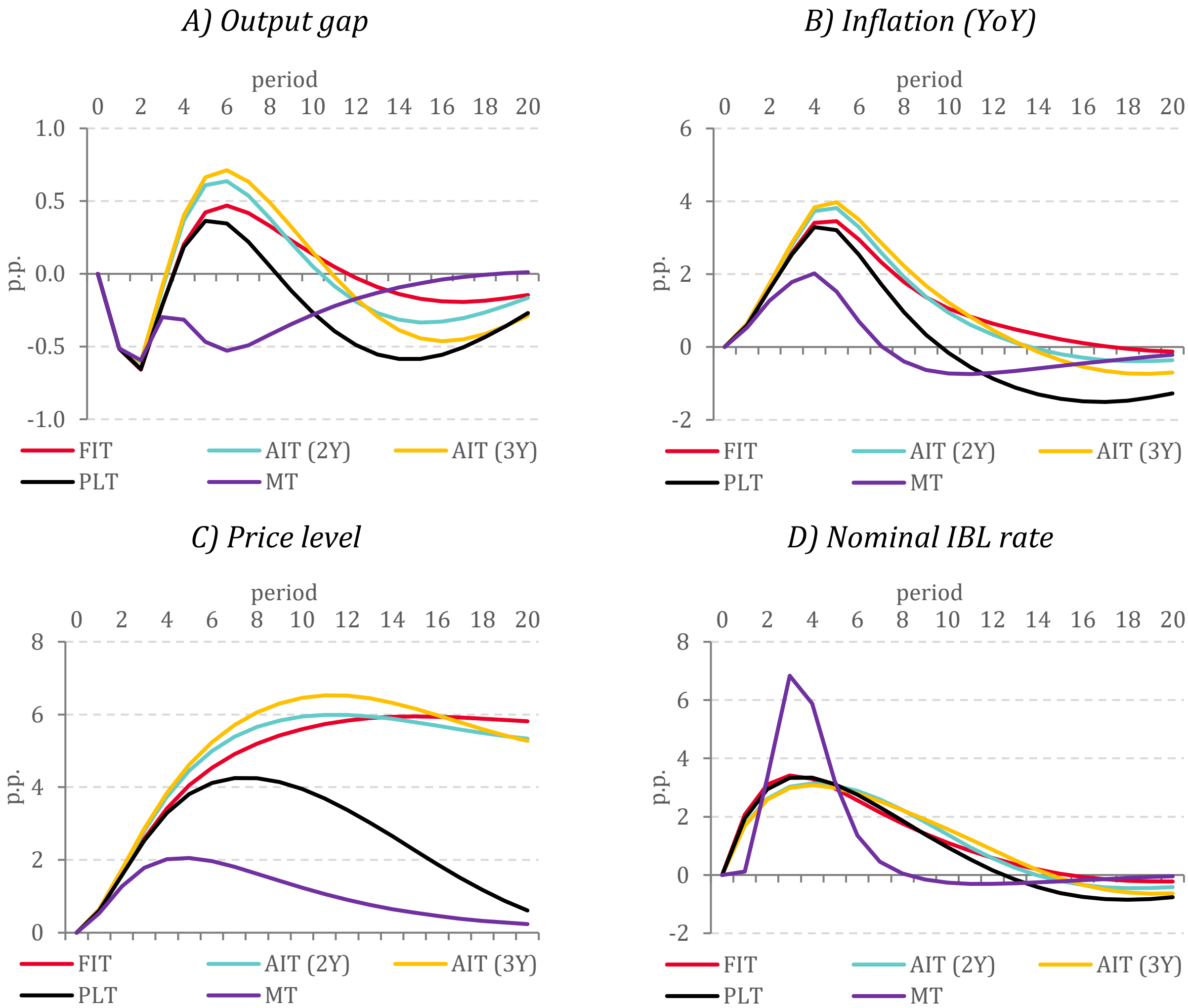
Source: author's calculations.

Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

The flexible price level targeting regime exhibits better stabilization capacity when simulating a shock of deteriorating external economic conditions compared to the regimes of flexible inflation targeting and flexible average inflation targeting. Moreover, the required adjustment of the interest rate in the price level targeting regime is much smaller than in the monetary targeting regime (Figure 4). Flexible inflation targeting allows for smaller losses compared to flexible average inflation targeting (Table 6).

The conclusions regarding the effectiveness of monetary policy regimes in the context of low trust in the National Bank remain consistent (Table 7). The stabilizing power of monetary targeting is accompanied by excessively high interest rate volatility (Figure 5). It cannot be ruled out that such volatility in the interest rate may lead to a weakening of its signaling function's effectiveness, potentially giving rise to negative effects on trust in the monetary regulator beyond the scope of increasing inflation persistence.

Figure 4: Reaction of macroeconomic indicators to the shock of worsening external economic conditions: baseline model specification



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Under strict capital flow restrictions, flexible price level targeting becomes the most effective response to the shock of worsening external economic conditions (Table 8). In this case, the effectiveness of monetary targeting decreases, especially when giving significant weight to interest rate volatility in the loss function. Overall, the interest rate trajectory in the monetary targeting regime looks "undesirable" for the central bank, as sharp increases and decreases in the rate are challenging to communicate (Figure 6). In the presence of strict capital flow restrictions, inflation targeting becomes relatively more effective.

Table 7: Simulation results of a scenario of worsening external economic conditions: low National Bank credibility

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	0.4	0.5	0.5	0.5	0.5
$\sigma(\pi^4)$	1.9	2.1	2.2	1.6	1.1
$\sigma(p)$	3.9	4.2	4.4	3.3	1.9
$\sigma(\Delta i)$	0.6	0.5	0.5	0.6	2.1
$L(\gamma = 0.25)$	9.4	11.1	12.2	6.9	3.5
$L(\gamma = 0.50)$	9.5	11.1	12.3	7.0	4.5
$L(\gamma = 0.75)$	9.6	11.2	12.4	7.1	5.6

Source: author's calculations.

Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

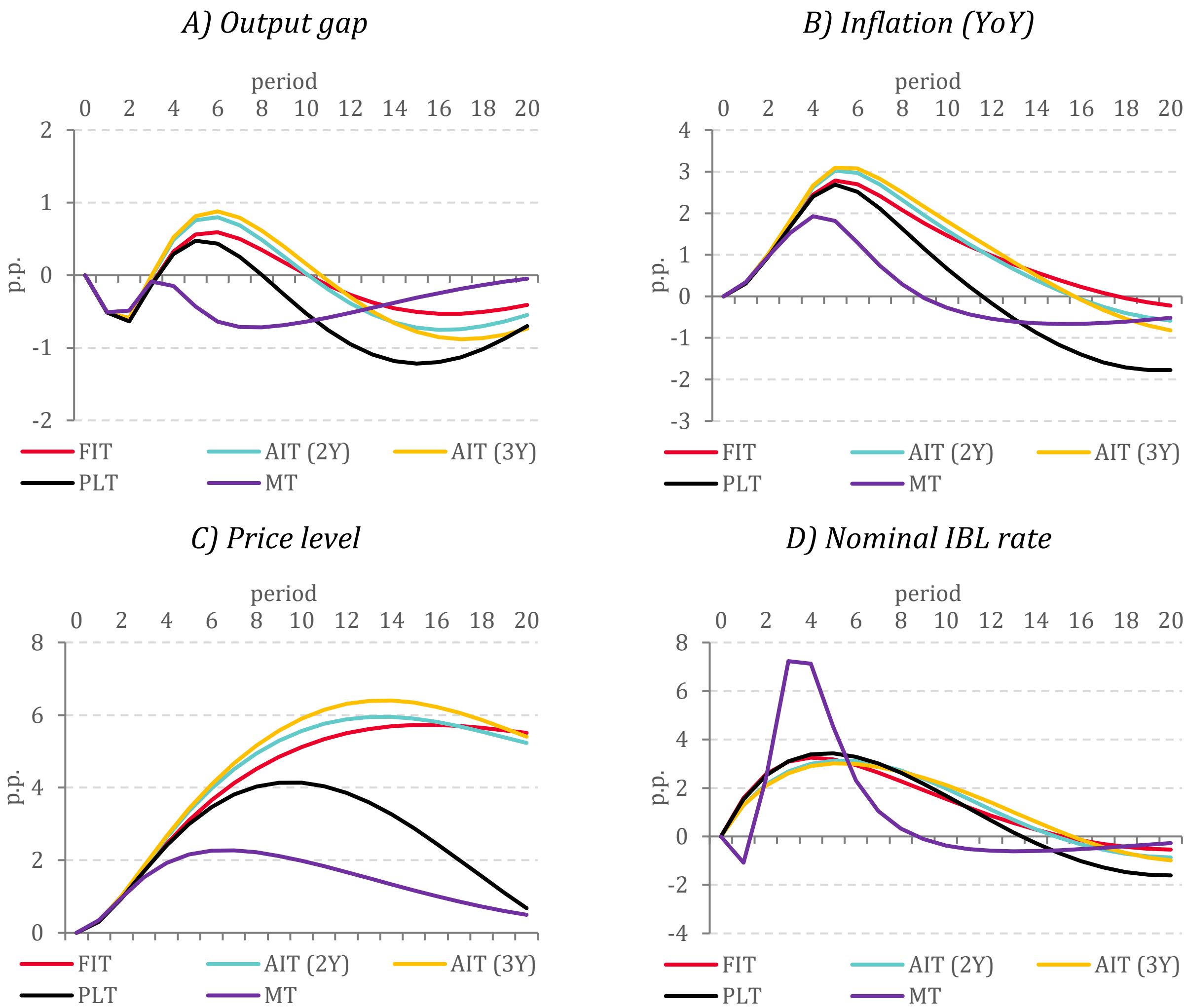
Table 8: Simulation results of a scenario of worsening external economic conditions: strict restrictions on capital flows

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
$\sigma(\hat{y})$	0.3	0.3	0.3	0.3	0.4
$\sigma(\pi^4)$	1.2	1.3	1.3	1.1	1.2
$\sigma(p)$	2.4	2.6	2.8	1.9	1.1
$\sigma(\Delta i)$	0.4	0.3	0.3	0.4	2.1
$L(\gamma = 0.25)$	3.7	4.3	4.8	2.4	2.6
$L(\gamma = 0.50)$	3.7	4.3	4.9	2.5	3.7
$L(\gamma = 0.75)$	3.8	4.3	4.9	2.5	4.8

Source: author's calculations.

