Bank of Russia

Semi-structural economic model of Far Eastern macroregion

Working Paper Series

No. 127 / February 2024

V. Zhurakovsky
A. Novopashina
D. Grishin
E. Bulyga

Vladislav Zhurakovsky
Far Eastern Main Branch of the Bank of Russia
E-mail: ZhurakovskiyVP@cbr.ru

Alina Novopashina
Far Eastern Main Branch of the Bank of Russia
E-mail: NovopashinaAN@cbr.ru

Danil Grishin
Far Eastern Main Branch of the Bank of Russia
E-mail: GrishinDV@cbr.ru

Elizaveta Bulyga
Far Eastern Main Branch of the Bank of Russia
E-mail: bulygaes@cbr.ru

Cover photo: Primorye Territory, Russky Bridge. Source: Shutterstock/FOTODOM

Bldg. B, 12 Neglinnaya Street, Moscow 107016, Russia
Tel.: +7 499 300-30-00, +7 495 621-64-65 (fax)
Bank of Russia website: www.cbr.ru

Contents

Abstract

A high degree of heterogeneity in key macroeconomic indicators is characteristic of Russia's regions. This may cause an asymmetric reaction of regional economies to various shocks, including common monetary policy shocks. The purpose of this study is to develop a tool for analysing the economy of the Far Eastern macroregion (FEMR): a semi-structural model that takes into account the particularities of the Russian Far East. These include the region's smaller contribution to main national macroeconomic indicators compared to the other macroregion's, greater integration into Asia-Pacific markets in contrast to the country as a whole, and a high share of external demand-oriented industries in output.

The model is used to estimate the contribution of internal and external shocks to the dynamics of the main macroeconomic variables of the FEMR such as output and inflation. By comparing the contribution of shocks to output and inflation in 2016–2022, we show that oil price shocks and fiscal policy shocks contributed more to the development of the output gap in the Far Eastern macroregion than in Russia as a whole in this period. This is due to the heavy dependence of the Far East economy on oil exports and the influx of funds from the federal budget to implement large investment projects. However, external sector shocks made a smaller contribution to the dynamics of the macroregion's output gap in comparison with the entire country. Compared to Russia as a whole, inflation in the Far Eastern macroregion has greater inertia and dependence on service price shocks but less contribution of food price shocks. The reason is the low self-sufficiency of the macroregion in food, as a result, a significant share of products is delivered from other regions. This determines a high share of logistics costs in the price of final consumer goods, which in some periods partially offset the high volatility of food prices.

Key words: Far Eastern macroregion, semi-structural model, output gap, inflation, monetary policy

JEL codes: E31, E32, E37, E52

1. Introduction

Under the inflation targeting strategy pursued by the Bank of Russia since the end of 2014, an economic forecast over the horizon of the transmission mechanism plays an important role in making monetary policy decisions. The medium-term forecast of the Bank of Russia made on the basis of aggregated information at the countrywide level. However, Russia is characterised by heterogeneity of its regions in terms of business cycle stages, economic structure, participation in foreign economic relations, price levels, and inflation. Consequently, the same shocks, as well as the monetary policy pursued taking them into account, may have varying impacts on the economies of different Russian regions.

The Far Eastern macroregion[1] (FEMR) is characterised by a larger share of the extractive sector in the output structure than in the country as a whole. Economic ties in the macroregion are more developed with Asian countries than in other Russian regions, and are poorly oriented towards the demand of the rest of Russia. These features may cause deviations from the Russian as a whole dynamics of macroeconomic variables and lead to different responses to various shocks.

Our study aims to develop a model that helps assess the impact of internal and external shocks on the main macroeconomic indicators of the Far Eastern macroregion, taking into account the particularities of its economy.

Semi-structural quarterly projection models (QPMs) are one of the tools widely used by central banks to estimate the impact of various shocks on the economy. This class of models is based on neo-Keynesian assumptions. First, they are based on the assumptions of imperfect competition in commodity and/or factor markets and nominal price rigidity. These two basic conditions determine that nominal variables (in particular, nominal interest rates) can influence real variables (in particular, real income and output) in the short and medium term. That is, these assumptions shape the core of the monetary policy transmission mechanism. Second, the dynamics of output are determined by changes in demand in the short term. In other words, fluctuations in aggregate demand form the basis of economic cycles. Third, the main macroeconomic variables are determined by both rational (forward-looking) and adaptive (backward-looking) expectations.

The model is based on four behavioural equations (*Berg et al., 2006a, 2006b*): (i) an aggregate demand curve describing the relationship between aggregate demand and the interest rate; (ii) an aggregate supply (Phillips) curve describing the relationship between inflation and output; (iii) the monetary policy (Taylor) rule governing the setting of the interest rate in the economy; and (iv) the no-arbitrage condition in financial markets (also known as the uncovered interest rate parity condition) determining the dynamics of the national currency exchange rate as a function of the ratio between interest rates in domestic and foreign markets.

This paper describes a tool (a semi-structural model) for analysing the FEMR economy. This model is mainly characterised by the division of aggregate demand into three components: (1) consumer demand, which is driven by the ability and willingness of the macroregion's population to buy goods and services on the local market; (2) resource demand, which relies on demand from external (primarily Asian) markets; and (3) investment

[1] In this paper, the Far Eastern macroregion is understood to comprise nine regions (the Republic of Sakha (Yakutia), the Primorye Territory, the Khabarovsk Territory, the Amur Region, the Jewish Autonomous Region, the Sakhalin Region, the Magadan Region, the Kamchatka Territory, and the Chukotka Autonomous Area) that were part of the Far Eastern Federal District until 2018, that is before the Trans-Baikal Territory and the Republic of Buryatia were included in the Far Eastern Federal District. This approach is explained by the fact that the model described in this paper is an analysis tool used by the Far Eastern Main Branch of the Bank of Russia, which has territorial divisions located in these nine regions.

demand, which mostly depends on the implementation of large investment projects in the macroregion with significant government support.

Using the model, we estimated the impact of internal (arising within the FEMR) and external (arising in other Russian regions or in the external sector) shocks on output and inflation in the macroregion. Our findings show that the contribution of individual shocks to the dynamics of output in the FEMR was different from that in Russia as a whole in the period after the Bank of Russia's transition to the inflation targeting strategy. The reason for this is the higher dependence of the macroregion on resource exports and on the intensity of implementation of large investment projects. Thus, the dynamics of FEMR output in 2016–2022 were more affected by oil price and fiscal policy shocks than in the country at large. At the same time, external demand shocks had less impact, as business activity in Asian countries was less volatile than in the G7 countries, which were Russia's economic partners. The structure of the FEMR economy also causes its aggregate output to react less to changes in the key rate than in Russia as a whole. However, consumer demand in the macroregion and consumer demand in the entire country react to monetary policy shocks in a similar way. The inflation response to these shocks in the macroregion is similar to that in Russia as a whole, but it takes some more time (on average by one quarter) for inflation in the FEMR to return to target after changes in the key rate than in the country as a whole.

The rest of this paper is structured as follows. Section 2 reviews the literature on the significance of regional information in making monetary policy decisions and discusses approaches to incorporating regional features in semi-structural models. Section 3 describes the characteristics of the FEMR economy that should be accounted for in the model. Section 4 outlines the structure, main equations, and properties of the model. Section 5 compares the impact of shocks on the main macroeconomic variables (output and inflation) of the FEMR and the entire country. Finally, Section 6 summarises the key findings and results.

2. Regional heterogeneity: significance for monetary policy and consideration in building semi-structural models

An important indicator in the context of studying the debt burden is the debt service ratio, which represents the ratio of interest and debt amortisation costs to income. *Drehmann and Juselius (2012)* developed a methodology for calculating the debt service ratio that takes into account the amount of outstanding debt, its maturity, and the interest rate (see the Methodology section for more detail).

The objective of the Bank of Russia's monetary policy is to maintain price stability. For this purpose, the regulator sets a public quantitative inflation target for the country as a whole. The country's regions are not uniform in terms of business cycle phases (*Kryzhanovskiy and Zykov, 2021*), and the level of prices and inflation. *Perevyshin et al. (2017)* showed that differences in regional price levels are driven by the Balassa–Samuelson effect. This effect is characterised by disparities in wages, the share of services in output, the share of social payments in income, the costs of regional trade (related to the distance between a given region and other regions of the country), and the level of monopolisation of retail trade. Regions react differently to countrywide shocks. According to *Perevyshin and Egorov (2016)*, in 2002–2015, 90% of the variation in regional inflation was explained by countrywide factors. According to *Deryugina et al. (2018)*, idiosyncratic (specific to a particular region and product) and sectoral shocks had a considerable (38% and 20%, respectively) impact on inflation between December 2003 and June 2016. Some regions (mainly in the Far East and North Caucasus) are characterised by a high contribution of idiosyncratic and regional factors to inflation. *Zhemkov (2019)* showed that differences in regional inflation in Russia in 2015–2018, that is after the transition to inflation targeting, are explained mainly by regional factors characterising the phase of the business cycle: the dynamics of differences in the productivity of tradable and non-tradable industries (the Balassa–Samuelson effect), the nominal effective exchange rate in the region, price expectations of companies in the region, current incomes of the regional population, and trends in grain stocks. Maintaining inflation at 4% for the country as a whole is possible even if there is a steady deviation of inflation in some regions from the target ('structural' inflation). Inflation growth rates may be higher than the national average in the Central and North-Western Federal Districts and lower in the Volga, Urals, Siberian, and Far Eastern Federal Districts. At the same time, the deviation of the structural inflation rate in the Far Eastern Federal District from the 4% target for Russia does not exceed 0.1pp.

The high degree of regional heterogeneity in key macroeconomic indicators may cause an asymmetric response of regional economies to shocks of common monetary policy. Researchers identify several sources of differences in the responses of regions and countries to this policy.

The first source is the diversity of the economic structure, which determines the asymmetric impact of the ***interest rate channel*** of the transmission mechanism. Demand for the industrial sector products is more sensitive to changes in interest rates in the economy than demand in the services sector (*Bennett, 1990*). Consequently, the response of regions to a monetary policy shock will become stronger as the share of the industrial sector in output increases. The more diversified the structure of the economy, the less sensitive a region is to monetary policy shocks.

The second source of heterogeneity in the response to monetary policy shocks is differences in the impact of the ***credit channel***. The higher the share of bank loans in companies' total borrowings and the share of regional banks in the economy, the stronger monetary policy effects (*Kashyap and Stein, 1997*). In addition, tightening results in a meaningful reduction in lending to small companies, causing significant differences in sales and investment growth between small and large companies in the two years after the shock (*Gertler and Gilchrist, 1993; Gertler and Gilchrist, 1994*). Thus, the effect of the credit channel also depends on market concentration: the higher the share of small companies, the greater the impact of a change in monetary policy on the economy.

The third source of heterogeneity is differences in the impact of the ***currency channel*** of the transmission mechanism. This channel is of high significance in small open economies characterised by a strong dependence on foreign trade. For example, *Svensson (2012)*, using a VAR-model built on data from 1993 Q1 to 2007 Q4, showed that employment response heterogeneity to a common monetary policy shock in 21 regions of Sweden is due to the asymmetric impact of both the interest rate and currency channels: monetary policy effects are more pronounced in regions with high export intensity.

Carlino and DeFina (1998) found empirical evidence of heterogeneity in regional responses to a common monetary policy shock due to asymmetry in the functioning of the interest rate and credit channels, based on an example of US regions between 1958 Q1 and 1992 Q4. The authors identify a region (the Great Lakes) where the personal income response to a monetary policy shock is stronger than for the United States as a whole, and regions (the Rocky Mountains and the Southwest) where the personal income response is, to the contrary, weaker than for the USA as a whole. *Pizzuto (2020)* also showed the heterogeneous effects of monetary policy tightening in US regions, using data over the extended period from 1963 Q3 to 2008 Q4, based on a spatial model describing the dependence of real household income and unemployment on monetary conditions.

The findings of *Carlino and DeFina (1998)* were further used to determine the extent to which euro area countries respond to common monetary policy shocks (*Carlino and DeFina, 2000*). The authors identified three groups of countries: those responding strongly to monetary policy shocks (Finland, Ireland, and Spain), those responding weakly (France, Italy, and the Netherlands), and countries whose response is close to that of the euro area as a whole (Austria, Belgium, Portugal, Germany, and Luxembourg).

Herreño and Pedemonte (2022) also found differences in monetary policy effects using disaggregated quarterly data of 28 US cities from 1969 to 2008. For this purpose, the authors used a model built on panel data and describing the dependence of inflation forecasts on monetary shocks, income, and monetary shocks multiplied by the income variable. To identify regional differences, the model was estimated on the entire sample and data from the 10^{th} and 90^{th} percentiles of cities ranked by income. The monetary policy shock leads to a smaller decline in inflation in high-income cities compared to low-income cities: inflation in the 10^{th} percentile declines 50% more than the sample average, whereas inflation in the 90^{th} percentile declines 50% less). This result is valid for both the overall CPI and its individual components, which are singled out depending on the tradability of goods and services. The impact of monetary policy on economic activity also varies unevenly across regions. Using a model for employment similar to that for inflation, the authors show that monetary policy shocks reduce employment in the entire sample, with the poorest cities making the main contribution. Monetary policy shocks have almost no impact on employment in high-income regions. To explain these regional differences, *Herreño and Pedemonte (2022)* used a TANK-model with two types of households: Ricardian (*non-hand-to-mouth*) and poor (*hand-to-mouth*). The share of poor households is higher in low-income regions. Such households, unlike Ricardian households, cannot smooth their consumption over time in response to a monetary policy shock, so they increase labour supply. This reduces marginal costs and, as a result, the prices of locally produced goods, thus causing variations in regional inflation rates. In addition, positive monetary policy shocks trigger a meaningful reduction in the labour supply of Ricardian households in regions with a high share of poor households. This determines differences in the employment response to monetary policy shocks. The authors also conclude that rising inequality across US regions magnifies the impact of monetary policy on both inflation and employment.

Studies based on EU data indicate that the optimal monetary policy varies from country to country. *Quint (2016)* assessed the differences between the actual interest rate set by the ECB and the optimal rate determined by the Taylor rule (the so-called monetary policy stress). The results show significant cross-country differences in the levels of monetary policy stress in the early years of the economic and monetary union. The ECB's monetary policy was too soft for periphery countries (Portugal, Ireland, Greece, and Spain) and too tight for some 'core' countries (e.g. Germany). The level of monetary policy stress declined and approached zero by 2009. More than half of the variance in monetary policy stress between 1999 and 2009 was accounted for by the periphery countries. After 2009, the stress level rose again, and the main contribution to this rise came from Greece and Germany, as the financial crisis had the opposite effect on the business cycles of these two countries (*Gächter et al., 2012*). Stress levels in euro area countries were in line with those in the US states and only slightly higher than in the German states before the introduction of the euro.