Note: standard deviations are calculated for the deviations of the relevant variables from their equilibrium levels. Standard deviations and loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

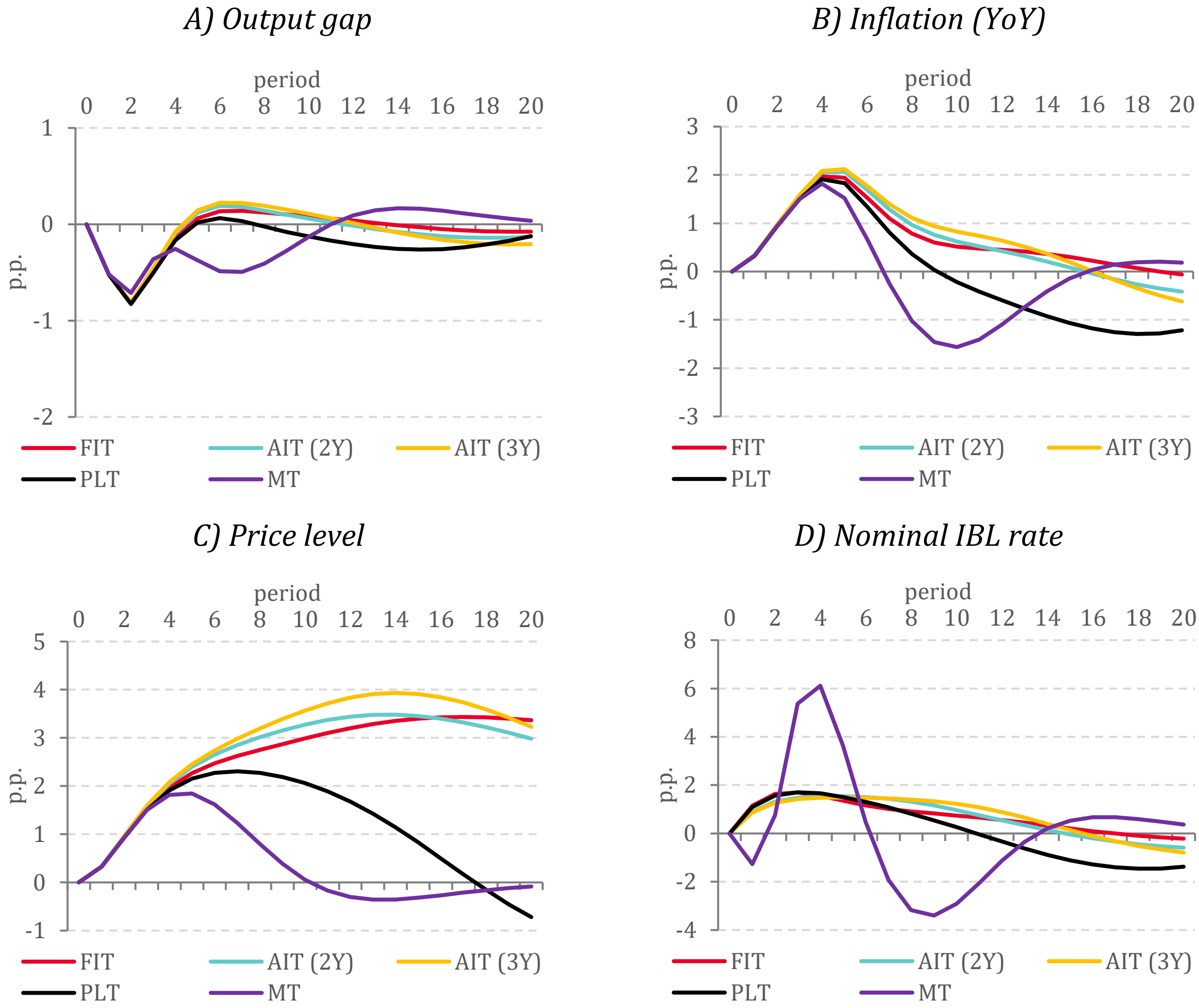
Figure 5: Reaction of macroeconomic indicators to the shock of worsening external economic conditions: low National Bank credibility



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Figure 6: Reaction of macroeconomic indicators to the shock of worsening external economic conditions: strict restrictions on capital flows



Source: author's calculations.

Note: the figure shows impulse response functions in the form of deviations of variables from sustainable equilibrium levels. FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

5. Assessing the robustness of the results

The presented simulations of the impact of shocks on domestic and external economic conditions show the conditional effectiveness of monetary policy regimes in large-scale, yet realistic scenarios. To verify the obtained results, it is also advisable to conduct an unconditional analysis that does not explore specific scenarios.

For such an analysis, simulation experiments were implemented for each model specification (baseline, low National Bank credibility, strict restrictions on capital flows) as follows. The economy, in which the National Bank applies one of the considered monetary policy regimes, faces the impact of a random shock of unit magnitude over twelve consecutive periods (a three-year time horizon relevant for monetary policy). To ensure a large number of possible shock combinations in the analysis, simulations for each regime and model specification were performed ten times.

For each simulation, the losses according to the loss function (28) were calculated for the respective monetary policy regimes. Within each of the ten simulations (for a specific model specification), the monetary policy regimes were ranked in descending order of their stabilization ability – from the lowest loss value to the highest. The resulting indicator of the regime's effectiveness is the average value of its rank. Ranking was used instead of averaging loss function values to exclude the distorting influence of high-amplitude shock combinations on the results.

The results of the simulation experiment within the baseline model specification (Table 9) confirm the high efficiency of the flexible price level targeting regime for stabilizing the economic system under the influence of macroeconomic shocks. The second most effective is the flexible inflation targeting regime, while the regimes of flexible average inflation targeting demonstrate the lowest stabilization ability. The monetary targeting regime potentially has a high capacity to smooth the volatility of inflation, price levels, and output during the shock impact period. However, this comes at the cost of significantly increasing interest rate volatility: the average rank of monetary targeting noticeably decreases when assigning greater importance to interest rates changes in the loss function (Table 9), and the volatility of the interest rate in this regime is on average more than six times higher compared to other considered monetary policy regimes.

In the simulation experiment under conditions of lack of trust in the National Bank, flexible price level targeting and flexible inflation targeting remain the most effective monetary policy regimes (Table 10). However, the effectiveness of monetary targeting noticeably decreases compared to simulations under the baseline model specification. This may support the thesis that gaining credibility is challenging when there is excessively high volatility in interest rates.

When conducting the simulation experiment under conditions of strict capital flow restrictions, the conclusions about the comparative effectiveness of monetary policy regimes, in general, remain unchanged (Table 11).

Table 9: Efficiency of monetary policy regimes in an unconditional simulation experiment: baseline model specification

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
Average rank ($\gamma = 0.25$)	2.3	3.6	4.7	1.6	2.8
Average rank $L(\gamma = 0.50)$	2.1	3.4	4.5	1.5	3.5
Average rank $L(\gamma = 0.75)$	2.1	3.4	4.2	1.5	3.8

Source: author's calculations.

Note: the table presents the average values of the ranks of monetary policy regimes, assigned in increasing order of the value of the loss function. Loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Table 10: Efficiency of monetary policy regimes in an unconditional simulation experiment: low National Bank credibility

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
Average rank ($\gamma = 0.25$)	2.2	3.6	4.4	1.5	3.3
Average rank $L(\gamma = 0.50)$	2.1	3.4	4.2	1.5	3.8
Average rank $L(\gamma = 0.75)$	2.0	3.4	4.2	1.3	4.1

Source: author's calculations.

Note: the table presents the average values of the ranks of monetary policy regimes, assigned in increasing order of the value of the loss function. Loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

Table 11: Efficiency of monetary policy regimes in an unconditional simulation experiment: strict restrictions on capital flows

Indicator	Monetary policy regime				
	FIT	AIT (2Y)	AIT (3Y)	PLT	MT
Average rank ($\gamma = 0.25$)	2.7	3.9	4.9	1.7	1.8
Average rank $L(\gamma = 0.50)$	2.4	3.7	4.7	1.6	2.6
Average rank $L(\gamma = 0.75)$	2.3	3.6	4.5	1.5	3.1

Source: author's calculations.

Note: the table presents the average values of the ranks of monetary policy regimes, assigned in increasing order of the value of the loss function. Loss functions are calculated over a horizon of twelve quarters after the shock (including the period of occurrence of the shock). FIT – flexible inflation targeting; AIT (2Y) and AIT (3Y) – flexible average inflation targeting with an averaging period of two and three years, respectively; PLT – flexible price level targeting; MT – monetary targeting.

5. Conclusion

In this study, an analysis of the effectiveness of monetary policy regimes in Belarus was conducted. A macroeconomic gap model was developed for the analysis, and its specification and parameterization reflect the key characteristics of the Belarusian economy, making it suitable for economies with emerging markets.

The results of simulations on the impact of shocks to both domestic and external economic conditions, as well as unconditional analyses within simulation experiments affecting the economy with a set of random disturbances, show that the most effective monetary policy strategy for Belarus could be flexible price level targeting. Monetary targeting can also be an effective regime for stabilizing inflation and price level. However, this effectiveness is achieved through extremely high volatility in interest rates, which may have significant nonlinear negative effects on macroeconomic and financial stability beyond the proposed macroeconomic model.

With low National Bank credibility, conclusions regarding the comparative effectiveness of monetary policy regimes remain valid. Under strict capital flow restrictions, the most stabilizing regimes are flexible inflation targeting and flexible price level targeting.

In the case of Belarus, the use of flexible inflation targeting appears to be the most preferable. Given existing sanction limitations and internal and external measures to control capital flows, flexible inflation targeting may be the most effective monetary policy strategy in the face of strong economic shocks. The application of monetary targeting may be challenging, as the extremely high volatility in interest rates it generates may hinder public trust in the National Bank and have unfavorable consequences for financial and macroeconomic stability.

During the transformation of the Belarusian economy and political system towards the inclusivity of political and economic institutions, considering the application of a flexible price level targeting regime is advisable.

This study focuses on model simulations of the stabilizing capacity of monetary policy regimes, deliberately omitting issues related to the likely complexity of communications by the National Bank with the public under a flexible price level targeting regime and potential difficulties in gaining credibility in this regime.

Another limitation of this study is the linearity of the used macroeconomic gap model (except for the National Bank credibility block in specific simulations). Nonlinear reactions may occur during strong shocks, which are beyond the scope of the proposed model.

It's also essential to consider that during significant political and economic transformations in Belarus, structural interconnections in the economy may change. This may require adjustments to the specification and parameterization of the macroeconomic gap model. However, the proposed approach to assessing the effectiveness of monetary policy regimes will remain valid.