Research conducted on Russian data has proved the importance of regional factors in explaining the heterogeneity of responses of Russian regions to monetary policy shocks. In particular, *Napalkov et al. (2021)* showed that the magnitude of the response of regional core inflation to the actions of monetary authorities is heterogeneous. Specifically, speaking of the region's core inflation responding to a monetary policy shock, the stronger the shock, the higher the share of mining industries in gross regional product (GRP), the share of loans to manufacturing-related businesses, the share of employment in small businesses in the region, and the regional unemployment rate. A stabilisation discretionary monetary policy is capable of moderately reducing the variation in regional inflation caused by heterogeneous reactions to foreign exchange rate shocks (this effect is not observed in the case of oil price or any long-term shocks). In the long run (over the horizon of five years), the contribution of monetary policy shocks to regional inflation is rather large (32%), which may cause differences in inflation rates.

Averin et al. (2018) failed to find a link between unemployment and inflation in regions characterised by high average per capita income, a high share of economically active population, and a low unemployment rate (mainly the Russian North and Moscow).[2] The authors explain this result by the fact that inflation in these regions is largely determined by high transport costs and government-subsidised wages, which distort market price mechanisms. However, the authors found a negative correlation between unemployment and inflation in the other Russian regions characterised by medium to low average per capita income, a medium to low share of active population, and medium to high unemployment. In this case, inflation is described by both adaptive and forward-looking components. The result obtained in the paper is indirect evidence that common monetary policy can exert various effects on regions: the responses to monetary policy shocks of regions with a high contribution of transport costs to prices and rigid wages will be weaker than the national average.

Thus, current empirical studies prove the possibility of an asymmetric impact of common monetary policy on individual regions of the country depending on the structure and size of their economies, economic cycles, and market structures. Should we consider the specific features of certain regions when implementing monetary policy? Can the consideration of disaggregated information improve the quality of monetary policy decisions?

The role of regional information in monetary policy decision-making is widely discussed in the literature. This issue has been more extensively studied in the case of euro area countries that do not possess monetary sovereignty. Conclusions regarding the importance of regional information in common monetary policy largely depend on both the period in which the research was conducted and the approach used.

One approach to investigating the value of regional information in monetary policy decision-making is to compare projections derived from aggregate information for the entire euro area with those derived from country-specific data. Based on a comparison of various forecasting models of inflation and indicators of actual economic activity (real GDP, industrial production, and unemployment) of the euro area countries from 1982 to 1997, *Marcellino et al. (2003)* concluded that forecasts constructed by aggregating country models are more accurate than those built on aggregate data. *Cristadoro et al. (2013)* compared an inflation forecast based on a set of variables for the entire euro area with one that utilises data for individual members of the monetary union and a weighted average forecast of country price indices using data for euro area countries for the more recent period from 1992 to 2010 (including the period after the establishment of the monetary union). The estimates obtained indicate that complementing the euro area data with country-specific information does not lead to a meaningful improvement in forecast quality. Preliminary selection of country variables only marginally improves forecasts. Short-term interest rates react strongly to

[2] In total there are eight regions of this type: Moscow, the Tyumen Region, the Magadan Region, the Sakhalin Region, the Murmansk Region, the Komi Republic, the Kamchatka Territory, and the Chukotka Autonomous Area.

expected inflation in the euro area as a whole and do not respond to expected inflation in individual countries.

Another common approach to investigating the issue of incorporating information about specific euro area countries in monetary policy decisions is the use of regression models that help estimate the impact of various factors on inflation and economic activity. *Beck et al. (2009)* showed that the impact of common factors on inflation is heterogeneous in individual euro area countries. Using monthly data from January 1995 to October 2004, the authors built a model of the dependence of inflation in the euro area on three groups of factors: common and country-specific factors, and an idiosyncratic component. The estimation results show that the components unrelated to the common and external factors explain at least 25% of the variation in inflation, whereas the contribution of the idiosyncratic component is not significant. Thus, the authors conclude that information on euro area inflation rates may help improve the understanding of the overall regional inflation dynamics needed to make monetary policy decisions.

The role of information on individual euro area countries, especially those located in the periphery (Portugal, Ireland, Greece, and Spain, which account for less than 20% of euro area GDP), increased significantly when ECB rates were set before and during the 2009–2010 debt crisis (*Bouvet et al., 2013*). The authors introduce additional variables into the Taylor rule: the deviation of GDP and inflation expected in 12 months in core euro area countries (Germany, France, Italy, the Netherlands, Austria, Belgium, and Finland) and in the periphery countries from median GDP and inflation in the euro area as a whole, and the second lag of the interest rate. The results show that the contribution of the output gap of the periphery countries in the Taylor rule increased, whereas that of the core countries remained insignificant between November 2009 and October 2010. Thus, the authors conclude that when the periphery countries experienced an economic downturn, the ECB supported them by softening monetary policy, that is by deviating from the policy based on data from the euro area as a whole.

The results of studies based on data from developing countries do not allow us to draw a clear conclusion about the contribution of countrywide and regional factors to inflation trends. For example, *Marques et al. (2014)* showed that countrywide factors explain only a small part of the variance of inflation, using a model describing the dependence of the inflation rate on countrywide and spatial factors. The model was constructed on the basis of monthly price growth data of 98 traded goods in 23 cities in Chile from January 2003 to September 2006. This result contradicts the conclusion obtained by *Beck et al. (2009)* for euro area countries. Spatial effects, that is inflation dynamics in neighbouring regions, contribute the most to inflation variance. *Winkelried and Gutierrez (2015)* used an error correction model based on monthly data for inflation in nine regions of Peru from 1996 to 2011; it takes into account spatial effects. The authors find that the growth rates in individual regions are largely shaped by inflation in the capital city of Lima, which accounts for about one-third of the country's population and 70% of its total expenditure. The convergence of price growth rates in individual regions and Lima occurs over the monetary policy horizon, that is within 1–2 years after the rate change. Based on this, the authors conclude that it is sufficient for the Central Reserve Bank of Peru to focus only on the price growth rate in the capital to stabilise inflation in the entire country.

The use of structural models is another widely used approach to investigating the inclusion of regional information in monetary policy decisions. *Benigno (2004)* studied the optimal implementation of monetary policy in a currency area and showed that more weight should be given to the inflation rate in regions with greater nominal price rigidities when making monetary policy decisions, if regional price responses to shocks are asymmetric. The reason is that such regions suffer greater well-being losses from changes in inflation than regions with lower nominal price rigidities. Hence, such regions contribute more to the overall loss function of the currency area. However, if nominal regional price rigidities are equal, then the optimal strategy is to target regional inflation rates weighted by the size of the economies. This conclusion was later refined by *Benigno and Lopez-Salido (2006)*. They showed that neo-Keynesian Phillips curves vary considerably across euro area countries. Thus, inflation in Germany (35% of euro area GDP) is determined by the forward-looking component, while inflation in France, Italy, Spain, and, to a lesser extent, the Netherlands (53% of euro area GDP combined) is driven by both inflation expectations (the forward-looking component) and historical inflation (the adaptive component). Greater weight in monetary policy decision-making should be given to regions where inflation is driven by the adaptive component. In other words, the optimal inflation targeting strategy implies the adjustment of country weights for price rigidity and for the proportion of companies focusing on past inflation when setting prices. The authors note, however, that such a policy may give wrong incentives to countries, as it is more centred on countries where high inflation persists.

Empirical studies on the role of regional information in monetary policy decision-making in Russia are limited. *Novak and Shulgin (2020)* offered the most detailed treatment of this subject to date by comparing the impulse responses of three structural models: a multi-regional (global) full information model, a regional model, and an aggregated country data-only model. These models were built on quarterly data for the period from 2014 Q1 to 2019 Q4. The authors conclude that the regional approach to monetary policy decisions, which involves the weighting of rates consistent with monetary policy rules for individual regions, does not substantially improve the analysis of monetary policy provided by the aggregate information approach. This conclusion is based on the fact that the correlation of deviations of monetary policy decisions for these two approaches from the decisions obtained in the full information model is high. The authors note, however, that the correlation is not 100%, so weighting monetary policy decisions using the two approaches still has the potential to improve the quality of such decisions. Moreover, if a shock originates in a region with price rigidity above the country average, both regional and aggregate approaches lead to an inadequate monetary policy response to the shock. This finding confirms the results of *Benigno (2004)* on the appropriateness of increasing the inflation weights of regions with higher nominal price rigidities.

Thus, the available studies confirm the importance of disaggregated information in the case of regional heterogeneity and support the need to take it into account when making monetary policy decisions.

The Bank of Russia's modelling framework used for medium-term macroeconomic projections to make monetary policy decisions, including the QPM (*Orlov, 2021; Monetary Policy Report, No. 2, 2022*) and a number of DSGE-models (*Kreptsev and Seleznev, 2016; Kreptsev and Seleznev, 2017; Andreyev, 2020*), takes into account the specific features of the Russian economy, but does not involve the use of regional information.

In particular, the QPM accounts for the specific features of the Russian economy, first, by modelling individual inflation components (food products, non-food products, and services excluding utilities) linked to the overall inflation rate through relative prices (*Orlov, 2021*). Inflation of individual components depends on annual inflation expected in one year, the output gap, the change in the real exchange rate gap, and the gap in the relative prices of the respective component.

Second, the QPM for Russia includes the public sector, which plays a significant role in the creation of aggregate demand. In addition, the output gap is also determined by the real price of oil, modelled in a reduced form, and specified by an AR(1) process. Fiscal policy has an impact on aggregate demand: the greater the fiscal stimulus, the larger the output gap. Aggregate fiscal stimulus consists of federal budget stimulus and stimulus of the constituent entities of the Russian Federation. Each component is composed of stimulus from the revenue and expenditure parts of the budget, which are determined by the sum of discretionary shocks and adjustments for changes in the structural component.

The model was modified after the introduction of capital controls in February–March 2022 (*Monetary Policy Report, No. 2, 2022*). Under capital controls, the dynamics of the exchange rate became dependent on the state of the trade balance. To account for this feature, the output gap was subdivided into the domestic demand, export, and import gaps. The domestic demand gap is defined within the logic of Euler equations linking the current output gap to its future value, the real market interest rate gap, fiscal stimulus, and the real oil price gap. The export gap is determined by the external demand, real exchange rate, and oil price gaps, whereas the import gap is driven by the domestic demand and real exchange rate gaps. The uncovered interest parity equation introduces an additional condition of dependence of the real exchange rate gap on the trade balance gap (the difference of the export and import gaps) and the real oil price gap (the larger the trade balance gap and the real oil price gap, the smaller the real exchange rate gap). In the case of a partially isolated domestic financial market, a weighted combination of the standard uncovered parity equation and its modification for a capital-control regime is used. The tighter the capital controls, the more weight is given to the trade balance and real oil price gaps in the real exchange rate equation.

The DSGE-model in *Kreptsev and Seleznev (2016*) is based on a small number of equations and, for simplification, no capital is introduced into the model, and it is assumed that all exports are oil exports. The oil export assumption is also retained in the enhanced version of this model (with the banking sector included) presented in *Kreptsev and Seleznev (2017*). The model introduced by *Andreyev (2020*) includes equations describing the mechanism of the fiscal rule in the Russian Federation, which assumes the replenishment of the budget from oil and gas revenues and limitations on budget expenditures subject to oil and gas and non-oil and gas revenues, interest income, and 0.5% of GDP.

To date, models for certain Russian regions have been developed. They include, among others, the QPM for the Central Federal District (*Nelyubina, 2020; Korshunov and Nelyubina, 2021*), the regional semi-structural model of the Urals economy (DEMUR) (*Kryzhanovskiy and Zykov, 2021*), and the DSGE-model for the Volga-Vyatka region (*Novak and Shulgin, 2020*) were designed. The need to develop models for individual regions is due to the fact that, first, this provides additional information for monetary policy decision-making and, second, helps understand how common shocks, as well as those realised in other regions, affect the economy of a given region. The models for the Central Federal District and the Urals divide the Russian economy into two parts: the region under consideration and the rest of Russia (excluding this region), which are modelled separately but linked through the mutual influence of inflation and demand. Both models include the public sector block, which affects aggregate demand.

In the model for the Urals economy, in addition to the factors included in the conventional QPM and the budget expenditure gap, aggregate demand is also determined by the oil conditions index, which takes into account deviations of current oil production and world oil prices from average annual values, and by the price index of exported base metals, which is defined in terms of deviations from average annual values. The inclusion of these two variables in the aggregate demand equation is due to the resource nature of the Urals economy and its specialisation in oil and metal exports. The second feature of the model for the Urals economy is the inclusion of equations for regional nominal and real interest rates. The authors explain their addition by the significant excess of the nominal interest rate on loans in the region over the key rate of the Bank of Russia, as well as by the lower value of the consumer price index in the region compared to Russia as a whole, which has an additional impact on the difference between the regional and countrywide nominal rates.

The specific feature of the QPM for the Central Federal District is that, first, by analogy with the QPM for Russia as a whole, it includes four Phillips curves for individual components of inflation. Second, due to the single currency and common monetary policy throughout Russia, the uncovered interest rate parity equation and the monetary policy rule are the same for the entire country. The value of the interest rate depends on annual inflation expected in one year for the country as a whole and its deviation from the target. In other words, the dynamics of inflation in the region have an indirect impact on monetary policy decision-making, and the target is the annual inflation rate in Russia as a whole.[3] The specific features of the Central Federal District economy are also taken into account in the model when calibrating its parameters. In particular, the authors of the model note that the share of imported goods in the Central Federal District is higher than in the rest of Russia, and, accordingly, the elasticity of inflation relative to the exchange rate in the Central Federal District should be higher than in Russia as a whole. The elasticity of regional output relative to oil prices is lower in the Central Federal District than in the rest of Russia, as oil producing companies are dispersed across the regions, with only their head offices located in the Central Federal District.

The specific information about the economy of the Volgo-Vyatka region in a model described by *Novak and Shulgin (2020)* is taken into account in parameterisation; in particular, this model is a source of ex ante information.

The developed regional models consider the specific features of individual regions. Consequently, the analysis of the FEMR economy requires the development of a model that addresses its particularities. Therefore, we now turn to a description of the key features of the FEMR and approaches to accounting for them in the QPM.

3. Features of Far Eastern macroregion economy and approaches to their integration into model

The selection of approaches to building a semi-structural model of the FEMR is determined by its specific features, which should be taken into account when conducting macroeconomic analysis. The main features of the macroregion are the following:

- **Small role** of the macroregion in the Russian economy. The region accounts for less than 6% of Russia's total population and GDP (Table 1). The region makes a small contribution to the total monetary income of the population, retail trade turnover, and the amount of paid services to the public, which indicates its limited influence on consumer demand in Russia as a whole. Excluding fish exports, the share of final consumption goods produced in the FEMR is significantly lower than the national average, resulting in the need to purchase consumer goods from other regions of Russia or trading partner countries. The import of both food and non-food products from other regions means that their price trends in the FEMR depend on the price trends in the supplying regions. Transporting products takes time, and therefore price shocks realised immediately in supplying regions reach consumer price dynamics in the FEMR with a certain lag, which, according to our estimates, averages three months. Transport costs contribute to the divergence of prices between the FEMR and the rest of Russia, while serving as a buffer in the event of growth in suppliers' costs unrelated to transport. Overall, both higher prices and the lag for transporting goods

[3] The authors of the model note that they intentionally excluded the output gap from the monetary policy rule, which emphasises the fact that the main objective of the Bank of Russia is to minimise the deviation of expected inflation from the target.

from the rest of Russia result in the higher inertia of inflationary processes in the FEMR relative to the rest of the country.

Table 1. Share of FEMR in selected national indicators, %

Indicator	2015	2016	2017	2018	2019	2020	2021
Population size	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Number of employed	4.4	4.4	4.4	4.4	4.3	4.4	4.3
GDP*	5.5	5.4	5.3	5.6	5.5	5.7	5.7
Fixed capital investments	6.1	6.8	7.2	7.3	7.7	7.2	7.4
Industrial production	6.4	6.3	5.9	6.5	6.4	6.7	6.3
Mining and quarrying	13.8	13.7	12.1	12.9	12.7	15.4	12.2
Manufacturing	1.7	1.7	1.7	1.5	1.6	1.6	1.5
Retail turnover	4.3	4.4	4.4	4.4	4.5	4.5	4.4
Paid services to the public	5.8	5.7	6.0	5.7	5.4	5.2	5.1
Household money income	4.9	4.9	4.9	4.9	5.0	5.0	4.9

* GDP of Russia is the sum of GRP of regions.
Sources: Rosstat,[4] authors' calculations.

- **Low spatial connectivity and integration** of the economy of the Far Eastern macroregion with the **rest of Russia**. This is primarily due to the large geographical distances, vast unpopulated territories between the populated areas of the Far East and the rest of the country, and underdeveloped transport and support infrastructure, and high transportation costs. Thus, *Kolomak (2020)* showed that Russian regions are characterised by a low degree of spatial connectedness of economic activities, and that cooperation between Russian regions is not deep in the spatial dimension and quickly fades as distance increases. *Kryukov and Kolomak (2021)* noted that Russia is marked by the disintegration of economic space. This problem is especially acute in Siberia and the Far East. There is a shrinking economic space, lack of transport infrastructure (as a consequence, high production costs), low efficiency of utility systems, and very limited opportunities for attracting businesses and diversifying the economic structure. Commodity markets in the Far East regions are the least integrated among all Russian regions (*Glushchenko, 2020*).

We can also draw similar conclusions by analysing the matrix of interregional trade flows (Annex 1). FEMR regions have interregional trade links with each other, meaningfully different from zero. For most Russian regions, the share of FEMR regions in the import of goods is close to zero, with FEMR regions being significantly less connected with the rest of Russia than most other regions. Other Russian regions outside the FEMR, in particular, the Central Federal District (mainly Moscow and the Moscow Region), the Siberian Federal District, and the Urals Federal District, play a prominent role in the total volume of interregional imports of goods to the FEMR regions.

- The economic structure of the FEMR is characterised by a significantly **higher share of mining industries** (2.2 times the Russian as a whole) and a **low share of manufacturing industries** (3.4 times lower than in Russia) (Table 2), especially those oriented towards final consumer demand (Table 3).

For example, about 60% of industrial production in the FEMR is made up of products of mining industries (about a quarter in the entire country). The share of consumer goods in industrial output in the FEMR is close to countrywide values (12.2% in the FEMR and 15.0%

[4] Federal State Statistics Service (Rosstat) https://rosstat.gov.ru

in Russia as a whole in 2021), but approximately half of these volumes are taken up by fish products, which are mainly exported or sold in other Russian regions.

- The FEMR is a **labour shortage region** with a large number of fly-in fly-out (FIFO) workers involved in its economy (primarily in mining and construction). Thus, fluctuations in demand and business activity lead to changes in the quantity of imported labour rather than to variations in wages of the resident population (that is, labour supply is flexible and wages tend to be rigid). The income earned by FIFO workers and migrants is spent outside the region and does not fully affect intraregional demand.

- **A high dependence of the FEMR economy on public sector expenditures**. Budget expenditures account for about 20% of the macroregion's GRP, which is higher than in the country as a whole (approximately 14%) (Table 4). In some regions (e.g., the Kamchatka Territory and the Chukotka Autonomous Area), the ratio of budget expenditures to GRP is two or more times higher than the national average. Furthermore, the FEMR fiscal policy is strongly dependent on transfers: the share of transfers in the consolidated budget revenues of the Far East regions is nearly 30%. This figure is higher only in the North Caucasian Federal District (Table 5).

- **Price growth in the Far East lags behind the dynamics of inflation in Russia as a whole.** Price growth (SAAR) in the FEMR reacts to changes in the countrywide inflation rate with a certain lag (Figure 1). This is due to the low self-supply of goods in the region and the need to deliver them from other parts of Russia or abroad.

The chart shown in Figure 1 indicates the points at which the co-directional movement of inflation trends in the FEMR and Russia as a whole ends. The time series for the Far East is shifted forward by two months relative to the countrywide time series. The chart shows that there are more co-directional cases of acceleration than deceleration. According to our estimates, the lag in the price growth rate for some goods reaches 2-3 months.

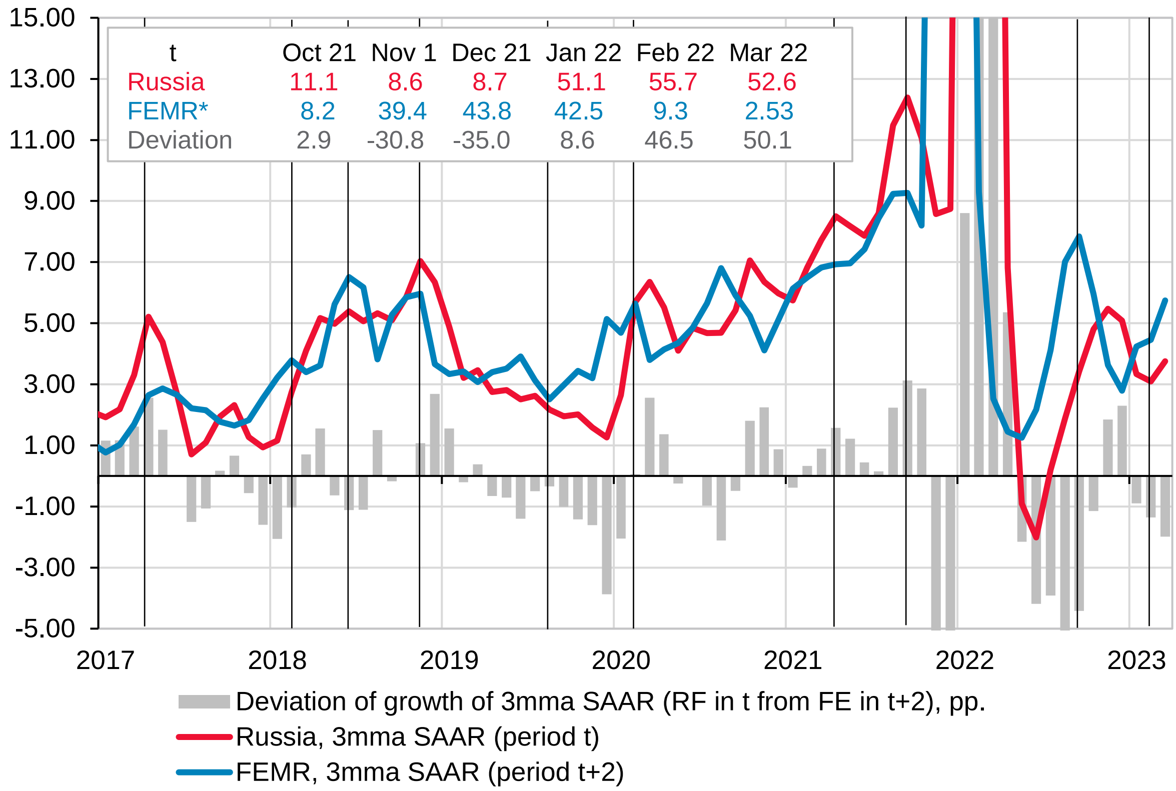

Figure 1. Inflation dynamics, % of 3mma SAAR increase[5]

[5] 3mma SAAR is a 3-month moving average seasonally adjusted annual rate.

- **Greater integration into Asia-Pacific markets**, primarily China, Japan, and South Korea, than the nationwide indicator, dependence on resource exports to these markets, and thus dependence on the phases of their business cycle. Specifically, the share of China, Japan, and South Korea in the Far Eastern macroregion's exports in 2016–2021 was about 75%, which greatly exceeds the share of these countries in Russian exports (approximately 20%) (Table 2).

Table 2. Selected economic indicators of FEMR and Russia, %

Indicator	FEMR							Russia						
	2015	2016	2017	2018	2019	2020	2021	2015	2016	2017	2018	2019	2020	2021
Real GRP growth*	0.7	0.2	-0.1	3.5	3.0	-2.5	6.7	-0.6	0.8	1.9	2.8	1.6	-2.2	7.3
Share of mining in GVA	28.4	25.9	26.3	32.3	30.7	28.5	32.6	11.2	10.2	11.3	13.9	13.5	10.4	14.4
Share of manufacturing in GVA	5.3	5.1	5.2	4.7	4.7	5.0	4.8	17.2	15.9	16.2	17.3	16.7	17.1	17.2
Share of public administration, education, and healthcare in GVA	15.5	16.9	17.2	15.8	16.0	17.2	14.8	12.4	12.6	12.5	12.3	12.5	13.7	11.5
Share of exports in GRP*	34.9	31.3	31.3	34.8	33.3	29.5	28.8	31.7	25.8	26.1	31.2	28.9	25.7	29.6
Share of imports in GRP*	10.0	9.7	8.8	7.7	9.7	10.2	11.0	16.9	16.5	16.6	16.5	16.6	17.7	17.7
Share of APR countries in exports, including:	86.9	86.4	80.8	82.8	86.4	84.2	84.2	22.5	23.9	24.8	25.6	27.4	29.0	30.8
China, Japan, and South Korea	79.2	72.0	73.4	77.3	76.1	76.2	75.6	16.3	16.3	16.8	18.9	20.0	21.0	19.6
Share of APR countries in imports, including:	82.5	80.1	77.4	82.5	83.4	80.5	80.1	38.2	40.4	42.6	42.9	43.2	44.3	45.2
China, Japan, and South Korea	62.3	57.4	67.5	70.1	69.6	69.0	73.6	25.3	27.3	27.6	28.5	29.1	29.9	32.3

* GDP of Russia is the sum of GRP of regions.
Sources: Rosstat, authors' calculations.

Table 3. Industrial production structure of FEMR and Russia, %

Indicator	FEMR					Russia				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Intermediate goods, including:	**67.2**	**71.7**	**71.6**	**72.0**	**74.9**	**55.6**	**58.6**	**54.8**	**54.2**	**61.1**
Mineral resources	62.1	66.7	57.1	53.7	57.9	25.1	26.5	25.6	22.6	25.8
Manufacturing products	5.0	5.0	14.5	18.3	17.0	30.5	32.1	29.2	31.6	35.3
Investment goods, including:	**5.3**	**4.2**	**4.2**	**4.1**	**4.1**	**17.2**	**17.1**	**18.7**	**18.8**	**15.9**
Construction materials	2.6	2.1	2.0	2.0	2.2	5.1	4.5	5.1	5.1	4.8
Machinery products	2.7	2.2	2.2	2.1	1.9	12.0	12.6	13.6	13.8	11.1
Consumer goods, including:	**15.9**	**14.3**	**13.7**	**13.3**	**12.2**	**16.4**	**14.4**	**15.8**	**16.6**	**15.0**
Non-durable goods, including:	13.6	11.9	11.3	11.1	10.1	13.0	11.1	12.0	12.7	11.8
Processed and canned fish	6.0	6.1	6.3	6.3	5.6	0.6	0.6	0.7	0.7	0.6
Durable goods	2.4	2.4	2.4	2.2	2.0	3.4	3.4	3.8	3.9	3.2
Electricity/water supply and other utilities	**11.6**	**9.8**	**10.5**	**10.6**	**8.8**	**10.8**	**9.9**	**10.8**	**10.3**	**8.0**

Sources: Rosstat, authors' calculations.

* Indicator value in period t+2.

Table 4. Ratio of budget expenditure to nominal GRP (GDP), %

Region	2015	2016	2017	2018	2019	2020	2021
Russia	**14**	**13**	**14**	**13**	**14**	**17**	**14**
FEMR, including	**22**	**20**	**19**	**18**	**20**	**22**	**19**
Republic of Sakha (Yakutia)	*26*	*23*	*22*	*21*	*21*	*24*	*20*
Primorye Territory	*15*	*13*	*13*	*13*	*15*	*17*	*15*
Khabarovsk Territory	*17*	*16*	*17*	*17*	*17*	*18*	*16*
Amur Region	*20*	*18*	*19*	*19*	*20*	*23*	*23*
Kamchatka Territory	*37*	*32*	*33*	*33*	*34*	*36*	*34*
Magadan Region	*26*	*22*	*23*	*22*	*20*	*18*	*18*
Sakhalin Region	*25*	*21*	*17*	*13*	*17*	*20*	*15*
Jewish Autonomous Region	*26*	*25*	*21*	*22*	*27*	*32*	*28*
Chukotka Autonomous Area	*42*	*42*	*43*	*43*	*59*	*42*	*41*
Central FD	13	12	13	13	14	16	14
North-Western FD	14	14	14	14	14	16	11
Southern FD	13	14	15	15	16	18	16
North Caucasian FD	22	19	20	20	22	27	25
Volga FD	14	13	13	13	13	16	14
Urals FD	11	10	10	9	10	13	10
Siberian FD	17	16	15	13	15	17	15

Sources: Federal Treasury, Unified Budget System Portal, Rosstat, authors' calculations.