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Appendix A

Structure and calibration of the baseline macroeconomic gap model for Belarus

Aggregate demand block and monetary conditions

$$y_t = \bar{y}_t + \hat{y}_t \quad \text{(A.1)}$$

$$\Delta 4y_t = y_t - y_{t-4} \quad \text{(A.2)}$$

$$\Delta y_t = 4 * (y_t - y_{t-1}) \quad \text{(A.3)}$$

$$\bar{y}_t = \bar{y}_{t-1} + \Delta\bar{y}_t/4 + \varepsilon_t^{\bar{y}} \quad \text{(A.4)}$$

$$\Delta\bar{y}_t = ab_1\Delta\bar{y}_{t-1} + (1 - ab_1) * \Delta\bar{y}_{ss} + \varepsilon_t^{\Delta\bar{y}} \quad \text{(A.5)}$$

$$\Delta 4\bar{y}_t = \bar{y}_t - \bar{y}_{t-4} \quad \text{(A.6)}$$

$$\hat{y}_t = a_1\hat{y}_{t-1} + a_2E_t\hat{y}_{t+1} - a_3mci_{t-1} + a_4\hat{y}_t^* + a_5r\widehat{wage}_{t-1} + a_6fi_t + \varepsilon_t^{\hat{y}} \quad \text{(A.7)}$$

$$E_t\hat{y}_{t+1} = \hat{y}_{t+1} \quad \text{(A.8)}$$

$$mci_t = m_1 * (m_2\hat{r}_t + m_3\widehat{r\_l}_t + (1 - m_2 - m_3) * \widehat{r\_d}_t) - (1 - m_1) * \hat{z}_t \quad \text{(A.9)}$$

Fiscal sector and wages

$$rfx_t = \widehat{rfx}_t + \overline{rfx}_t \quad \text{(A.10)}$$

$$\widehat{rfx}_t = f_1\widehat{rfx}_{t-1} + \varepsilon_t^{\widehat{rfx}} \quad \text{(A.11)}$$

$$\Delta\overline{rfx}_t = f_2\Delta\overline{rfx}_{t-1} + (1 - f_2) * \Delta\overline{rfx}_{ss} + \varepsilon_t^{\Delta\overline{rfx}} \quad \text{(A.12)}$$

$$\Delta\overline{rfx}_t = 4 * (\Delta\overline{rfx}_t - \Delta\overline{rfx}_{t-1}) \quad \text{(A.13)}$$

$$fi_t = (\widehat{rfx}_t + \widehat{rfx}_{t-1})/2 \quad \text{(A.14)}$$

$$\Delta wage_t = aa_1E_t\Delta wage_{t+1} + (1 - aa_1) * \Delta wage_{t-1} + aa_2\hat{y}_t - aa_3\, r\widehat{wage}_{t-1} + \\ + \varepsilon_t^{\Delta wage} \quad \text{(A.15)}$$

$$\Delta wage_t = 4 * (wage_t - wage_{t-1}) \quad \text{(A.16)}$$

$$\Delta 4wage_t = wage_t - wage_{t-4} \tag{A.17}$$

$$E_t \Delta wage_{t+1} = \Delta wage_{t+1} \tag{A.18}$$

$$rwage_t = wage_t - cpi_t \tag{A.19}$$

$$\Delta 4rwage_t = rwage_t - rwage_{t-4} \tag{A.20}$$

$$\Delta rwage_t = 4 * (rwage_t - rwage_{t-1}) \tag{A.21}$$

$$rwage_t = \overline{rwage}_t + r\widehat{wage}_t \tag{A.22}$$

$$\Delta\overline{rwage}_t = aa_4 \Delta\overline{rwage}_{t-1} + (1 - aa_4) * (\Delta\bar{y}_t + wedge) + \varepsilon_t^{\Delta\overline{rwage}} \tag{A.23}$$

$$\Delta\overline{rwage}_t = 4 * (\overline{rwage}_t - \overline{rwage}_{t-1}) \tag{A.24}$$

Inflation block

$$\pi_t = 4 * (cpi_t - cpi_{t-1}) \tag{A.25}$$

$$\pi_t^4 = cpi_t - cpi_{t-4} \tag{A.26}$$

$$\pi_t = weight * \pi_{core_t} + (1 - weight) * \pi_{noncore_t} + \varepsilon_t^{\pi} \tag{A.27}$$

$$rp_t = cpi_{core_t} - cpi_t \tag{A.28}$$

$$rp_t = \widehat{rp}_t + \overline{rp}_t \tag{A.29}$$

$$\Delta\overline{rp}_t = rr_1 \Delta\overline{rp}_{t-1} + (1 - rr_1) * \Delta\overline{rp}_{ss} + \varepsilon_t^{\Delta\overline{rp}} \tag{A.30}$$

$$\Delta\overline{rp}_t = 4 * (\Delta\overline{rp}_t - \Delta\overline{rp}_{t-1}) \tag{A.31}$$

$$\pi_{core_t} = 4 * (cpi_{core_t} - cpi_{core_{t-1}}) \tag{A.32}$$

$$\pi_{core_t} = b_1 E_t \pi_{core_{t+1}} + (1 - b_1 - b_2) * \pi_{core_{t-1}} + b_2 \pi_{imp_t} + b_3 rmc_t + \varepsilon_t^{\pi_{core}} \tag{A.33}$$

$$rmc_t = k_1 \hat{y}_t + k_2 r\widehat{wage}_t + (1 - k_1 - k_2) * (\hat{z}_t - \widehat{rp}_t) \tag{A.34}$$

$$\pi_{imp_t} = \pi_t^* + \Delta s_t - (\Delta\bar{z}_t - \Delta\overline{rp}_t) \tag{A.35}$$

$$\pi_{core_t}^4 = cpi_{core_t} - cpi_{core_{t-4}} \tag{A.36}$$

$$\pi_{noncore_t} = bb_1 E_t \pi_{noncore_{t+1}} + (1 - bb_1) * \pi_{noncore_{t-1}} + bb_2 \widehat{rp\_oil}_t +$$

$$+ bb_3 * (\hat{z}_t + \frac{weight}{1-weight} * \widehat{rp}_t) + \varepsilon_t^{\pi_{noncore}} \quad (A.37)$$

$$\pi_{noncore_t} = 4 * (cpi_{noncore_t} - cpi_{noncore_{t-1}}) \quad (A.38)$$

$$\pi^4_{noncore_t} = cpi_{noncore_t} - cpi_{noncore_{t-4}} \quad (A.39)$$

$$E_t \pi^4_{t+3} = \pi^4_{t+3} \quad (A.40)$$

$$E_t \pi^4_{t+1} = \pi^4_{t+1} \quad (A.41)$$

$$E_t \pi_{core_{t+1}} = \pi_{core_{t+1}} \quad (A.42)$$

$$E_t \pi_{noncore_{t+1}} = \pi_t - \frac{1}{1-weight} * (weight * \Delta\overline{rp}_t + \varepsilon_t^{\pi}) \quad (A.43)$$

$$\pi_t^T = tar_1 \pi_{t-1}^T + (1 - tar_1) * \pi_{ss}^T + \varepsilon_t^{\pi^T} \quad (A.44)$$

Exchange rate

$$s_t = (1 - h_1) * s_t^{uip} + h_1 s_t^{bop} + \varepsilon_t^s \quad (A.45)$$

$$s_t^{bop} = s_{t-1} + \frac{\Delta\bar{s}_t}{4} - h_2 \widehat{bop}_t \quad (A.46)$$

$$\Delta\bar{s}_t = \Delta\bar{z}_t + \pi_t^T - \pi_{ss}^* \quad (A.47)$$

$$s_t^{uip} = E_t s_{t+1} + \frac{i_t^* - i_t + prem_t}{4} \quad (A.48)$$

$$E_t s_{t+1} = h_3 s_{t+1} + (1 - h_3) * s_{t+1}^{nf} \quad (A.49)$$

$$s_{t+1}^{nf} = s_{t-1} + \frac{2\Delta\bar{s}_t}{4} \quad (A.50)$$

$$\Delta s_t = 4 * (s_t - s_{t-1}) \quad (A.51)$$

$$\Delta 4 s_t = s_t - s_{t-4} \quad (A.52)$$

$$E_t \Delta s_{t+1} = \Delta s_{t+1} \quad (A.53)$$

$$\Delta z_t = \Delta s_t + \pi_t^* - \pi_t \quad (A.54)$$

$$\Delta z_t = 4 * (z_t - z_{t-1}) \quad (A.55)$$

$$\Delta 4z_t = z_t - z_{t-4} \quad (A.56)$$

$$z_t = \bar{z}_t + \hat{z}_t \quad (A.57)$$

$$\Delta\bar{z}_t = z_1\Delta\bar{z}_{t-1} + (1 - z_1) * \Delta\bar{z}_{ss} + \varepsilon_t^{\Delta\bar{z}} \quad (A.58)$$

$$\Delta\bar{z}_t = 4 * (\bar{z}_t - \bar{z}_{t-1}) \quad (A.59)$$

$$\Delta 4\bar{z}_t = \bar{z}_t - \bar{z}_{t-4} \quad (A.60)$$

$$prem_t = \overline{prem}_t + \widehat{prem}_t \quad (A.61)$$

$$\overline{prem}_t = pr_1\overline{prem}_{t-1} + (1 - pr_1) * \overline{prem}_{ss} + \varepsilon_t^{\overline{prem}} \quad (A.62)$$

$$\widehat{prem}_t = pr_2\widehat{prem}_{t-1} + \varepsilon_t^{\widehat{prem}} \quad (A.63)$$

Foreign trade

$$x_t = \bar{x}_t + \hat{x}_t \quad (A.64)$$

$$\Delta\bar{x}_t = u_1\Delta\bar{x}_{t-1} + (1 - u_1) * \Delta\bar{x}_{ss} + \varepsilon_t^{\Delta\bar{x}} \quad (A.65)$$

$$\bar{x}_t = \bar{x}_{t-1} + \Delta\bar{x}_t/4 + \varepsilon_t^{\bar{x}} \quad (A.66)$$

$$\hat{x}_t = c_1\hat{x}_{t-1} + c_2\hat{y}_t^* + c_3\hat{z}_{t-1} + \varepsilon_t^{\hat{x}} \quad (A.67)$$

$$\Delta 4\bar{x}_t = \bar{x}_t - \bar{x}_{t-4} \quad (A.68)$$

$$\Delta 4x_t = x_t - x_{t-4} \quad (A.69)$$

$$\Delta x_t = 4 * (x_t - x_{t-1}) \quad (A.70)$$

$$m_t = \bar{m}_t + \hat{m}_t \quad (A.71)$$

$$\Delta\bar{m}_t = uu_1\Delta\bar{m}_{t-1} + (1 - uu_1) * \Delta\bar{m}_{ss} + \varepsilon_t^{\Delta\bar{m}} \quad (A.72)$$

$$\bar{m}_t = \bar{m}_{t-1} + \Delta\bar{m}_t/4 + \varepsilon_t^{\bar{m}} \quad (A.73)$$

$$\hat{m}_t = d_1\hat{m}_{t-1} + d_2\hat{y}_t - d_3\hat{z}_{t-1} + \varepsilon_t^{\hat{m}} \quad (A.74)$$

$$\Delta 4\bar{m}_t = \bar{m}_t - \bar{m}_{t-4} \quad (A.75)$$

$$\Delta 4m_t = m_t - m_{t-4} \quad (A.76)$$

$$\Delta m_t = 4 * (m_t - m_{t-1}) \quad (A.77)$$

$$tot_t = \widehat{tot}_t + \overline{tot}_t \quad (A.78)$$

$$\widehat{tot}_t = r_1 \widehat{tot}_{t-1} + \varepsilon_t^{\widehat{tot}} \quad (A.79)$$

$$\Delta\overline{tot}_t = r_2 \Delta\overline{tot}_{t-1} + (1 - r_2) * \Delta\overline{tot}_{ss} + \varepsilon_t^{\Delta\overline{tot}} \quad (A.80)$$

$$\Delta\overline{tot}_t = 4 * (\Delta\overline{tot}_t - \Delta\overline{tot}_{t-1}) \quad (A.81)$$

$$\widehat{bop}_t = \widehat{tot}_t + \hat{x}_t - \widehat{m}_t \quad (A.82)$$

Monetary policy reaction function

$$i_t = mm_1 i_{t-1} + (1 - mm_1) * (\bar{r}_t + E_t\pi_{t+4}^4 + mm_2 * (E_t\pi_{t+3}^4 - \pi_{t+3}^T) + mm_3\hat{y}_t) + \varepsilon_t^i. \quad (A.83)$$

$$i_t^n = \bar{r}_t + E_t\pi_{t+4}^4 \quad (A.84)$$

$$r_t = i_t - E_t\pi_{t+1}^4 \quad (A.85)$$

$$r_t = \bar{r}_t + \hat{r}_t \quad (A.86)$$

$$\bar{r}_t = w_1\bar{r}_{t-1} + (1 - w_1) * (\Delta\bar{y}_t + \Delta\bar{z}_t) + \varepsilon_t^{\bar{r}} \quad (A.87)$$

Interest rates of the loans and deposits market

$$\Delta i\_l_t = s_1\Delta i_t + s_2\Delta i_{t-1} + s_3(i\_l_{t-1} - s_4 i_{t-1} - s_5) + \varepsilon_t^{\Delta i\_l} \quad (A.88)$$

$$\Delta i\_l_t = i\_l_t - i\_l_{t-1} \quad (A.89)$$

$$r\_l_t = i\_l_t - E_t\pi_{t+1}^4 \quad (A.90)$$

$$r\_l_t = \overline{r\_l}_t + \widehat{r\_l}_t \quad (A.91)$$

$$\overline{r\_l}_t = \bar{r}_t + \overline{spread}_t^l \quad (A.92)$$

$$spread_t^l = \overline{spread}_t^l + \widehat{spread}_t^l \quad (A.93)$$

$$spread_t^l = i\_l_t - i_t \quad (A.94)$$

$$\overline{spread}_t^l = w_2\overline{spread}_{t-1}^l + (1 - w_2) * \overline{spread}_{ss}^l + \varepsilon_t^{\overline{spread}^l} \quad (A.95)$$

$$\Delta i\_d_t = q_1\Delta i_t + q_2\Delta i_{t-1} + q_3(i\_l_{t-1} - q_4 i_{t-1} - q_5) + \varepsilon_t^{\Delta i\_d} \quad (A.96)$$

$$\Delta i\_d_t = i\_d_t - i\_d_{t-1} \quad (A.97)$$

$$r\_d_t = i\_d_t - E_t\pi^4_{t+1} \quad (A.98)$$

$$r\_d_t = \overline{r\_d}_t + \widehat{r\_d}_t \quad (A.99)$$

$$\overline{r\_d}_t = \bar{r}_t + \overline{spread}^d_t \quad (A.100)$$

$$spread^d_t = \overline{spread}^d_t + \widehat{spread}^d_t \quad (A.101)$$

$$spread^d_t = i\_d_t - i_t \quad (A.102)$$

$$\overline{spread}^d_t = w_3\overline{spread}^d_{t-1} + (1 - w_3) * \overline{spread}^d_{ss} + \varepsilon_t^{\overline{spread}^d} \quad (A.103)$$

External sector

$$\hat{y}^*_t = w^{ru}\hat{y}^{ru}_t + w^{eu}\hat{y}^{eu}_t + w^{cn}\hat{y}^{cn}_t + (1 - w^{ru} - w^{eu} - w^{cn}) * \hat{y}^{us}_t \quad (A.104)$$

$$\hat{y}^{ru}_t = a^{y\_ru}\hat{y}^{ru}_{t-1} + \varepsilon_t^{\hat{y}^{ru}} \quad (A.105)$$

$$\hat{y}^{eu}_t = a^{y\_eu}\hat{y}^{eu}_{t-1} + \varepsilon_t^{\hat{y}^{eu}} \quad (A.106)$$

$$\hat{y}^{cn}_t = a^{y\_cn}\hat{y}^{cn}_{t-1} + \varepsilon_t^{\hat{y}^{cn}} \quad (A.107)$$

$$\hat{y}^{us}_t = a^{y\_us}\hat{y}^{us}_{t-1} + \varepsilon_t^{\hat{y}^{us}} \quad (A.108)$$

$$\pi^*_t = w^{ru}\pi^{ru}_t + w^{eu}\pi^{eu}_t + w^{cn}\pi^{cn}_t + (1 - w^{ru} - w^{eu} - w^{cn}) * \pi^{us}_t \quad (A.109)$$

$$\pi 4^*_t = \frac{\pi^*_t + \pi^*_{t-1} + \pi^*_{t-2} + \pi^*_{t-3}}{4} \quad (A.110)$$

$$\pi^{ru}_t = b^{\pi\_ru}\pi^{ru}_{t-1} + (1 - b^{\pi\_ru}) * \pi^{ru}_{ss} + \varepsilon_t^{\pi^{ru}} \quad (A.111)$$

$$\pi 4^{ru}_t = cpi^{ru}_t - cpi^{ru}_{t-4} \quad (A.112)$$

$$\pi^{ru}_t = 4 * (cpi^{ru}_t - cpi^{ru}_{t-1}) \quad (A.113)$$

$$\pi^{eu}_t = b^{\pi\_eu}\pi^{eu}_{t-1} + (1 - b^{\pi\_eu}) * \pi^{eu}_{ss} + \varepsilon_t^{\pi^{eu}} \quad (A.114)$$

$$\pi 4^{eu}_t = cpi^{eu}_t - cpi^{eu}_{t-4} \quad (A.115)$$

$$\pi^{eu}_t = 4 * (cpi^{eu}_t - cpi^{eu}_{t-1}) \quad (A.116)$$

$$\pi_t^{cn} = b^{\pi\_cn}\pi_{t-1}^{cn} + (1 - b^{\pi\_cn}) * \pi_{ss}^{cn} + \varepsilon_t^{\pi^{cn}} \quad (A.117)$$

$$\pi 4_t^{cn} = cpi_t^{cn} - cpi_{t-4}^{cn} \quad (A.118)$$

$$\pi_t^{cn} = 4 * (cpi_t^{cn} - cpi_{t-1}^{cn}) \quad (A.119)$$

$$\pi_t^{us} = b^{\pi\_us}\pi_{t-1}^{us} + (1 - b^{\pi\_us}) * \pi_{ss}^{us} + \varepsilon_t^{\pi^{us}} \quad (A.120)$$

$$\pi 4_t^{us} = cpi_t^{us} - cpi_{t-4}^{us} \quad (A.121)$$

$$\pi_t^{us} = 4 * (cpi_t^{us} - cpi_{t-1}^{us}) \quad (A.122)$$

$$i_t^* = w^{ru} i_t^{ru} + w^{eu} i_t^{eu} + w^{cn} i_t^{cn} + (1 - w^{ru} - w^{eu} - w^{cn}) * i_t^{us} \quad (A.123)$$

$$\bar{r}_t^* = w^{ru}\bar{r}_t^{ru} + w^{eu}\bar{r}_t^{eu} + w^{cn}\bar{r}_t^{cn} + (1 - w^{ru} - w^{eu} - w^{cn}) * \bar{r}_t^{us} \quad (A.124)$$

$$r_t^* = w^{ru} r_t^{ru} + w^{eu} r_t^{eu} + w^{cn} r_t^{cn} + (1 - w^{ru} - w^{eu} - w^{cn}) * r_t^{us} \quad (A.125)$$

$$\hat{r}_t^* = r_t^* - \bar{r}_t^* \quad (A.126)$$

$$i_t^{ru} = c^{i\_ru} i_{t-1}^{ru} + \left(1 - c^{i\_ru}\right) * (\bar{r}_{ss}^{ru} + \pi_{ss}^{ru}) + \varepsilon_t^{i^{ru}} \quad (A.127)$$

$$\bar{r}_t^{ru} = c^{r\_ru}\bar{r}_{t-1}^{ru} + (1 - c^{r\_ru}) * \bar{r}_{ss}^{ru} + \varepsilon_t^{\bar{r}^{ru}} \quad (A.128)$$

$$r_t^{ru} = i_t^{ru} - \pi 4_{t+1}^{ru} \quad (A.129)$$

$$\hat{r}_t^{ru} = r_t^{ru} - \bar{r}_t^{ru} \quad (A.130)$$

$$i_t^{eu} = c^{i\_eu} i_{t-1}^{eu} + \left(1 - c^{i\_eu}\right) * (\bar{r}_{ss}^{eu} + \pi_{ss}^{eu}) + \varepsilon_t^{i^{eu}} \quad (A.131)$$

$$\bar{r}_t^{eu} = c^{r\_eu}\bar{r}_{t-1}^{eu} + (1 - c^{r\_eu}) * \bar{r}_{ss}^{eu} + \varepsilon_t^{\bar{r}^{eu}} \quad (A.132)$$

$$r_t^{eu} = i_t^{eu} - \pi 4_{t+1}^{eu} \quad (A.133)$$

$$\hat{r}_t^{eu} = r_t^{eu} - \bar{r}_t^{eu} \quad (A.134)$$

$$i_t^{cn} = c^{i\_cn} i_{t-1}^{cn} + \left(1 - c^{i\_cn}\right) * (\bar{r}_{ss}^{cn} + \pi_{ss}^{cn}) + \varepsilon_t^{i^{cn}} \quad (A.135)$$

$$\bar{r}_t^{cn} = c^{r\_cn}\bar{r}_{t-1}^{cn} + (1 - c^{r\_cn}) * \bar{r}_{ss}^{cn} + \varepsilon_t^{\bar{r}^{cn}} \quad (A.136)$$

$$r_t^{cn} = i_t^{cn} - \pi 4_{t+1}^{cn} \quad (A.137)$$

$$\hat{r}_t^{cn} = r_t^{cn} - \bar{r}_t^{cn} \quad (A.138)$$

$$i_t^{us} = c^{i\_us} i_{t-1}^{us} + \left(1 - c^{i\_us}\right) * (\bar{r}_{ss}^{us} + \pi_{ss}^{us}) + \varepsilon_t^{i^{us}} \quad (A.139)$$

$$\bar{r}_t^{us} = c^{r\_us} \bar{r}_{t-1}^{us} + (1 - c^{r\_us}) * \bar{r}_{ss}^{us} + \varepsilon_t^{\bar{r}^{us}} \quad (A.140)$$

$$r_t^{us} = i_t^{us} - \pi 4_{t+1}^{us} \quad (A.141)$$

$$\hat{r}_t^{us} = r_t^{us} - \bar{r}_t^{us} \quad (A.142)$$

$$rp\_oil_t = p\_oil_t - cpi_t^{us} \quad (A.143)$$

$$rp\_oil_t = \overline{rp\_oil}_t + \widehat{rp\_oil}_t \quad (A.144)$$

$$\Delta rp\_oil_t = 4 * (rp\_oil_t - rp\_oil_{t-1}) \quad (A.145)$$

$$\Delta 4rp\_oil_t = rp\_oil_t - rp\_oil_{t-4} \quad (A.146)$$

$$\Delta\overline{rp\_oil}_t = 4 * (\overline{rp\_oil}_t - \overline{rp\_oil}_{t-1}) \quad (A.147)$$

$$\Delta\overline{rp\_oil}_t = o_1 \Delta\overline{rp\_oil}_{t-1} + (1 - o_1) * \Delta\overline{rp\_oil}_{ss} + \varepsilon_t^{\Delta\overline{rp\_oil}} \quad (A.148)$$

$$\widehat{rp\_oil}_t = o_2 \widehat{rp\_oil}_{t-1} + \varepsilon_t^{\widehat{rp\_oil}} \quad (A.149)$$