On the basis of the above features of the Far East economy, we decided to use the following **approaches to building a semi-structural model:**

- **The whole country is subdivided into two blocks: the FEMR (dv) and the rest of Russia (ror)**. Inflation and the output gap in these blocks are modelled separately. Due to the significant volume of interregional imports from regions outside the Far East, the impact of other regions of Russia on the FEMR is taken into account. In particular, the FEMR demand gap is affected by the rest of Russia's demand gap. Inflation in the macroregion is also influenced by the deviation of inflation in the FEMR from countrywide inflation. If the price growth rate in Russia as a whole is higher than in the FEMR, inflation is accelerated in the macroregion, and vice versa. The underlying cause is that the price growth rates in the FEMR and the entire country do not differ meaningfully in the long term (*Zhemkov, 2019*). Shocks originating in the Far East (e.g. demand shocks or cost-push shocks) lead to a reaction of the relevant variables at the national level, but the magnitude of this reaction is close to 5% of the FEMR shock, which corresponds to the long-term contribution of the FEMR to output and inflation in Russia.

- **The exchange rate for the Far East is set exogenously** owing to the fact that the FEMR economy, due to its small size, does not influence the exchange rate but is its recipient.

- **The Bank of Russia's common monetary policy is in effect in the Far East**. Monetary policy decisions are made on the basis of the economic situation in the entire country.

- **Four Phillips curves are modelled**: for food products, non-food products, services excluding utilities, and utilities. This approach is widely used in the development of semi-structural models due to the fact that various inflation components respond differently to the same shocks depending on price rigidity, government intervention in pricing, and on whether goods are tradable. For example, the model for Belarus (*Musil et al., 2018*) separately simulates the regulated part of inflation, which accounts for the price growth rates of utilities and transport fares set by the government, and core inflation (75% of the CPI basket), which accounts for market-driven changes in prices for goods and services.

Table 5. Share of transfers in the revenues of FEMR consolidated regional budgets and federal districts, %

Region	2015	2016	2017	2018	2019	2020	2021
FEMR, including	**24**	**25**	**26**	**30**	**31**	**36**	**33**
Republic of Sakha (Yakutia)	*35*	*33*	*32*	*33*	*36*	*44*	*37*
Primorye Territory	*23*	*15*	*19*	*22*	*23*	*31*	*27*
Khabarovsk Territory	*18*	*17*	*19*	*22*	*23*	*33*	*27*
Amur Region	*22*	*23*	*18*	*22*	*27*	*32*	*34*
Kamchatka Territory	*61*	*60*	*60*	*61*	*58*	*63*	*61*
Magadan Region	*32*	*29*	*37*	*36*	*37*	*35*	*31*
Sakhalin Region	*2*	*3*	*4*	*14*	*12*	*9*	*8*
Jewish Autonomous Region	*46*	*43*	*32*	*34*	*46*	*61*	*62*
Chukotka Autonomous Area	*44*	*49*	*57*	*63*	*72*	*54*	*58*
Central FD	11	10	9	10	10	17	12
North-Western FD	12	14	14	15	16	22	17
Southern FD	21	26	28	30	30	40	35
North Caucasian FD	60	57	58	58	61	68	65
Volga FD	20	17	17	18	20	33	28
Urals FD	9	9	8	9	11	17	13
Siberian FD	24	20	21	21	23	33	26

Sources: Federal Treasury, Unified Budget System Portal, Rosstat, authors' calculations.

- Aggregate demand is influenced by **fiscal policy described by means of budget deficits** (in the FEMR and Russia as a whole). The rationale for including the public sector in the model is that such a policy is countercyclical, that is government spending increases during economic downturns, which affects aggregate demand. The public sector block in the semi-structural model can be described in a reduced form (e.g., it is simulated by the AR-model of the ratio of budget deficit to nominal GDP for Belarus (*Musil et al., 2018*)) or using the budget deficit gap. For example, the fiscal sector is described using the observed budget deficit in the Integrated System of Models of the Eurasian Economic Union (*Demidenko et al., 2016*). First, the budget deficit is determined by the government's targets for the medium and long term. Second, it depends on the government's response to the deviation of debt from the target, and also on the automatic stabiliser (a negative output gap reduces budget revenues and increases the budget deficit). We used the second of these approaches to build the FEMR model.

- **FEMR aggregate demand is divided into: consumer demand**, which directly affects inflation in the macroregion (includes retail trade turnover and paid services to the public); **resource demand**, which does not exert direct inflationary pressure, that is demand for the products of mining and manufacturing industries from Russia as a whole and foreign countries (described by the industrial production index);[6] and **investment demand**, which is generated by the implementation of large investment projects, financed mainly from sources external to the Far East, such as private investors or the federal budget (described by construction volumes).

Labour resources are often attracted from other regions of Russia in the mining and construction sectors, and the rise in labour incomes does not translate into an increase in consumption in the Far East. In addition, a significant share of taxes from mining companies and large investment projects are paid to the federal budget, limiting the ability of regional authorities to stimulate demand. As a result, aggregate demand grows while extraction and construction increase significantly, which should spur inflation in the neo-Keynesian framework. In reality, however, proinflationary pressure does not materialise since a large part of the earnings of workers in the mining and construction sectors is transferred outside the Far East.

A similar approach to simulating aggregate demand was used, for example, in a model of the economy of Rwanda (*Vlček et al., 2020*). In this model, the output gap is described by two IS curves: for the agricultural (nearly 25% of GDP) and non-agricultural sectors of the economy, as their dynamics are determined by various factors having different effects on inflation. The output of the agricultural sector depends primarily on weather conditions, and the impact of real interest rates, fiscal policy, and external demand on it is limited. Thus, the output gap in the agricultural sector is modelled using an AR-process. The agricultural output gap affects only food inflation, and it does so with a negative sign: the larger the positive gap, the lower the inflation. The non-agricultural output gap is determined by monetary conditions, the foreign output gap, fiscal impulse, and the gap change in the subsidies to GDP ratio gap. A positive non-agricultural output gap leads to an increase in all inflation components: core, food, and energy inflation.

In a model for the Croatian economy (*Bokan and Ravnik, 2018*), aggregate demand was divided into three components: domestic demand, exports, and imports. The domestic demand gap is driven by the real interest rate gap on short-term bank loans, fiscal impulse, domestic demand expected in one quarter, and inertia. The export gap, which characterises external demand for Croatian goods and services, depends on the output gap in the euro area and the real exchange rate gap, whereas the import gap, which describes domestic demand for foreign goods and services, depends on the aggregate demand gap and the difference between the real marginal costs of importers and domestic producers. Higher real marginal costs of importers compared with domestic producers cause a reduction in imports. A similar approach to the description of aggregate demand was used in a QPM for Russia adapted to the capital flow control framework (*Monetary Policy Report, No. 2, 2022*).

- **Various external sectors are included in the aggregate demand equations for the FEMR and Russia as a whole**, which is determined by significant differences in the structure of foreign trade (external demand) between the Far East and the entire country. The external sector for the FEMR is represented by its main foreign trading partners: China, Japan, and South Korea. The external sector for the rest of Russia is represented by the G20 member countries.

[6] In the structure of FEMR industrial production, almost 60% is mineral extraction, and the bulk of production is exported. Approximately 30% of industrial production is manufacturing, whose products are mainly exported or supplied to other Russian regions: precious metals (10.8% in 2021), fish processing (5.6%), aircraft industry (3.2%), and car manufacturing (1.2%). Therefore, this demand component mostly characterises external demand for the Far East generated by the rest of Russia and foreign countries. However, to separate this component from external sector demand and the external demand gap, we use the concept of 'resource demand'.

After we have defined the key approaches to building the model, let us proceed with the description of its main equations.

4. Semi-structural economic model of Far Eastern macroregion

4.1. Model structure

The FEMR model is based on **variables in gaps**, that is deviations of actual indicators from trend values. A trend is a long-term expected value determined by fundamental factors. Trends are modelled as autoregressive processes converging to their stationary states and can be extracted using a **multivariate Kalman filter**.

In addition to multivariate filters, there are also **univariate filters**, e.g. HP filters *(Hodrick and Prescott, 1997)*, whose main advantage is their ease of use. However, such filters are based on a weighted average of observations in the past, current, and future periods of a given time series, which leads to a shift in the initial and final estimates of trend values. The estimates are also very sensitive to the addition of new observations. Only data from the given time series are used for filtering with the help of univariate filters, which also considerably worsens the quality of the resulting estimates.

To obtain the most accurate estimates, we use **multivariate filtering**. Such estimates are obtained by considering data from several time series to filter the selected variables. Compared to estimates obtained with univariate filters, multivariate filter estimates are robust to endpoint bias and other structural weaknesses of univariate filters.

The model includes three blocks: the FEMR block, the Rest of Russia (RoR) block, and the External Sector block. The RoR block is based on the model presented by *Orlov (2021*) as modified in *Monetary Policy Report, No. 2, 2022*. The general structure of the model is presented in Figure 2.

The model can be applied under various capital control regimes (zero, partial, or full control). This is possible by separating trade flows (exports and imports) from Russia's total output and incorporating the real trade balance and the terms of trade into the standard uncovered interest rate parity equation.

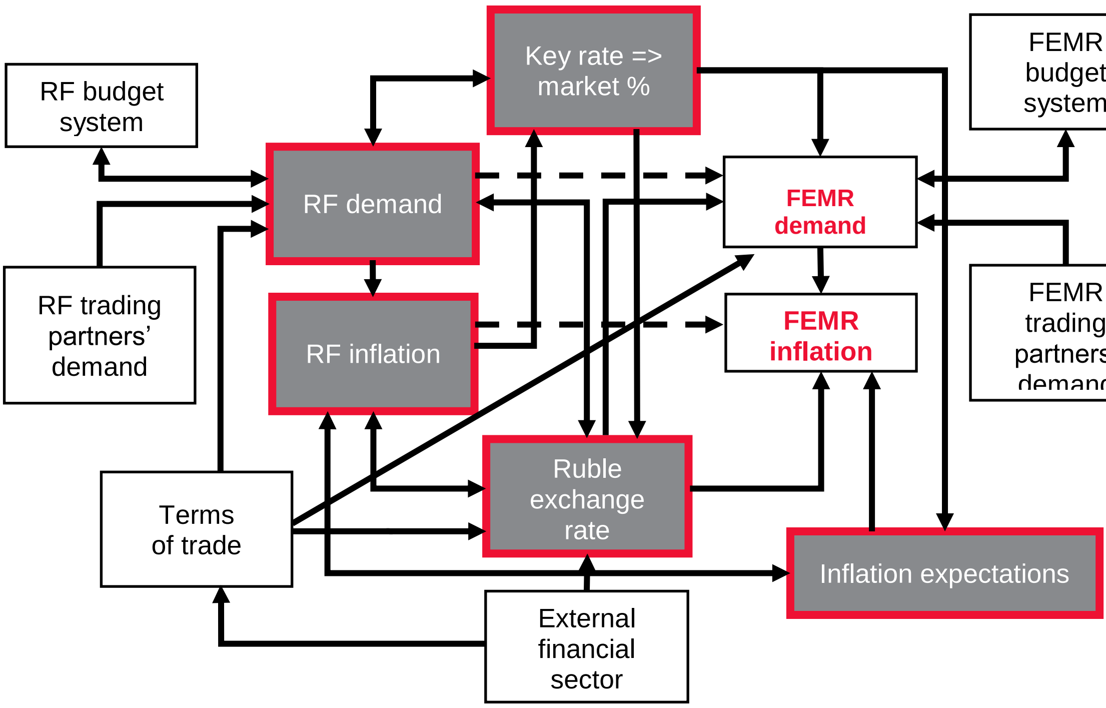

Figure 2. Main relationships of variables in FEMR semi-structural model

The general logic of relationships in the model is as follows. In response to steady growth in consumer prices, the Bank of Russia raises its key rate. A change in the key rate leads to changes in market rates. An increase in market rates results in reduced demand for borrowings. Loans for businesses become more expensive. Reduced credit availability leads to a reduction in domestic demand. In addition, domestic demand is influenced by fiscal policy as well as external factors such as foreign demand, the terms of trade, and exchange rates. If there are no capital controls, the exchange rate channel plays an important role in the transmission mechanism: movements in the exchange rate affect inflation directly through the prices of imported goods and services and indirectly through demand and output. If capital flows are controlled, the exchange rate channel becomes less important.

Aggregate demand in the FEMR is influenced by economic activities in other regions of Russia. However, due to the structure of the FEMR economy, such activities do not exert direct pressure on prices and do not determine inflation. Consumer demand is the primary driver of prices for goods and services in the Far East and, consequently, of inflation in the macroregion. Inflation in the FEMR is also affected by inflation in Russia as a whole.

The equations below capture the main macroeconomic relationships.

1. Aggregate demand curve

The output level y_t is the sum of the potential output $\overline{y_t}$ and its gap $\widehat{y_t}$:

$$y_t = \overline{y_t} + \widehat{y_t}$$

The potential output $\bar{y}_t$ is given by a first-order autoregression.

The FEMR aggregate demand gap ($\hat{y}_t^{dv}$) consists of the FEMR consumer demand gap ($\hat{d}_t^{dv}$), the industrial production gap ($\widehat{prod}_t^{dv}$), which is a proxy for resource demand, and the investment demand gap ($\widehat{proj}_t^{dv}$), which is related to large investment projects in the macroregion:

$$\hat{y}_t^{dv} = \omega_d^{dv} \cdot \hat{d}_t^{dv} + \omega_{prod}^{dv} \cdot \widehat{prod}_t^{dv} + \omega_{proj}^{dv} \cdot \widehat{proj}_t^{dv} + \varepsilon_t^{\hat{y}^{dv}}, \tag{1}$$

where ω_j^{dv} is the weight of the corresponding component *j* in the aggregate FEMR output;

$\varepsilon_t^{\hat{y}^{dv}}$ is the FEMR aggregate demand shock.