Table A.1: Model variables

Designation	Variable
y_t	Real GDP
$\bar{y}_t$	Equilibrium (potential) real GDP
$\hat{y}_t$	Output gap (deviation of real GDP from the equilibrium level)
Δy_t	Annualized real GDP growth
$\Delta 4y_t$	Growth of real GDP period to corresponding period of previous year
$\Delta\bar{y}_t$	Annualized real equilibrium GDP growth
$\Delta 4\bar{y}_t$	Growth of real equilibrium GDP period to corresponding period of previous year
$E_t\hat{y}_{t+1}$	Output gap expected in period t+1
mci_t	Monetary conditions index

Continuation of the table A.1

Designation	Variable
rfx_t	Real non-interest budget expenditures of the general government
$\overline{rfx}_t$	Equilibrium real non-interest budget expenditures
$\widehat{rfx}_t$	Budget expenditures gap (deviation of real non-interest budget expenditures from the equilibrium level)
$\Delta\overline{rfx}_t$	Annualized equilibrium real non-interest budget expenditures growth
fi_t	Fiscal impulse
$\Delta wage_t$	Annualized growth rate of nominal wages
$wage_t$	Nominal wages
$\Delta 4wage_t$	Growth rate of nominal wages period to corresponding period of previous year
$E_t\Delta wage_{t+1}$	Expected growth rate of nominal wages in period t+1
$rwage_t$	Real wages
$\Delta 4rwage_t$	Growth rate of real wages period to corresponding period of previous year
$\Delta rwage_t$	Annualized growth rate of real wages
$\overline{rwage}_t$	Equilibrium real wages
$r\widehat{wage}_t$	Wages gap (deviation of real wages from equilibrium level)
$\Delta\overline{rwage}_t$	Annualized growth rate of equilibrium real wages
π_t	Inflation (annualized growth rate of consumer price index)
cpi_t	Headline consumer price index
π_t^4	Growth rate of consumer price index period to corresponding period of previous year
rp_t	Relative price (the ratio of the core consumer price index to the headline index)
$\widehat{rp}_t$	Relative price gap
$\overline{rp}_t$	Equilibrium relative price
$\Delta\overline{rp}_t$	Annualized growth rate of equilibrium relative price
$cpi_{core\,t}$	Core consumer price index
$\pi_{core\,t}$	Core inflation (annualized growth rate of the core consumer price index)
$\pi_{core\,t}^4$	Growth rate of core consumer price index period to corresponding period of previous year

Continuation of the table A.1

Designation	Variable
rmc_t	Real marginal costs
π_{imp_t}	Imported inflation
$\pi_{noncore_t}$	Non-core inflation (annualized growth rate of the non-core consumer price index)
$cpi_{noncore_t}$	Non-core consumer price index
$\pi^4_{noncore_t}$	Growth rate of non-core consumer price index period to corresponding period of previous year
$E_t\pi^4_{t+1}$	Expected growth rate of consumer price index period to corresponding period of previous year in period t+1
$E_t\pi^4_{t+3}$	Expected growth rate of consumer price index period to corresponding period of previous year in period t+3
$E_t\pi^4_{t+4}$	Expected growth rate of consumer price index period to corresponding period of previous year in period t+4
$E_t\pi_{core_{t+1}}$	Expected core inflation in period t+1
$E_t\pi_{noncore_{t+1}}$	Expected non-core inflation in period t+1
π^T_t	Inflation target
s_t	Nominal effective exchange rate of the Belarusian ruble (NEER)
s^{bop}_t	NEER determined by foreign trade conditions
s^{uip}_t	NEER determined by uncovered interest rate parity
$\Delta\bar{s}_t$	Annualized growth rate of trend NEER
$E_t s_{t+1}$	Expected NEER in period t+1
s^{nf}_{t+1}	Naïve forecast of NEER for period t+1
Δs_t	Annualized growth of NEER
$\Delta 4 s_t$	Growth of NEER period to corresponding period of previous year
$E_t\Delta s_{t+1}$	Annualized growth of NEER expected in period t+1
z_t	Real effective exchange rate of the Belarusian ruble (REER)
Δz_t	Annualized growth of REER
$\Delta 4 z_t$	Growth of REER period to corresponding period of previous year

Continuation of the table A.1

Designation	Variable
$\bar{z}_t$	Equilibrium REER
$\hat{z}_t$	REER gap (deviation of REER from the equilibrium level)
$\Delta\bar{z}_t$	Annualized growth of equilibrium REER
$\Delta4\bar{z}_t$	Growth of equilibrium REER period to corresponding period of previous year
$prem_t$	Risk premium for investments in assets denominated in Belarusian rubles
$\overline{prem}_t$	Equilibrium risk premium for investments in assets denominated in Belarusian rubles
$\widehat{prem}_t$	Gap of risk premium for investments in assets denominated in Belarusian rubles
x_t	Physical volume of exports of goods and services
$\bar{x}_t$	Equilibrium physical volume of exports
$\hat{x}_t$	Exports gap (deviation of the physical volume of exports from the equilibrium level)
$\Delta\bar{x}_t$	Annualized growth of equilibrium physical volume of exports
$\Delta4\bar{x}_t$	Growth of equilibrium physical volume of exports period to corresponding period of previous year
$\Delta4x_t$	Growth of physical volume of exports period to corresponding period of previous year
Δx_t	Annualized growth of physical volume of exports
m_t	Physical volume of imports of goods and services
$\bar{m}_t$	Equilibrium physical volume of imports
$\hat{m}_t$	Imports gap (deviation of the physical volume of imports from the equilibrium level)
$\Delta\bar{m}_t$	Annualized growth of the equilibrium physical volume of imports
$\Delta4\bar{m}_t$	Growth of equilibrium physical volume of imports period to corresponding period of previous year
$\Delta4m_t$	Growth of physical volume of imports period to corresponding period of previous year
Δm_t	Annualized growth of physical volume of imports
tot_t	Terms of trade (ratio of export prices to import prices)

Continuation of the table A.1

Designation	Variable
$\overline{tot}_t$	Equilibrium terms of trade
$\widehat{tot}_t$	Terms of trade gap
$\Delta\overline{tot}_t$	Annualized growth of equilibrium terms of trade
$\widehat{bop}_t$	Approximation of the foreign trade balance gap (deviation of the value of the foreign trade balance from the equilibrium level)
i_t	Nominal IBL interest rate
i_t^n	Neutral nominal IBL rate
r_t	Real IBL interest rate
$\bar{r}_t$	Equilibrium real IBL rate
$\hat{r}_t$	IBL rate gap (deviation of the real IBL rate from the equilibrium level)
i_l_t	Nominal interest rate on new market ruble loans to individuals and organizations
Δi_l_t	Change in nominal interest rate on new market ruble loans to individuals and organizations
r_l_t	Real interest rate on new market ruble loans to individuals and organizations
$\overline{r\_l}_t$	Equilibrium real interest rate on new market ruble loans to individuals and organizations
$\widehat{r\_l}_t$	Lending rate gap
$spread_t^l$	Spread of nominal lending rate to nominal IBL rate (credit spread)
$\overline{spread}_t^l$	Equilibrium credit spread
$\widehat{spread}_t^l$	Credit spread gap
i_d_t	Nominal interest rate on new ruble time deposits for individuals and organizations
Δi_d_t	Change in nominal interest rate on new ruble time deposits for individuals and organizations
r_d_t	Real interest rate on new ruble time deposits for individuals and organizations
$\overline{r\_d}_t$	Equilibrium real interest rate on new ruble time deposits for individuals and organizations
$\widehat{r\_d}_t$	Deposit rate gap

Continuation of the table A.1

Designation	Variable
$spread_t^d$	Spread of nominal interest rate on deposits to nominal IBL rate (deposit spread)
$\overline{spread}_t^d$	Equilibrium deposit spread
$\widehat{spread}_t^d$	Deposit spread gap
$\hat{y}_t^*$	Aggregate output gap in countries - Belarus' trading partners
$\hat{y}_t^{ru}$	Output gap in Russia
$\hat{y}_t^{eu}$	Output gap in the EU
$\hat{y}_t^{cn}$	Output gap in China
$\hat{y}_t^{us}$	Output gap in the US
π_t^*	Aggregate annualized growth rate of the consumer price index (inflation) in countries – Belarus' trading partners
$\pi 4_t^*$	Growth of consumer price index in countries – Belarus' trading partners period to corresponding period of previous year
π_t^{ru}	Annualized growth in consumer price index in Russia
$\pi 4_t^{ru}$	Growth in consumer price index in Russia period to corresponding period of previous year
cpi_t^{ru}	Consumer price index in Russia
π_t^{eu}	Annualized growth in consumer price index in the Eurozone
$\pi 4_t^{eu}$	Growth in consumer price index in the Eurozone period to corresponding period of previous year
cpi_t^{eu}	Consumer price index in the Eurozone
π_t^{cn}	Annualized growth in consumer price index in China
$\pi 4_t^{cn}$	Growth in consumer price index in China period to corresponding period of previous year
cpi_t^{cn}	Consumer price index in China
π_t^{us}	Annualized growth in consumer price index in the US
$\pi 4_t^{us}$	Growth in consumer price index in the US period to corresponding period of previous year
cpi_t^{us}	Consumer price index in the US
i_t^*	Aggregate nominal IBL rate in countries - Belarus' trading partners

Continuation of the table A.1

Designation	Variable
$\bar{r}_t^*$	Aggregate equilibrium real IBL rate in countries - Belarus' trading partners
r_t^*	Aggregate real IBL rate in countries - Belarus' trading partners
$\hat{r}_t^*$	Gap of aggregate real IBL rate in countries - Belarus' trading partners
i_t^{ru}	Nominal IBL rate in Russia
$\bar{r}_t^{ru}$	Equilibrium real IBL rate in Russia
r_t^{ru}	Real IBL rate in Russia
$\hat{r}_t^{ru}$	Real IBL rate gap in Russia
i_t^{eu}	Nominal IBL rate in the Eurozone
$\bar{r}_t^{eu}$	Equilibrium real IBL rate in the Eurozone
r_t^{eu}	Real IBL rate in the Eurozone
$\hat{r}_t^{eu}$	Real IBL rate gap in the Eurozone
i_t^{cn}	Nominal IBL rate in China
$\bar{r}_t^{cn}$	Equilibrium real IBL rate in China
r_t^{cn}	Real IBL rate in China
$\hat{r}_t^{cn}$	Real IBL rate gap in China
i_t^{us}	Nominal IBL rate in the US
$\bar{r}_t^{us}$	Equilibrium real IBL rate in the US
r_t^{us}	Real IBL rate in the US
$\hat{r}_t^{us}$	Real IBL rate gap in the US
p_oil_t	Nominal price of Brent crude oil (oil price)
rp_oil_t	Relative oil price
Δrp_oil_t	Annualized growth of the relative oil price
$\Delta 4rp\_oil_t$	Growth of the relative oil price period to corresponding period of previous year
$\overline{rp\_oil}_t$	Equilibrium relative oil price
$\widehat{rp\_oil}_t$	Relative oil price gap
$\Delta\overline{rp\_oil}_t$	Annualized growth of the equilibrium relative oil price
$\varepsilon_t^{\bar{y}}$	Shock to the level of equilibrium GDP

Continuation of the table A.1

Designation	Variable
$\varepsilon_t^{\Delta\bar{y}}$	Shock to the growth of equilibrium GDP
$\varepsilon_t^{\hat{y}}$	Demand shock (output gap shock)
$\varepsilon_t^{\widehat{rfx}}$	Budget expenditures gap shock
$\varepsilon_t^{\Delta\overline{rfx}}$	Shock to the growth of equilibrium budget expenditures
$\varepsilon_t^{\Delta wage}$	Nominal wages shock
$\varepsilon_t^{\Delta\overline{rwage}}$	Shock to real equilibrium wages growth
ε_t^{π}	Inflation measurement shock
$\varepsilon_t^{\Delta\overline{rp}}$	Equilibrium relative price growth shock
$\varepsilon_t^{\pi_{core}}$	Core inflation shock
$\varepsilon_t^{\pi_{noncore}}$	Non-core inflation shock
$\varepsilon_t^{\pi^T}$	Inflation target shock
ε_t^{s}	Shock to NEER
$\varepsilon_t^{\Delta\bar{z}}$	Equilibrium REER growth shock
$\varepsilon_t^{\overline{prem}}$	Equilibrium risk premium shock
$\varepsilon_t^{\widehat{prem}}$	Risk premium gap shock
$\varepsilon_t^{\Delta\bar{x}}$	Equilibrium exports growth shock
$\varepsilon_t^{\bar{x}}$	Equilibrium exports level shock
$\varepsilon_t^{\hat{x}}$	Exports gap shock
$\varepsilon_t^{\Delta\bar{m}}$	Equilibrium imports growth shock
$\varepsilon_t^{\bar{m}}$	Equilibrium imports level shock
$\varepsilon_t^{\hat{m}}$	Imports gap shock
$\varepsilon_t^{\widehat{tot}}$	Terms of trade gap shock
$\varepsilon_t^{\Delta\overline{tot}}$	Equilibrium terms of trade growth shock
ε_t^{i}	Nominal IBL rate shock (monetary policy shock)
$\varepsilon_t^{\bar{r}}$	Equilibrium real IBL rate shock

End of the table A.1

Designation	Variable
$\varepsilon_t^{\Delta i\_l}$	Nominal lending rate change shock
$\varepsilon_t^{\overline{spread}^l}$	Equilibrium credit spread shock
$\varepsilon_t^{\Delta i\_d}$	Nominal deposit rate change shock
$\varepsilon_t^{\overline{spread}^d}$	Equilibrium deposit spread shock
$\varepsilon_t^{\hat{y}^{ru}}$	Russia output gap shock
$\varepsilon_t^{\hat{y}^{eu}}$	EU output gap shock
$\varepsilon_t^{\hat{y}^{cn}}$	China output gap shock
$\varepsilon_t^{\hat{y}^{us}}$	US output gap shock
$\varepsilon_t^{\pi^{ru}}$	Russia inflation shock
$\varepsilon_t^{\pi^{eu}}$	Eurozone inflation shock
$\varepsilon_t^{\pi^{cn}}$	China inflation shock
$\varepsilon_t^{\pi^{us}}$	US inflation shock
$\varepsilon_t^{i^{ru}}$	Shock of nominal IBL rate in Russia
$\varepsilon_t^{\bar{r}^{ru}}$	Shock of equilibrium real IBL rate in Russia
$\varepsilon_t^{i^{eu}}$	Shock of nominal IBL rate in the Eurozone
$\varepsilon_t^{\bar{r}^{eu}}$	Shock of equilibrium real IBL rate in the Eurozone
$\varepsilon_t^{i^{cn}}$	Shock of nominal IBL rate in China
$\varepsilon_t^{\bar{r}^{cn}}$	Shock of equilibrium real IBL rate in China
$\varepsilon_t^{i^{us}}$	Shock of nominal IBL rate in the US
$\varepsilon_t^{\bar{r}^{us}}$	Shock of equilibrium real IBL rate in the US
$\varepsilon_t^{\Delta\overline{rp\_oil}}$	Shock of equilibrium relative oil price growth
$\varepsilon_t^{\widehat{rp\_oil}}$	Shock of relative oil price gap

Source: author's calculations.

Table A.2: Calibration of the baseline model parameters

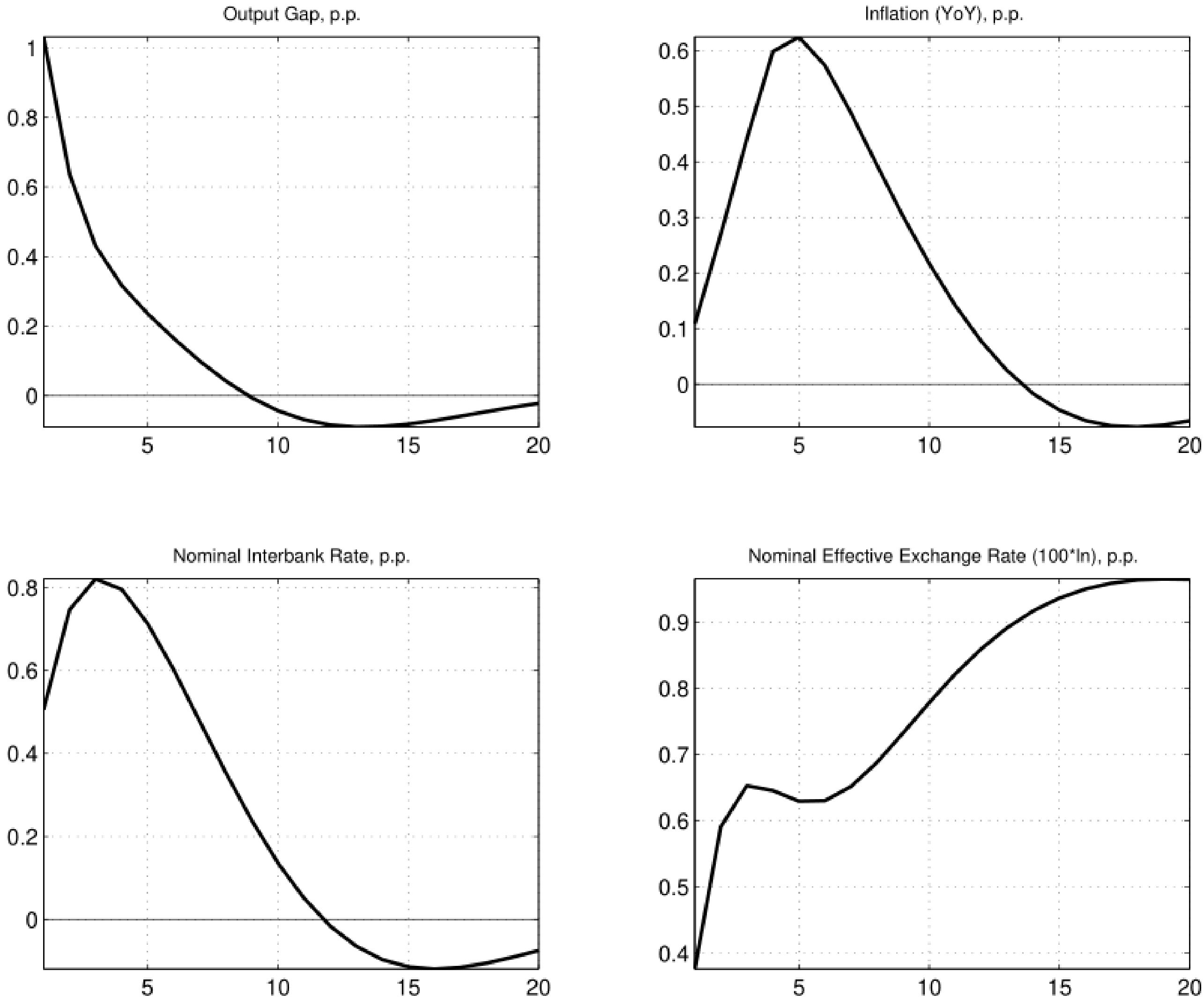
Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
ab_1	0.90	k_2	0.25	$\Delta\overline{tot}_{ss}$	2.00	a^{y_us}	0.50
$\Delta\bar{y}_{ss}$	1.00	bb_1	0.60	π^*_{ss}	3.20	b^{π_ru}	0.60
a_1	0.55	bb_2	0.05	mm_1	0.60	π^{ru}_{ss}	4.00
a_2	0.05	bb_3	0.10	mm_2	0.55	b^{π_eu}	0.60
a_3	0.20	tar_1	0.90	mm_3	0.30	π^{eu}_{ss}	2.00
a_4	0.35	π^T_{ss}	6.00	w_1	0.70	b^{π_cn}	0.60
a_5	0.10	h_1	0.30	s_1	0.15	π^{cn}_{ss}	2.00
a_6	0.15	h_2	0.90	s_2	0.10	b^{π_us}	0.60
m_1	0.50	h_3	0.45	s_3	-0.15	π^{us}_{ss}	2.00
m_2	0.15	z_1	0.75	s_4	0.70	c^{i_ru}	0.75
m_3	0.35	$\Delta\bar{z}_{ss}$	2.00	s_5	4.70	$\bar{r}^{ru}_{ss}$	2.00
f_1	0.50	pr_1	0.80	w_2	0.90	c^{r_ru}	0.90
f_2	0.90	pr_2	0.40	$\overline{spread}^l_{ss}$	2.00	c^{i_eu}	0.75
$\Delta\overline{rfx}_{ss}$	1.00	$\overline{prem}_{ss}$	-0.40	q_1	0.50	$\bar{r}^{eu}_{ss}$	0.00
aa_1	0.55	u_1	0.80	q_2	0.20	c^{r_eu}	0.90
aa_2	0.40	$\Delta\bar{x}_{ss}$	2.00	q_3	-0.30	c^{i_cn}	0.75
aa_3	0.25	c_1	0.45	q_4	0.85	$\bar{r}^{cn}_{ss}$	1.00
aa_4	0.85	c_2	0.45	q_5	1.35	c^{r_cn}	0.90
$wedge$	3.00	c_3	0.25	w_3	0.90	c^{i_us}	0.75
$weight$	0.7070	uu_1	0.90	$\overline{spread}^d_{ss}$	0.00	$\bar{r}^{us}_{ss}$	0.50
rr_1	0.90	$\Delta\bar{m}_{ss}$	2.00	w^{ru}	0.60	c^{r_us}	0.90
$\Delta\overline{rp}_{ss}$	-0.80	d_1	0.40	w^{eu}	0.10	o_1	0.90
b_1	0.35	d_2	1.00	w^{cn}	0.10	$\Delta\overline{rp\_oil}_{ss}$	-2.00
b_2	0.09	d_3	0.10	a^{y_ru}	0.50	o_2	0.50
b_3	0.20	r_1	0.55	a^{y_eu}	0.50		
k_1	0.45	r_2	0.90	a^{y_cn}	0.50		

Source: author’s calculations.