1.1. FEMR consumer demand gap

The FEMR consumer demand gap is a modified standard demand curve:

$$\hat{d}_t^{dv} = \alpha_{d0}^{dv} \cdot E_t\hat{d}_{t+1}^{dv} + \alpha_{d1}^{dv} \cdot \hat{d}_{t-1}^{dv} - \alpha_{d2}^{dv} \cdot \widehat{r_m}_{t-1} + \alpha_{d3}^{dv} \cdot \hat{d}_t^{ror} + \alpha_{d4}^{dv} \cdot \hat{g}_t^{dv_{ma8}} + \alpha_{d5}^{dv} \cdot \hat{q}_t^{oil} -$$

$$-\alpha_{d6}^{dv} \cdot \left(\hat{d}_t^{dv} - \hat{y}_t^{dv}\right) + \varepsilon_t^{\widehat{d^{dv}}}, \tag{2}$$

where $\hat{y}_t^{dv}$ is the aggregate demand gap in the FEMR;

$\hat{d}_t^{dv}$ is the consumer demand gap in the FEMR;

$E_t\hat{d}_{t+1}^{dv}$ is the expected consumer demand gap in the FEMR in period $t+1$;

$\hat{d}_t^{ror}$ is the domestic demand gap in the RoR;

$\widehat{r_m}_t$ is the real market rate gap in Russia;

$\hat{g}_t^{dv_{ma8}}$ is the moving average of the structural deficit of the FEMR budget system (regional + federal + extra-budgetary funds) in relation to GRP:

$$\hat{g}_t^{dv_{ma8}} = \sum_{i=1}^{8} \hat{g}_{t-i}^{dv} / 8,$$

where $\hat{g}_t^{dv}$ is the budget deficit gap in the FEMR;

$\hat{q}_t^{oil}$ is the real oil price gap;

$\varepsilon_t^{\widehat{d^{dv}}}$ is the consumer demand shock in the FEMR.

The real market interest rate is estimated as the difference between the nominal rate and expected inflation in the country. The actual path of the real market interest rate is split into trend and cyclical ($\widehat{r_{m_t}}$) components. The nominal market interest rate is simulated as a weighted average expected return on money market rates of various maturities adjusted for the internal risk premium.

An increase in the real market interest rate gap ($\widehat{r_{m_t}}$) in (2) leads to a reduction in aggregate demand. This results from consumers solving an intertemporal choice problem: under a higher current market rate, future consumption becomes more favourable relative to current consumption for the rational agent. This is due to the fact that aggregate consumption grows with the increase in interest income, which stimulates savings and reduces current expenditures. The budget deficit ($\hat{g}_t^{dv_{ma8}}$) characterises the expenditures of economic agents. These expenditures depend on current net payments from the state: an increase in the budget deficit (stimulating fiscal policy) leads to an increase in aggregate demand. A rise in the real price of oil ($\hat{q}_t^{oil}$) means more export revenues at the same level of crude oil production. Through income effects, this stimulates consumer demand and leads to a rise in it.[7] The inclusion of a lag of the consumer demand gap reflects the inertia of the economy's adjustment for changes in the above factors, and the inclusion of a forward-looking component reflects the occurrence of rational expectations. The rise in domestic demand from the rest of Russia ($\hat{d}_t^{ror}$) stimulates consumer demand in the FEMR.

The model also includes the relative magnitudes of demand by component ($\hat{d}_t^{dv} - \hat{y}_t^{dv}$). If one component of demand starts to actively grow or shrink, it will drive the increase or decrease of the other components through income dynamics.

1.2. FEMR resource demand gap

The FEMR resource demand gap is determined by the RoR demand, external demand, the relative prices of domestic and foreign goods, and the terms of trade:

$$\widehat{prod}_t^{dv} = \alpha_{prod1}^{dv} \cdot \widehat{prod}_{t-1}^{dv} + \alpha_{prod2}^{dv} \cdot \hat{y}_{t-1}^{ror} + \alpha_{prod3}^{dv} \cdot \hat{y}_{t-1}^{ROWdv} + \alpha_{prod4}^{dv} \cdot \hat{z}_{t-1} + \alpha_{prod5}^{dv} \cdot \hat{q}_t^{oil} - $$
$$-\alpha_{prod6}^{dv} \cdot \left(\widehat{prod}_t^{dv} - \hat{y}_t^{dv}\right) + \varepsilon_t^{\widehat{prod}^{dv}}, \quad (3)$$

where $\widehat{prod}_t^{dv}$ is the demand gap for FEMR manufactured goods;

$\hat{y}_t^{ror}$ is the output gap in the rest of Russia;

$\hat{y}_t^{ROWdv}$ is the output (demand) gap in the FEMR trading partner countries (China, Japan, and South Korea);

$\hat{z}_t$ is the real effective exchange rate gap;

$\varepsilon_t^{\widehat{prod}^{dv}}$ is the resource demand shock in the FEMR.

A rise in demand from the rest of Russia ($\hat{y}_{t-1}^{ror}$) stimulates the growth in the FEMR's manufacturing output to a greater extent; a rise in demand from the FEMR trading partner countries ($\hat{y}_t^{ROWdv}$) stimulates growth in the FEMR's mining output to a greater extent. A weakening of the real exchange rate (increase in $\hat{z}_{t-1}$) leads to a rise in demand for domestic goods compared to imported goods, and improves the competitiveness of domestic goods

[7] The nominal Urals price and external sector inflation are used to calculate the real price of oil.

in foreign markets. A rise in the real price of oil ($\hat{q}_t^{oil}$) indicates better trading conditions for the export of raw materials in general. This encourages supply growth and serves as an indicator of excess demand for raw materials.

1.3. FEMR investment demand gap

The FEMR investment demand gap is determined by demand in the rest of Russia and the state of the federal budget, as large investment projects implemented in the Far East are mainly funded from the federal budget, Russian extra-budgetary funds, and the budgets of major government-owned companies:

$$\widehat{proj}_t^{dv} = \alpha_{proj0}^{dv} \cdot E_t\widehat{proj}_{t+1}^{dv} + \alpha_{proj1}^{dv} \cdot \widehat{proj}_{t-1}^{dv} + \alpha_{proj2}^{dv} \cdot \hat{y}_{t-1}^{ror} + \alpha_{proj3}^{dv} \cdot \hat{g}_t^{RF_{ma8}} -$$

$$-\alpha_{proj4}^{dv} \cdot (\widehat{proj}_t^{dv} - \hat{y}_t^{dv}) + \varepsilon_t^{\widehat{proj}^{dv}}, \quad (4)$$

where $\widehat{proj}_t^{dv}$ is the FEMR investment demand gap;

$E_t\widehat{proj}_{t+1}^{dv}$ is the expected investment demand gap in the FEMR in period $t+1$;

$\hat{g}_t^{RF_{ma8}}$ is the budget deficit gap in Russia (average over the previous two years) relative to GDP.

A rise in the federal budget deficit gap ($\hat{g}_t^{RF_{ma8}}$), usually caused by an increase in expenditures, leads to increased investment demand in the FEMR, taking into account the ongoing federal programmes aimed at the development of the Far East. The budget deficit value is calculated as a moving average of the deficit over the previous two years. This is dictated by the long periods of time (two years and more) for the planning of investment project financing. Financing volumes are adjusted if there are substantial changes in economic activity. Market rates have no direct impact on investment demand (their impact is indirect through changes in aggregate demand of the rest of Russia ($\hat{y}_t^{ror}$)).

A rise in demand from the rest of Russia ($\hat{y}_t^{ror}$) is indicative of the stable financial position of the major Russian companies, whose investments are attracted to the Far East to a greater extent. The aggregate demand gap of the rest of Russia is modelled as a weighted sum of three components: the domestic demand gap, the export gap, and the import gap. The structure of the equations is similar to the QPM for Russia adapted to the capital flow control framework (*Monetary Policy Report, No. 2, 2022*).

The demand gap of Russia as a whole is also modelled using the gaps of three components: domestic demand, exports, and imports. The components of aggregate demand are calculated as a weighted average of RoR and FEMR.

2. Fiscal sector

The FEMR budget deficit gap is modelled similar to the QPM for the Central FD (*Korshunov and Nelyubina, 2021*) and represents the difference between the actual deficit and the structural deficit of the FEMR budget system relative to GRP:

$$\hat{g}_t^{dv} = g_t^{dv} - \bar{g}_t^{dv},$$

$$\bar{g}_t^{dv} = d_1^{dv} \cdot \bar{g}_{t-1}^{dv} + (1 - d_1^{dv}) \cdot \left(g_t^{dv_{TAR}} - d_2^{dv} \cdot (\bar{y}_t^{dv} - \bar{y}_{ss}^{SAAR})\right) + \varepsilon_t^{\bar{g}^{dv}}, \quad (5)$$

$$g_t^{dv} = d_3^{dv} \cdot g_{t-1}^{dv} + (1 - d_3^{dv}) \cdot \left(g_t^{dv_{TAR}} - d_4^{dv} \cdot (g_{t-1}^{dv} - g_{t-1}^{dv_{TAR}}) - d_5^{dv} \cdot \hat{y}_t^{dv}\right) + \varepsilon_t^{g^{dv}}, \quad (6)$$

where g_t^{dv} is the actual deficit of the FEMR budget system relative to GRP;

$\bar{g}_t^{dv}$ is the structural deficit of the FEMR budget system relative to GRP;

$g_t^{dv_{TAR}}$ are government targets of the FEMR for the medium term;

$\left(\bar{y}_t^{dv} - \bar{y}_{ss}^{SAAR}\right)$ is the deviation of output trend growth in the Far East from its sustainable path.

Russia's fiscal sector is modelled in a similar way.

3. Aggregate supply curve

The aggregate (total) supply curve, which determines the relationship between inflation and demand (output), is based in the model on a solution to the problem of producers in monopolistic competition markets, assuming that price rigidities are described according to Calvo[8] by the Phillips curve[9] (*Orlov, 2021, p. 8*).

Individual Phillips curves are generated for food products (f), non-food products (nf), unregulated services (excluding utilities) (swu), and regulated services (utilities) (u) in the FEMR. Using separate curves for the inflation components, we can model different magnitudes of the exchange rate pass-through effect on prices and different volatility of the components.

3.1. Price growth rate of food products in FEMR:

$$\pi_t^{f\,dv} = c_{f1}^{dv} \cdot E_t \pi_{t+1}^{f\,dv} + \left(1 - c_{f1}^{dv}\right) \cdot \pi_{t-1}^{f\,dv} + c_{f2}^{dv} \cdot \hat{z}_{t-1} + c_{f3}^{dv} \cdot \hat{d}_{t-1}^{dv} + c_{f4}^{dv} \cdot \left(\pi_{t-1}^{f\,ror} - \pi_{t-1}^{f\,dv}\right) - \\ - c_{f5}^{dv} \cdot \widehat{rp}_t^{f\,dv} + \varepsilon_t^{\pi^{f\,dv}}, \quad (7)$$

where $\pi_t^{f\,dv}$ is food inflation in the FEMR;

$\pi_t^{f\,ror}$ is food inflation in the RoR;

$E_t \pi_{t+1}^{f\,dv}$ is the expected food inflation in the FEMR in period $t+1$;

$\hat{d}_t^{dv}$ is the consumer demand gap in the FEMR;

$\hat{z}_t$ is the real effective exchange rate gap;

$\widehat{rp}_t^{f\,dv}$ is the gap in the relative prices of food products in the FEMR;

$\varepsilon_t^{\pi^{f\,dv}}$ is the food inflation shock in the FEMR.

The lag of seasonally adjusted growth is used as a measure of inertia. The lag of annualised inflation growth is used in the inflation equation for the rest of Russia. Accordingly, if we use the same structure for inertia and the same method for calculating shocks, their total value for the rest of Russia as a whole exceeds the FEMR values.

3.2. Price growth rate of non-food products in FEMR:

$$\pi_t^{nf\,dv} = c_{nf1}^{dv} \cdot E_t \pi_{t+1}^{nf\,dv} + \left(1 - c_{nf1}^{dv}\right) \cdot \pi_{t-1}^{nf\,dv} + c_{nf2}^{dv} \cdot \hat{z}_{t-1} + c_{nf3}^{dv} \cdot \left(\pi_{t-1}^{nf\,ror} - \pi_{t-1}^{nf\,dv}\right) + \\ + c_{nf4}^{dv} \cdot \hat{d}_{t-1}^{dv} - c_{nf5}^{dv} \cdot \widehat{rp}_t^{nf\,dv} + \varepsilon_t^{\pi^{nf\,dv}}, \quad (8)$$

where $\pi_t^{nf\,dv}$ is non-food inflation in the FEMR;

$\pi_t^{nf\,ror}$ is non-food inflation in the RoR;

$E_t \pi_{t+1}^{nf\,dv}$ is the expected non-food inflation in the FEMR in period $t+1$;

$\hat{z}_t$ is the real effective exchange rate gap;

$\hat{d}_t^{dv}$ is the consumer demand gap in the FEMR;

[8] In each period, only a certain random share of producers can set new prices.

[9] The (inverse) relationship between unemployment and inflation. The unemployment rate tends towards its natural level. Artificially reducing unemployment by boosting aggregate demand through government spending fuels inflation.

$\widehat{rp}_t^{nf_{dv}}$ is the gap in the relative prices of non-food products in the FEMR;

$\varepsilon_t^{\pi^{nf_{dv}}}$ is the non-food inflation shock in the FEMR.

3.3. Price growth rate of unregulated services in FEMR:

$$\pi_t^{swu_{dv}} = c_{swu1}^{dv} \cdot E_t\pi_{t+1}^{swu_{dv}} + \left(1 - c_{swu1}^{dv}\right) \cdot \pi_{t-1}^{swu_{dv}} + c_{swu2}^{dv} \cdot \hat{d}_{t-1}^{dv} + c_{swu3}^{dv} \cdot \hat{z}_{t-1} - -c_{swu4}^{dv} \cdot \widehat{rp}_t^{swu_{dv}} + \varepsilon_t^{\pi^{swu_{dv}}}, \quad (9)$$

where $\pi_t^{swu_{dv}}$ is the inflation of unregulated services in the FEMR;

$E_t\pi_{t+1}^{swu_{dv}}$ is the expected inflation of unregulated services in the FEMR in period $t+1$;

$\hat{d}_t^{dv}$ is the consumer demand gap in the FEMR;

$\hat{z}_t$ is the real effective exchange rate gap;

$\widehat{rp}_t^{swu_{dv}}$ is the gap in the relative prices of unregulated services in the FEMR;

$\varepsilon_t^{\pi^{swu_{dv}}}$ is the unregulated services inflation shock in the FEMR.

3.4. Price growth rate of regulated services (utilities) in FEMR:

$$\pi_t^{u_{dv}} = c_{u1}^{dv} \cdot \pi_{t-1}^{u_{dv}} + \left(1 - c_{u1}^{dv}\right) \cdot \pi_{ss}^{u_{RF}} + \varepsilon_t^{\pi^{u_{dv}}}, \quad (10)$$

where $\pi_t^{u_{dv}}$ is the inflation of regulated services in the FEMR;

$\pi_{ss}^{u_{RF}}$ is the inflation of regulated services in a steady state in Russia as a whole;

$\varepsilon_t^{\pi^{u_{dv}}}$ is the regulated services inflation shock in the FEMR.