Appendix B

Impulse response functions to underlying macroeconomic shocks

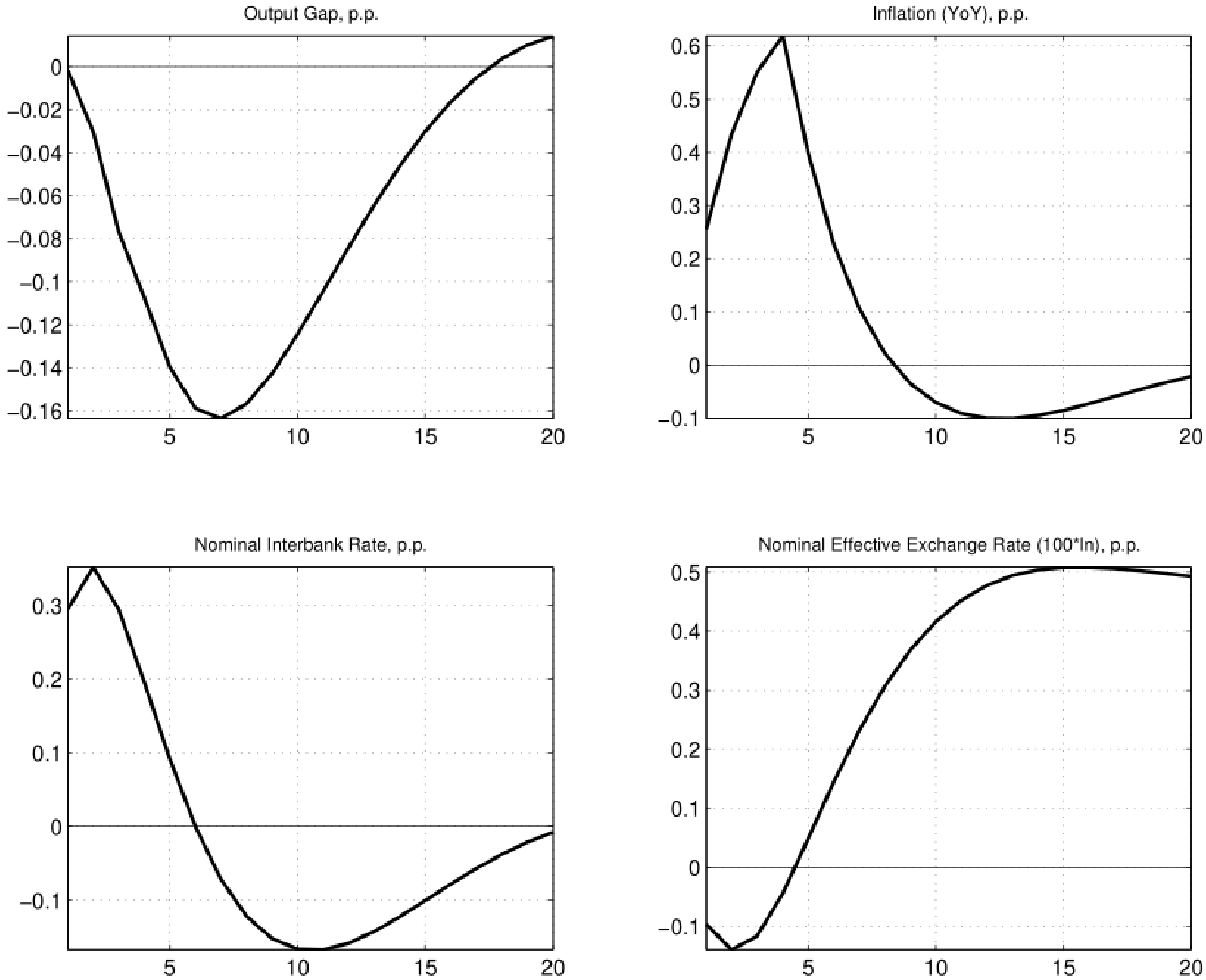
Figure B.1: Impulse response function to output gap shock



Source: author's calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

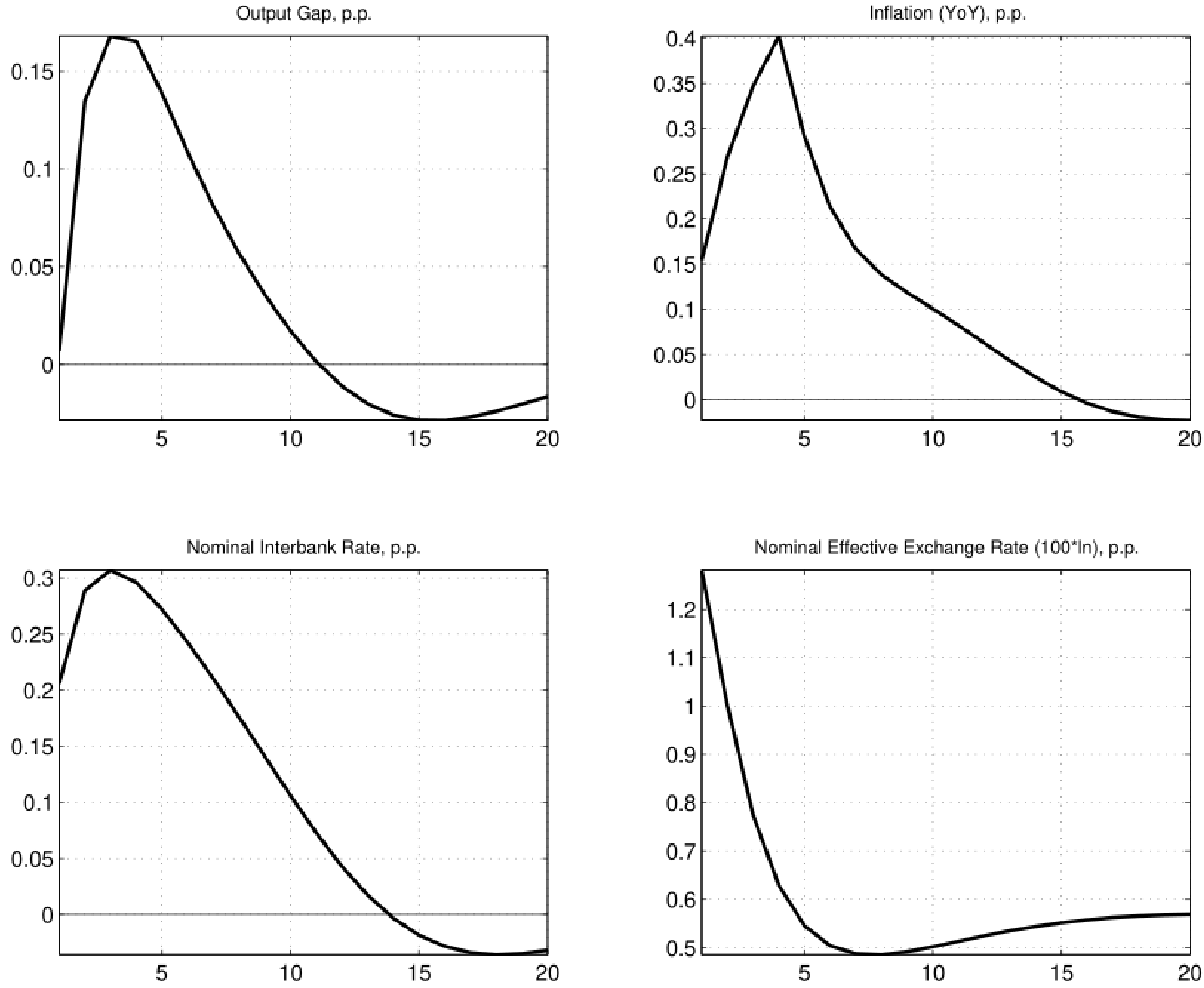
Figure B.2: Impulse response function to core inflation shock



Source: author's calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

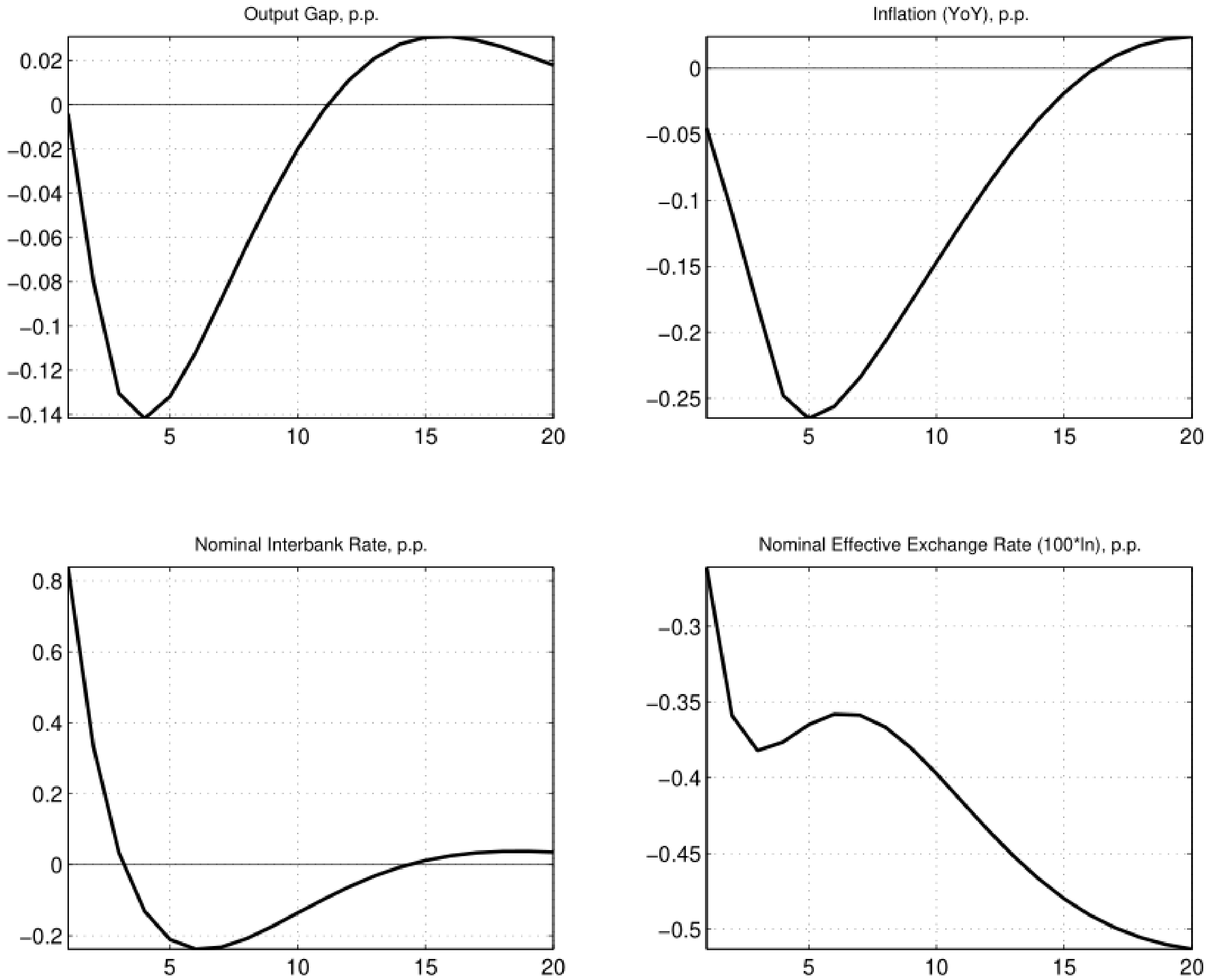
Figure B.3: Impulse response functions to a shock to the nominal effective exchange rate of the Belarusian ruble



Source: author's calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

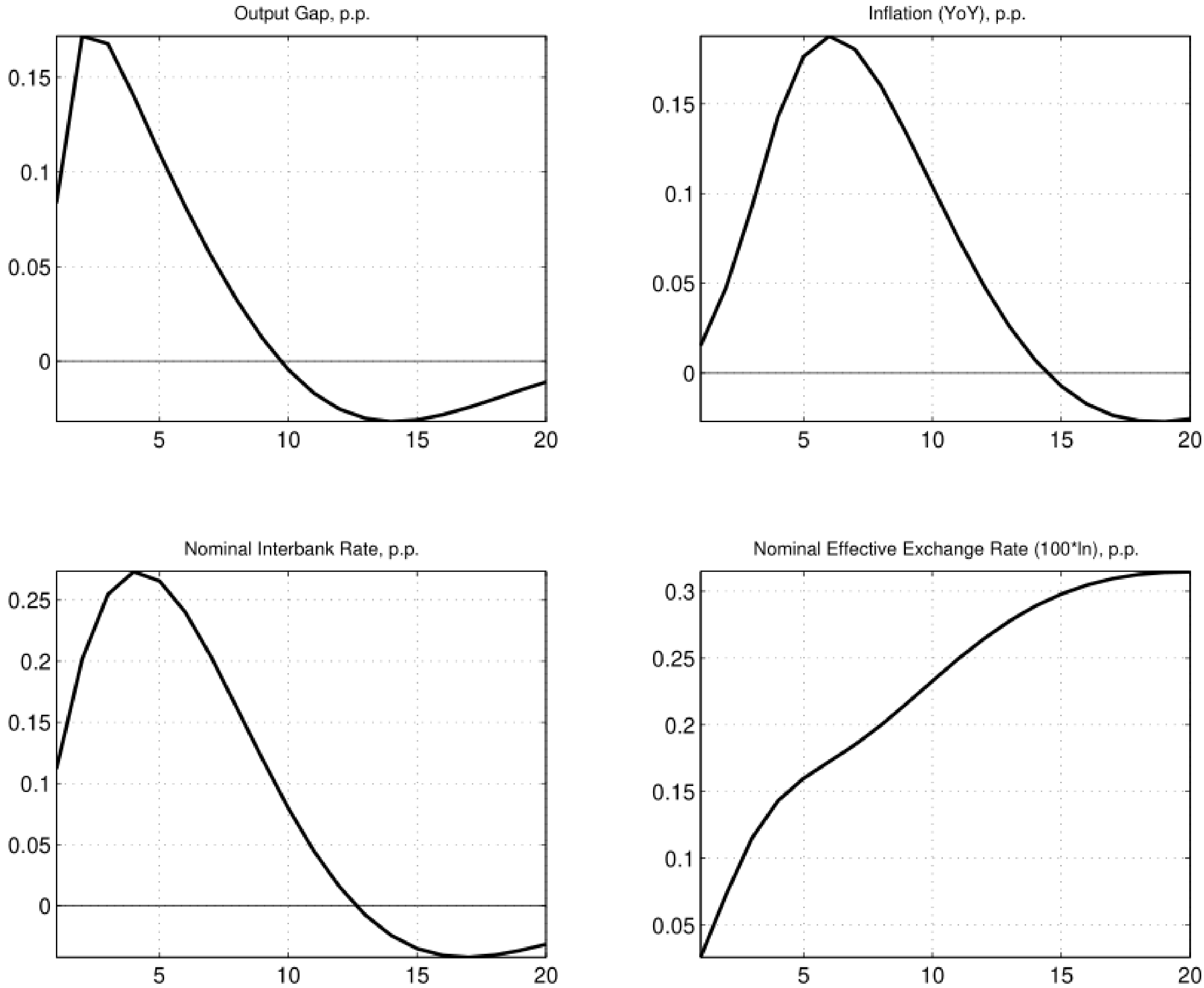
Figure B.4: Impulse response functions to a shock to the nominal interbank market rate



Source: author's calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

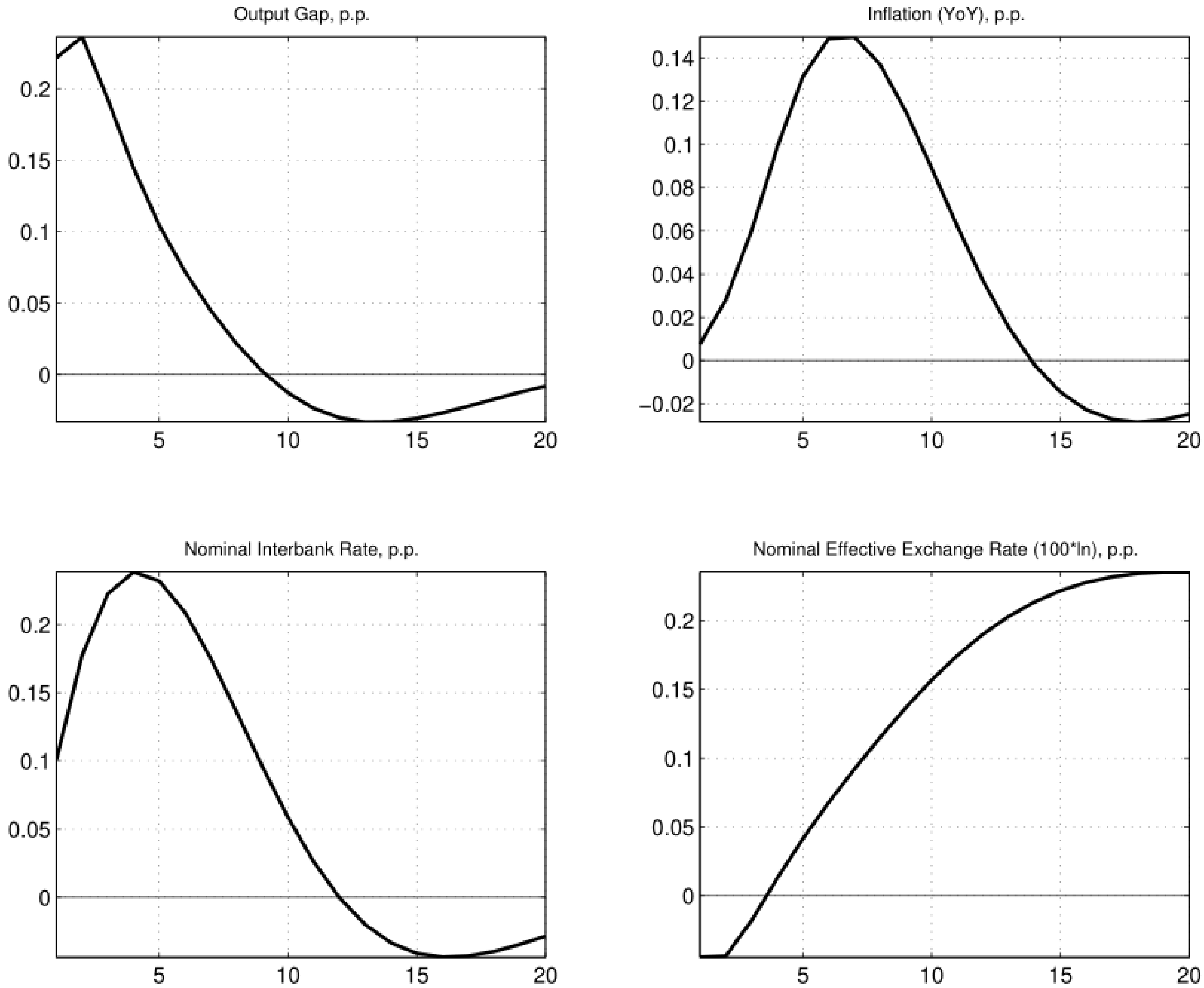
Figure B.5: Impulse response functions to a shock of real non-interest expenditures of the consolidated budget of Belarus



Source: author’s calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

Figure B.6: Impulse response functions to the output gap shock in Russia



Source: author's calculations.

Note: the impulse response functions are presented in terms of deviations of variables from their equilibrium levels.

Appendix C

In-sample simulations under the macroeconomic gap-model

Table C.1: Forecast accuracy based on historical data from 2016 to 2021

Variable	The ratio of RMSEs for a gap-model over random walk, for the forecast horizon quarters ahead					
	1Q	2Q	3Q	4Q	5Q	6Q
Headline inflation, % YoY	0.39	0.37	0.43	0.50	0.51	0.60
Core inflation, % YoY	0.57	0.49	0.52	0.61	0.62	0.72
Real GDP, % YoY	0.33	0.40	0.52	0.48	0.45	0.51
Nominal wage, 100*ln	0.39	0.33	0.32	0.32	0.30	0.28
NEER, 100*ln	0.92	0.85	0.74	0.61	0.48	0.43
Nominal IBL rate, %	0.73	0.45	0.45	0.47	0.44	0.37
Nominal rate on ruble market loans, %	0.55	0.44	0.42	0.54	0.57	0.56
Nominal rate on ruble time deposits, %	0.73	0.44	0.42	0.54	0.57	0.56

Source: author's calculations.

Note: YoY is the growth rate quarter to the corresponding quarter of the previous year. QoQ is the annualized growth rate quarter to the previous quarter. The simulations were conducted for the period from the Q1 2016 to the Q4 2021. The years 2022 and 2023 were not considered as the Belarusian economy experienced a shock from sanctions during this period, making it challenging to forecast based solely on the historical dynamics of macroeconomic variables. During the simulations, it is assumed that the values of all exogenous variables in the model are known, including budget expenditures, terms of trade, and non-core inflation, the specification of which in the model is simplified. All other observable variables are known only up to the quarter preceding the forecast period.