3.5. Regulated (utilities) service price growth rate in FEMR:

$$\pi_t^{dv} = \omega_{\pi_f}^{dv} \cdot \pi_t^{f_{dv}} + \omega_{\pi_{nf}}^{dv} \cdot \pi_t^{nf_{dv}} + \omega_{\pi_{swu}}^{dv} \cdot \pi_t^{swu_{dv}} + \omega_{\pi_u}^{dv} \cdot \pi_t^{u_{dv}} + \varepsilon_t^{\pi_{dv}}, \quad (11)$$

where $\omega_{\pi_f}^{dv}$ is the weight of food products in the regional CPI;

$\omega_{\pi_{nf}}^{dv}$ is the weight of non-food products in the regional CPI;

$\omega_{\pi_{swu}}^{dv}$ is the weight of unregulated services in the regional CPI;

$\omega_{\pi_u}^{dv}$ is the weight of regulated services in the regional CPI;

$\varepsilon_t^{\pi_{dv}}$ is the inflation (aggregate supply) shock in the FEMR.

Equations (7–9) are Phillips curves modified as follows:

1. The growth rates of prices for food products (7), non-food products (8), and unregulated services (9) are determined by the consumer demand gap in the FEMR ($\hat{d}_t^{dv}$). A rise in the consumer demand gap implies an increase in real marginal costs, such as real wages and capital prices. This leads to higher prices.

2. We assume that the deviations of the food and non-food price growth rates in the Far East from the rest of Russia in equations (7) and (8) are temporary and that inflation

in the Far East gradually approaches inflation in the rest of Russia[10]. If inflation in the rest of Russia is higher than in the FEMR, this accelerates inflation in the macroregion. The use of this component is largely due to differences in the cost structure caused by the substantial share of transport costs in the final prices of goods delivered to the Far East.

In view of the nominal rigidity of prices, producers consider not only current but also future real marginal costs when setting new price levels. This is reflected by the expected inflation variable ($E_t\pi_{t+1}^{dv}$).

Producers who do not reprice in the current period are focused on past inflation, which causes the inflation lag (π_{t-1}^{dv}). Since part of the consumer basket consists of imported goods, the dynamics of the exchange rate ($\hat{z}_t$) affect their cost and, consequently, inflation.

Phillips curves (7)–(9) also imply that any deviations of the inflation components (food, non-food, and unregulated services) from the inflation of all goods and services (excluding regulated services) are temporary and gradually fade out. In other words, a positive relative price gap ($\widehat{rp}_t^{f_{dv}}$, $\widehat{rp}_t^{nf_{dv}}$, $\widehat{rp}_t^{swu_{dv}}$) helps slow down the faster growth of inflation components, as compared to the general price level (*Orlov, 2021*).

Equation (10) of the inflation of utilities is modelled separately, since this component is regulated and its dynamics correspond to the average value of inflation over a certain period. This equation is a first-order autoregression that converges to the equilibrium value of the indexation of utilities in a steady state ($\pi_{ss}^{u_{RF}}$).

All weights of the inflation components ω_π^{dv} in equation (11) are dynamic[11] and are specified on the basis of the relevant share of expenditures in total household consumption expenditures.

Aggregate supply for the rest of Russia is modelled similarly to the QPM for the entire country (*Orlov, 2021*). The dynamics of inflation for Russia as a whole are determined by the weighted average of the FEMR and the rest of Russia.

4. Monetary policy (Taylor) rule determining key rate setting

The nominal interest rate is simulated in the FEMR model in the same way as in the model for the entire country (*Orlov, 2021*). The regulator sets the nominal interest rate (i_t) based on the expected deviations of inflation for Russia as a whole from the target and Russian output from its potential level, thus flattening movements in the interest rate:

$$i_t = k_1 \cdot i_{t-1} + (1-k_1) \cdot (i_t^n + k_2 \cdot (E_t\pi 4_{t+3}^{RF} - \pi_t^{tar}) + k_3 \cdot \hat{y}_t^{RF}) + \varepsilon_t^i, \quad (12)$$

$$i_t^n = \overline{r_t} + E_t\pi 4_{t+3}^{RF},$$

$$\overline{r_t} = k_4 \cdot \overline{r_{t-1}} + (1-k_4) \cdot (\overline{r_t^*} + \overline{\vartheta}_t + \Delta\bar{z}_{t+1}) + \varepsilon_t^{\bar{r}},$$

where i_t is the nominal interest rate set by the regulator;

i_t^n is the nominal neutral interest rate;

---

[10] For the data period of 2010-2023, no statistically significant deviation of the Far Eastern macroregion inflation that contradicts the countrywide trend was found, which is confirmed by the results of other researchers *(Zhemkov, 2019)*. The price level in the Far Eastern macroregion is higher than the Russian one. The difference is due to transport distance from the commodity markets, low self-sufficiency, and severe working conditions, the payment of which includes proportional premiums compared to the countrywide level. Therefore, over time, even with the growth of self-sufficiency, relatively high costs, the growth rate of which is comparable to Russia as a whole, causes the convergence of inflation of the Far Eastern macroregion and the Russian Federation, the proportional deviation of price levels does not significantly change.

[11] The weights are calculated annually. When we calculate the CPI of all goods and services for the current year, we use, as weights, the data on the structure of average annual consumer expenditures for all goods and services in the CPI basket for the two shifted years preceding the current year.

$E_t\pi 4^{RF}_{t+3}$ is the expected inflation rate in Russia in three quarters YoY;

π^{tar}_t is the inflation target for Russia;

$\overline{r_t}$ is the real equilibrium interest rate;

$\overline{r_t^*}$ is the foreign real equilibrium interest rate;

$\overline{\vartheta_t}$ is the equilibrium value of the country risk premium;

$\Delta\bar{z}_{t+1}$ is the expected change in the real equilibrium exchange rate;

$\varepsilon^{\bar{r}}_t$ is the real equilibrium interest rate shock.

Equation (12) is a modification of the standard Taylor rule. The Bank of Russia targets annual inflation in three quarters, that is, it focuses on average quarterly inflation over the current and future quarters.

5. Uncovered interest rate parity under capital controls

If capital controls are introduced, the uncovered interest rate parity (UIP) equation is a control-weighted ($\omega^{CC} = 0{,}75$) combination of the standard UIP equation and its modification for the capital flow control framework (*Monetary Policy Report, No. 2, 2022)*:

$$s_t = (1-\omega^{CC})\cdot\left(e_1\cdot E_t s_{t+1} + (1-e_1)\cdot\left(s_{t-1} + \frac{\pi^{tar}_t - \bar{\pi}^*_{ss} + \Delta\bar{z}_t}{4} + \frac{\pi^{tar}_t - \bar{\pi}^*_{ss} + \Delta\bar{z}_{t+1}}{4}\right) + \right.$$
$$\left. + \frac{\left(-i_t + i^*_t + Prem^c + Prem^{Oil}_t + Prem^{Tr}_t\right)}{4}\right) +$$
$$+\omega^{CC}\cdot\left(s_{t-1} + \frac{\pi^{tar}_t - \bar{\pi}^*_{ss} + \Delta\bar{z}_t}{4}\cdot 2 - \mu\cdot\hat{z}_t - \theta\cdot\hat{\gamma}^{bop}_t\right) + \varepsilon^s_t, \quad (13)$$
$$z_t = s_t - \pi^{RF}_t + p^*_t,$$

where s_t is the nominal exchange rate;

s^e_{t+1} is the expected nominal exchange rate;

π^{tar}_t is the inflation target for Russia;

$\bar{\pi}^*_{ss}$ is the equilibrium foreign inflation;

$\Delta\bar{z}_t$ is the change in the real equilibrium exchange rate

$\Delta\bar{z}_{t+1}$ is the expected change in the real equilibrium interest rate

i^*_t is the nominal foreign interest rate;

$Prem^c$ is the country risk premium level;

$Prem^{Oil}_t$ is the risk premium level subject to the terms of trade:

$$Prem^{Oil}_t = -\delta_1\cdot 4\cdot(Oil_t - E_{t-1}Oil_t);$$

$Prem^{Tr}_t$ is the level of the transitive (temporary) risk premium:

$$Prem^{Tr}_t = \delta_2\cdot Prem^{Tr}_{t-1} + \varepsilon^{Prem_{TR}}_t;$$

p^*_t is the foreign baseline CPI;

ω^{CC} is the tightness of capital controls;

$\hat{\gamma}^{bop}_t$ is the trade balance gap calculated as the sum of the balance of trade ($\hat{x}^{RF}_t - \hat{m}^{RF}_t$) and the terms of trade ($\beta\cdot\hat{q}^{oil}_t$):

$$\hat{\gamma}^{bop}_t = \hat{x}^{RF}_t - \hat{m}^{RF}_t + \beta\cdot\hat{q}^{oil}_t,$$

where $\hat{x}^{RF}_t$ is the export gap in Russia;

$\hat{m}_t^{RF}$ is the import gap in Russia.

Countrywide inflation is used in equation (13) to model the real exchange rate.

6. External sector

The external blocks for both the Far East and the rest of Russia are modelled in a reduced form and specified by first-order autoregressions. Each block includes equations of the external output gap of partner countries for the rest of Russia (G20 countries) and the Russian Far East (China, Japan, and South Korea), inflation, and real and nominal interest rates in the US and the euro area.

4.2. Calibration and Bayesian estimation of parameters

The current parameterisation of the model takes into account, on the one hand, the experience of creating structural and semi-structural models by other central banks, including other main branches of the Bank of Russia, and, on the other hand, the specific features of the economy of the Russian Far East.

The procedure for selecting the model parameters includes three stages.

In the first stage, an interval of permissible values was set for each parameter according to the experience of other researchers (Table A2).

In the second stage, the coefficients were calibrated by experts to obtain economically sound filtering results, acceptable intrasample projection errors, and an accurate representation of the FEMR economic processes.

In equations (7)–(9) describing the dynamics of the FEMR inflation components, the coefficient at the expected inflation growth rate ($E_t\pi_{t+1}^{dv}$) is smaller than the corresponding coefficient in the Russian part due to the higher inertia of the FEMR economy. The coefficient for the variable economic activity of the FEMR ($\hat{d}_{t-1}^{dv}$) in equations (7) and (9) is smaller than the corresponding value for the rest of Russia given that fluctuations in local consumer demand affect the volume of goods supplied from the rest of Russia. Due to the small size of the FEMR economy, changes in its consumer demand will have less impact on price dynamics in the macroregion compared to the rest of Russia (changes in demand in the RoR can have a significant impact on the volume of production or imports of goods, which is more likely to lead to changes in average costs).

The third stage of calibration is related to the estimation of the semi-structural FEMR model using Bayesian methods, which make it possible to bring model estimates closer to actual data without losing consistency with economic logic. An important advantage of these methods is that they help estimate models with flexible stochastic processes, which in turn leads to more efficient evaluation of unobserved variables, such as the phase of the economic cycle, etc.

To perform the Bayesian estimation procedure, each parameter of the model was assigned a type of ex ante distribution, which is based on expert judgments about the economic nature, specific features, and characteristics of a particular parameter. The beta distribution was assigned to the weighting coefficients in the model since this distribution is used to describe random variables whose values are limited by a finite interval (in the case of weighting coefficients, the interval is from 0 to 1). Coefficient κ_2[12] follows a gamma distribution since its value is not strictly limited to the upper boundary. The values of the parameters of the model's main equations are shown in Annex 2.

[12] The coefficient for the deviation of the expected inflation rate from the target rate in the monetary policy rule equation (the Taylor rule).

The beta distribution has two parameters: $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$. Bayesian estimation in Matlab involves the construction of an ex ante distribution using the mathematical expectation ($\boldsymbol{\mu}$) and variance ($\boldsymbol{\sigma^2}$) defined by expert judgement, which are described using formulas (14) and (15):

$$\mu = \frac{\alpha}{\alpha+\beta} \quad (14)$$

$$\sigma^2 = \frac{\alpha \cdot \beta}{(\alpha+\beta)^2 \cdot (\alpha+\beta+1)} \quad (15)$$

In this case, no correction of the parameters is possible, and they are set automatically in Matlab, depending on the mathematical expectation and variance, according to formulas (16) and (17):

$$\alpha = \left(\frac{1-\mu}{\sigma^2} - \frac{1}{\mu}\right) \cdot \mu^2 \quad (16)$$

$$\beta = \alpha \cdot \left(\frac{1}{\mu} - 1\right) \quad (17)$$

Regional shocks are identified as the 'unexplained' part by comparing a number of indicators (demand gap, inflation, etc.) and their estimates. The procedure for shock estimation includes several steps. First, calibration is carried out considering information on the model structure, shock values from other studies, statistical tests, construction of additional (satellite) models, and applied analysis. The final stage involves filtering the shocks based on the previous information and adjusting them if necessary. For example, in 2022 Q3, the FEMR recorded an expected decline in oil production at one of the fields due to problems with shipment and filling of oil storage facilities. As mining makes a significant contribution to the macroregion's economy, this decline had a significant negative impact on the magnitude of production activity. To estimate the negative output shock in the FEMR, the share of oil production from this field and the contribution of its decline to the total output of the macroregion were calculated. Subsequently, the filtering results were adjusted taking into account these calculations.

4.3. Model properties

To describe the properties of the model, we consider a number of scenarios of various shocks both inside (internal shocks) and outside the FEMR (external shocks) and the responses of the main macroeconomic variables to these shocks, which are described by impulse response functions.[13]

FEMR consumer demand shock. A 1 pp rise in FEMR consumer demand leads to an increase in FEMR inflationary pressure (Figure 4). In terms of inflation components, food prices react most strongly to the FEMR consumer demand shock. This is due to the short sales cycle of such goods and relatively small stocks over time, which requires regular purchases; prices adjust to shocks rapidly. Consumer demand shocks have the least impact on the dynamics of non-food prices, as non-food products have a longer sales horizon and a larger volume of stocks, which flattens the adjustment of prices to shocks over time. At the time of occurrence of the shock, the response of services inflation is smaller than the changes in food prices, but the shock has the largest accumulated response over the horizon of two years. This is due to the limited ability to expand supply through own production, delivery from other Russian regions, or foreign imports in the short term (as most services are non-tradable).

[13] In the impulse response charts, 'Russia' indicates the paths of the indicators for the entire country.

Inflationary pressure in Russia as a whole grows insignificantly in response to a 1 pp consumer demand shock in the FEMR due to the small contribution of the FEMR to the countrywide inflation rate. The monetary policy rate responds to such an increase in inflationary pressure with a slight increase, which is much less than one standard step of the monetary policy rate change by the Bank of Russia. Therefore, the Bank of Russia does not change the rate in response to the FEMR consumer demand shock. Since the consumer demand shock is of a short-term nature, inflationary pressure is quickly relieved, which leads to a slowdown in inflation in the FEMR and its convergence with the national inflation rate. The decline in the rate of price growth is slower than the reduction in the consumer demand shock due to the high inertia of services inflation.

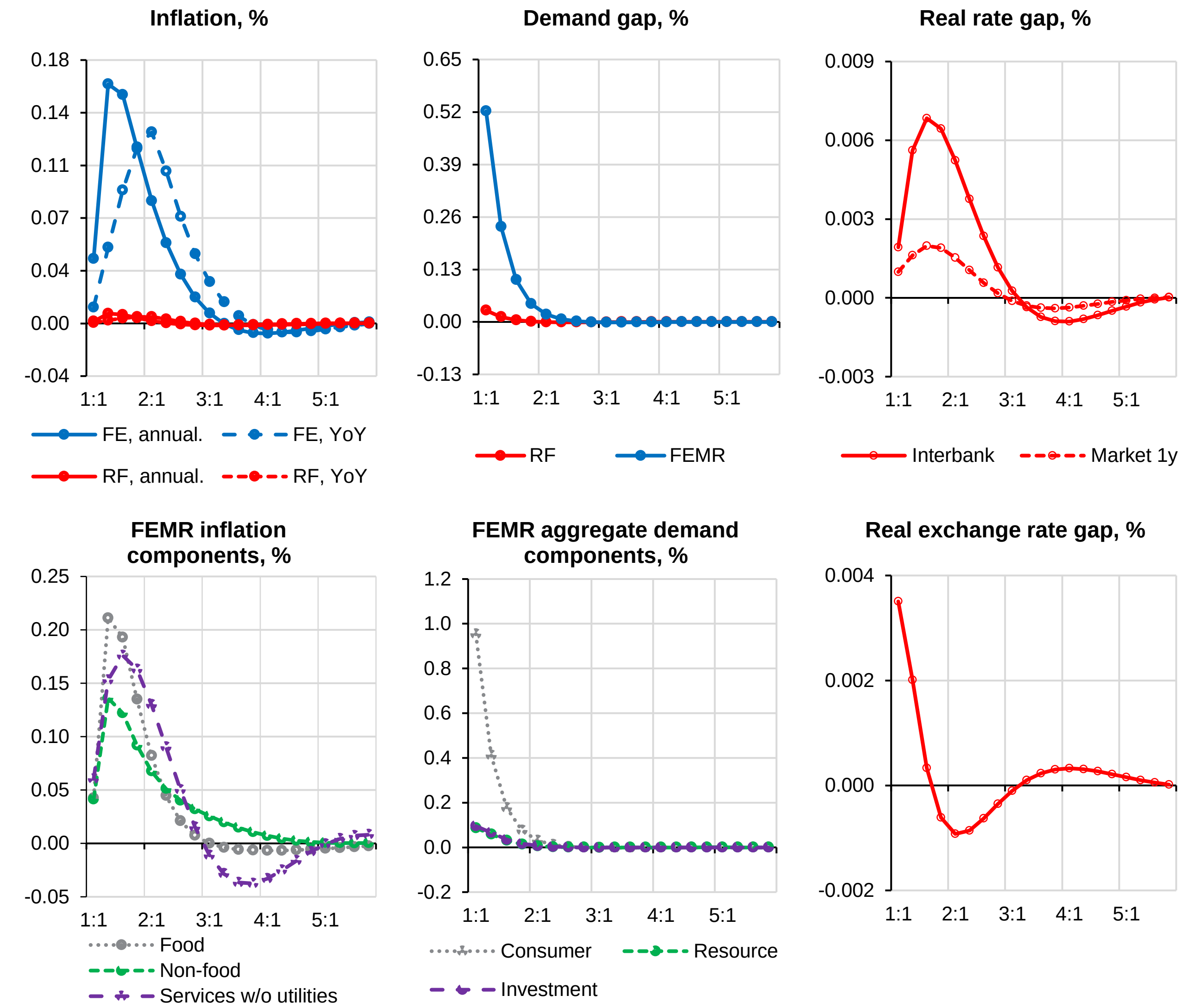

Figure 4. FEMR consumer demand shock

The consumer demand shock also causes growth in consumption of imported goods. The increase in demand for foreign currency to purchase imports leads to a weakening of the exchange rate of the national currency. However, the magnitude of the exchange rate change is small. As a result, the 1pp FEMR consumer demand shock leads to a temporary acceleration of inflation in the FEMR and has smaller impact on inflation and economic activity in Russia as a whole, the ruble exchange rate, or the monetary policy rate.

However, if the shock is significant at the countrywide level, it leads to the formation of a significant positive output gap in the Russian Federation, which contributes to the growth of the countrywide inflation. The Central Bank raises the key rate to bring the inflation back to the target. Thus, according to the model estimates, a 35 pp shock in consumer demand leads to a 0.25 pp (one standard step) increase in the policy rate within three quarters after the shock.

FEMR resource demand shock. A 1pp increase in resource demand in the FEMR leads to an small increase in exports in Russia as a whole. The exchange rate of the national currency strengthens due to the excess supply of foreign currencies, but the magnitude of its change is close to zero (Figure 5). The FEMR resource demand shock has a small positive impact on final consumption and inflation in the macroregion through the income channel[14]. The impact on Russian as a whole inflation is small, so the monetary policy rate is almost unresponsive to this shock. As a result, the FEMR resource demand shock significantly affects only the dynamics of FEMR economic activity, while the prices of consumer goods and services do not react meaningfully. The monetary policy rate weakly responds to the FEMR resource demand shock. A significant response of the monetary policy (a 0.25 pp rate increase within one quarter) is observed for a 120 pp shock of commodity demand in the FEMR.

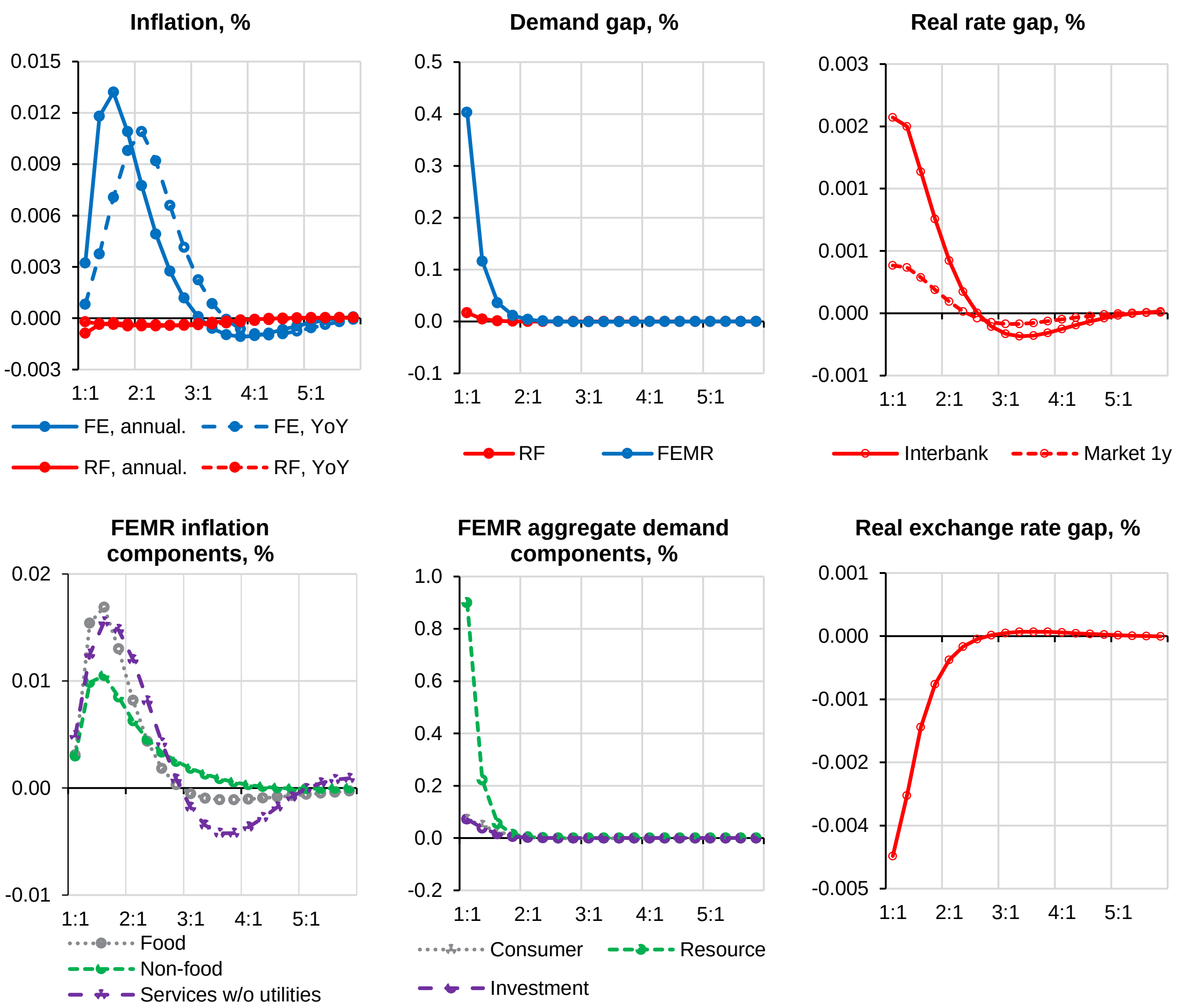

Figure 5. FEMR resource demand shock

FEMR investment demand shock. The investment demand shock in the FEMR arises due to the active implementation of investment projects in the macroregion. This

[14] Mostly services and food products.

shock leads to an increase in demand for equipment, raw materials, and supplies. In case of a 1 pp shock of investment demand the output gap in the country as a whole becomes weakly positive, but this does not create significant inflationary pressure (Figure 6). The investment demand shock has an insignificant (close to zero) impact on consumer demand and inflation in the FEMR through the income effect. In general, similar to other components of aggregate demand, a 1 pp investment demand shock has small impact on the countrywide variables (demand gap, inflation, and exchange rate). This is why the Bank of Russia does not react to the FEMR investment demand shock by changing the monetary policy rate. However, if the investment demand shock in the FEMR is large enough (it is equal to 300 pp according to model estimates), then in this case, inflation both in the FEMR and in Russia as a whole increases significantly. This leads to an increase in the monetary policy rate (up to 0.25 pp in the first two quarters after the shock).

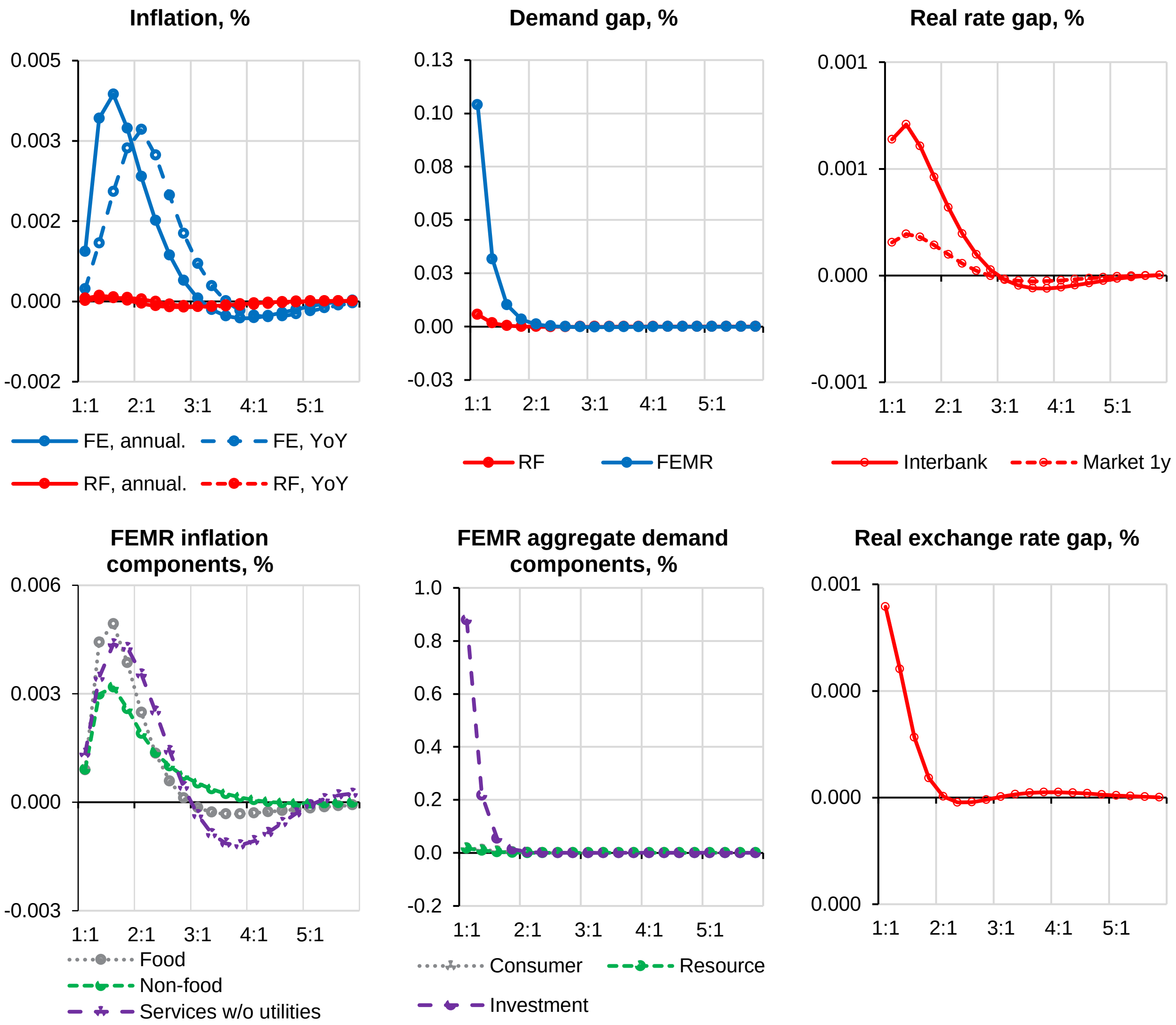

Figure 6. FEMR investment demand shock

FEMR aggregate demand shock. The dynamics of variables during the FEMR aggregate demand shock are consistent with the dynamics of variables during the shock of its components, namely, consumer, resource, and investment demand shocks (Figure 7). The 1 pp shock insignificantly affects the countrywide variables (inflation, all Russia's demand, and the exchange rate), so the interest rate changes weakly (less than one standard step of the monetary policy). A one standard step (0.25 pp) rate increase within three quarters of a shock occurs when the magnitude of the aggregate demand shock in the

FEMR is equal to 30 pp. This shock is only theoretical, as the scenario of a simultaneous shock of equal magnitude of three components of aggregate demand in the FEMR is unlikely to be realised.

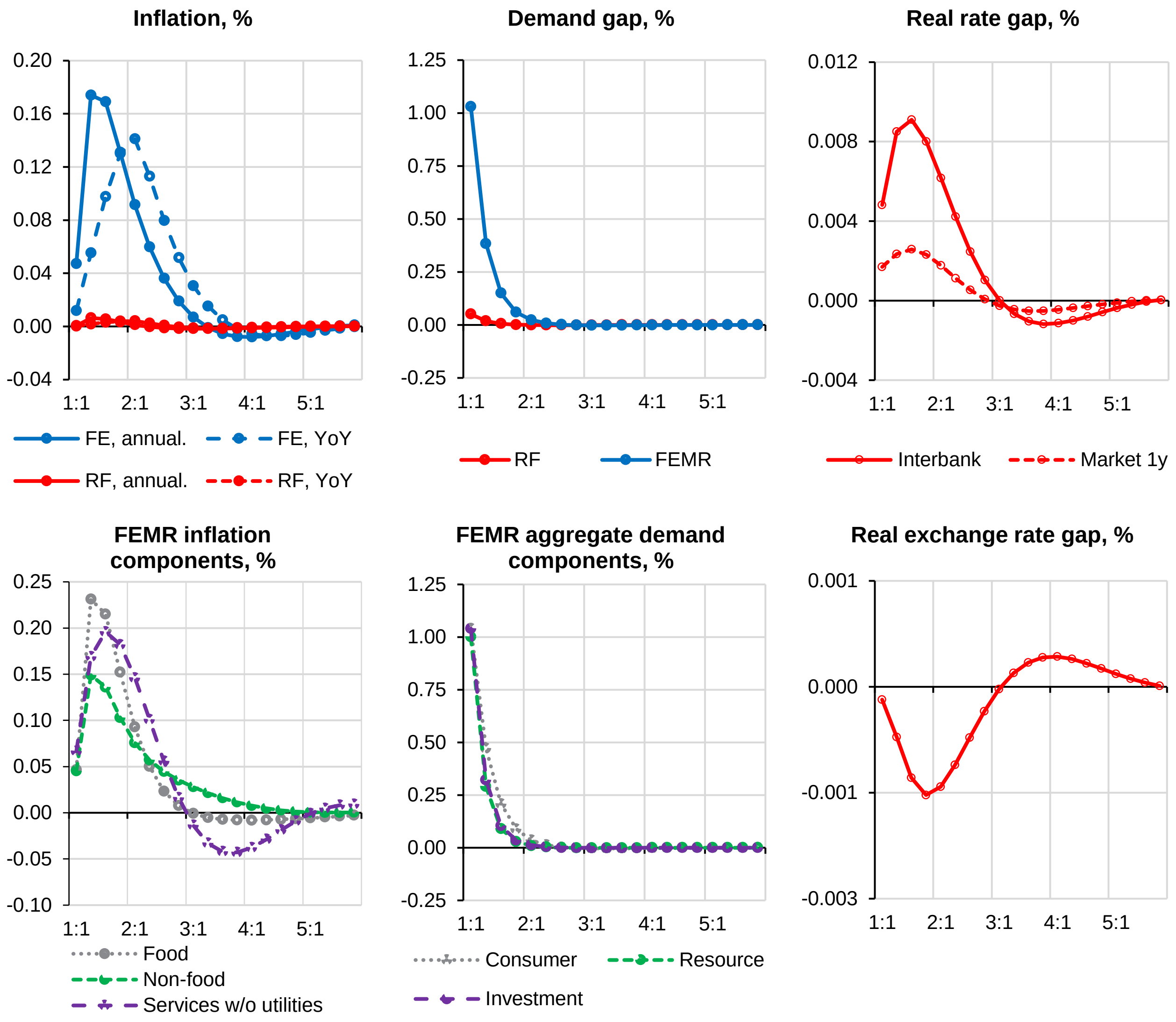

Figure 7. FEMR aggregate demand shock

Russian aggregate demand shock. The all-Russian aggregate demand shock generates a positive Russian output gap, leading to a rise in countrywide inflation (Figure 8). The acceleration of Russian price growth is transferred with a lag to the rise in inflationary pressure in the FEMR mainly through the supply of consumer goods to the Far East from the rest of Russia. The prices of these goods already take into account the increased countrywide demand. The rate of price growth in the FEMR is lower than in the country as a whole due to the greater contribution of logistics costs to the final prices of consumer goods, which partially offsets the impact of this shock in the macroregion. To return inflation to target, the Bank of Russia raises the key rate, which leads to an increase in the market rate. Due to price rigidities and active monetary policy, nominal rates increase faster than inflation expectations. This causes real interest rates to rise. There is also a reduction in demand and a temporary appreciation of the real exchange rate. As a result, inflation slows down, which makes it possible to ease monetary policy. Eventually, the real exchange rate and output return to equilibrium and inflation returns to target.

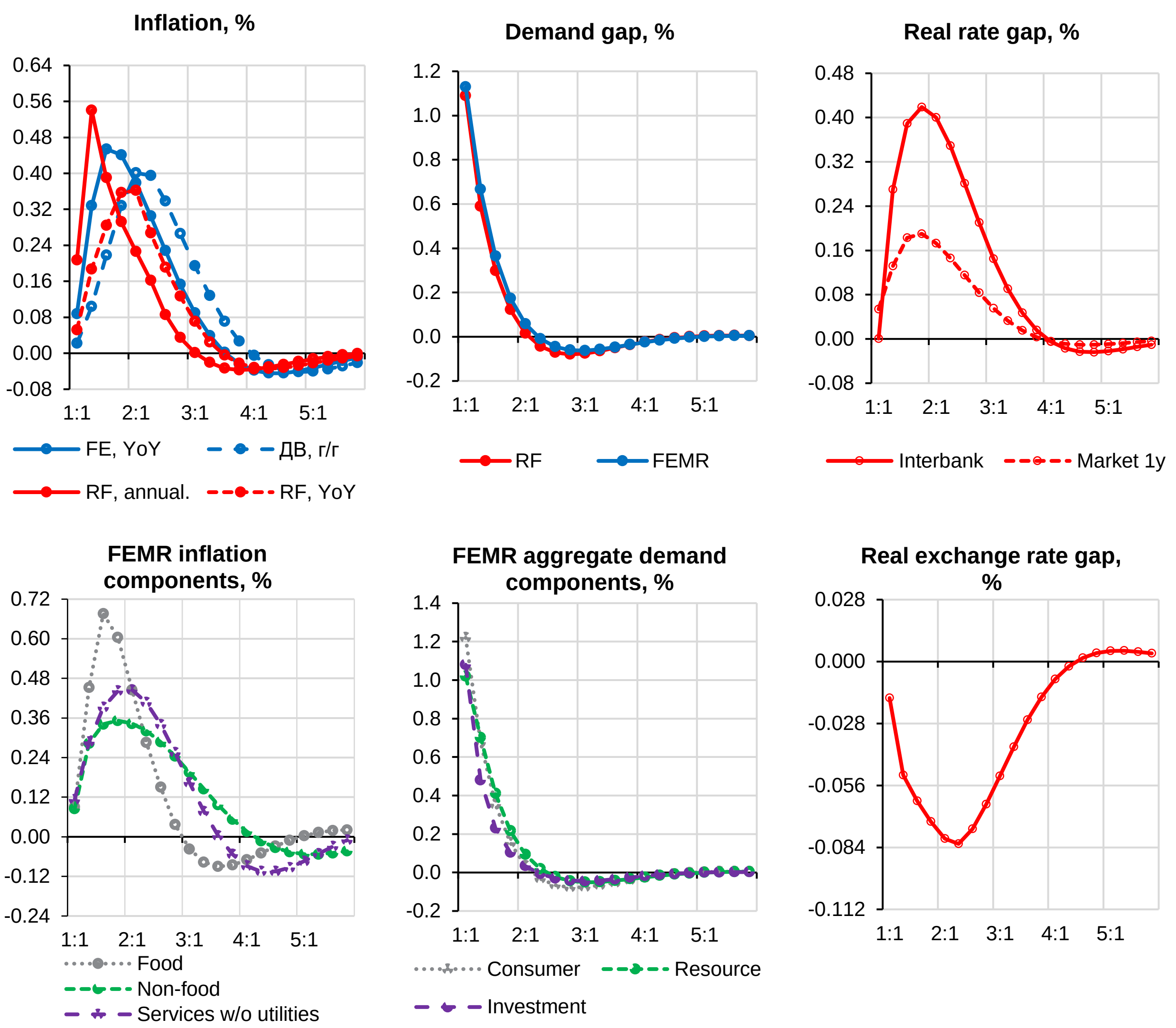

Figure 8. Russia's aggregate demand shock

FEMR cost-push shock. A 1pp FEMR cost-push shock leads to an increase in FEMR inflation (Figure 9). This shock has no significant impact on inflation in Russia as a whole. The response of the monetary policy rate to this shock is close to zero. Inflation in the FEMR slows down and converges with the Russian inflation rate due to the expansion of the supply of goods from other regions of the country and foreign imports. A significant monetary policy response (a 0.25 pp rate increase) is observed when the magnitude of the FEMR cost-push shock is 20 pp.

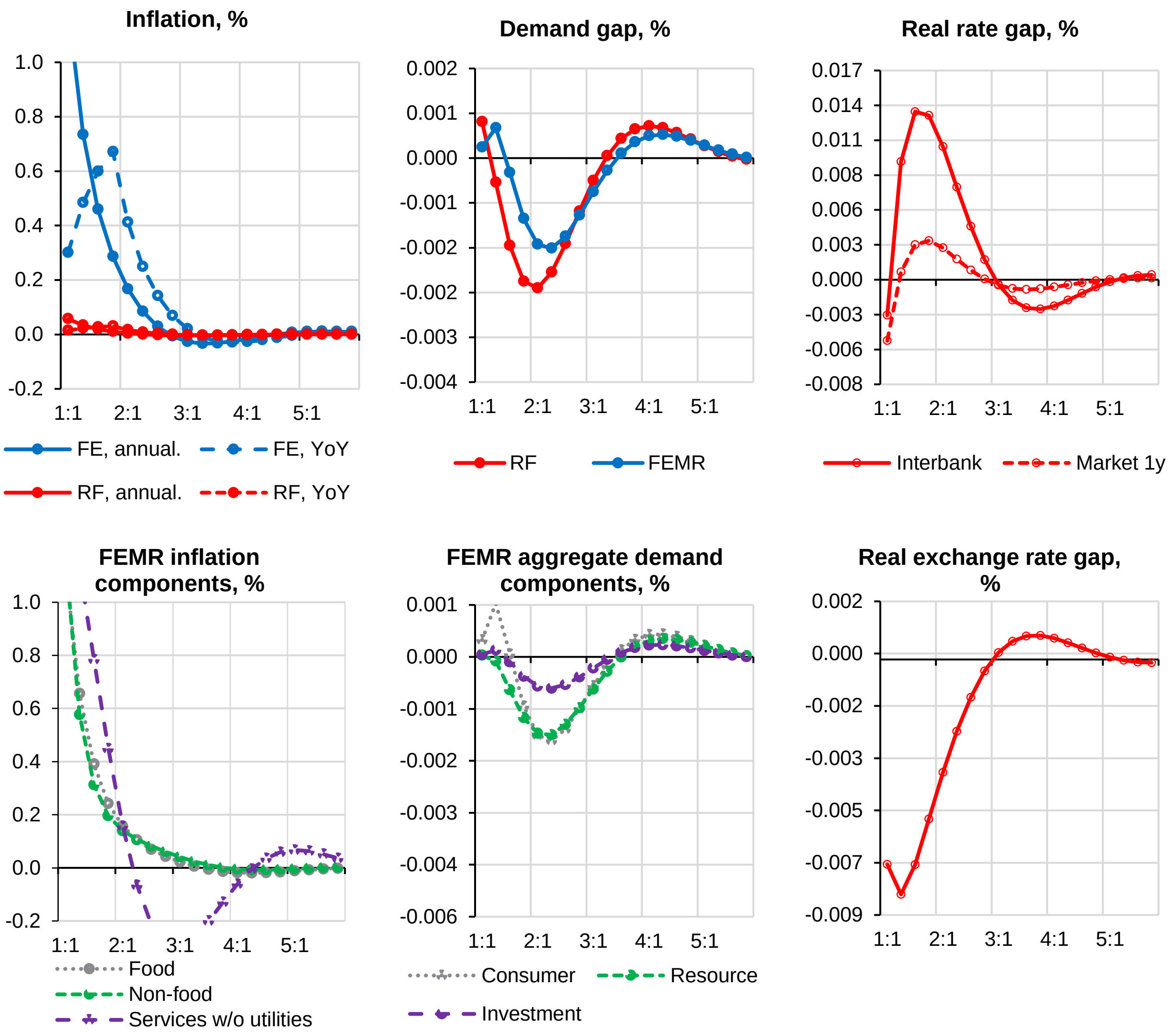

Figure 9. FEMR cost-push shock

Russia's cost-push shock. The Russian cost-push shock is composite and includes inflation shocks in the FEMR and the rest of Russia. In this case, the effects are realised from both the change in the rate of price growth in the FEMR and the acceleration of inflation in the rest of Russia (Figure 10). The impact from the rest of Russia occurs with a lag of one quarter due to the fact that delivery of consumer goods from other regions of the country takes a long time. In response to rising inflation, the Bank of Russia raises the key rate, and, consequently, interest rates in the economy increase and the real exchange rate appreciates. Economic activity shrinks both in Russia as a whole and in the FEMR. However, the response of aggregate demand in the FEMR is smaller than in the entire country. This is due to the weaker response of investment demand in the FEMR compared to other components of aggregate demand to an increase in the economy's interest rates. The weaker response of investment demand compared to other components is explained by the fact that it is significantly affected by the federal budget deficit. The response of the federal budget deficit to changes in the rates in the economy is modelled through the change in the gap of aggregate demand of the Russian Federation and is inversely proportional to it. A reduction in the Russian aggregate demand gap causes an increase in the federal budget deficit and compensation for the reduction in investment demand by the FEMR.

Due to positive real rates, inflation expectations are reduced and inflation returns to target.

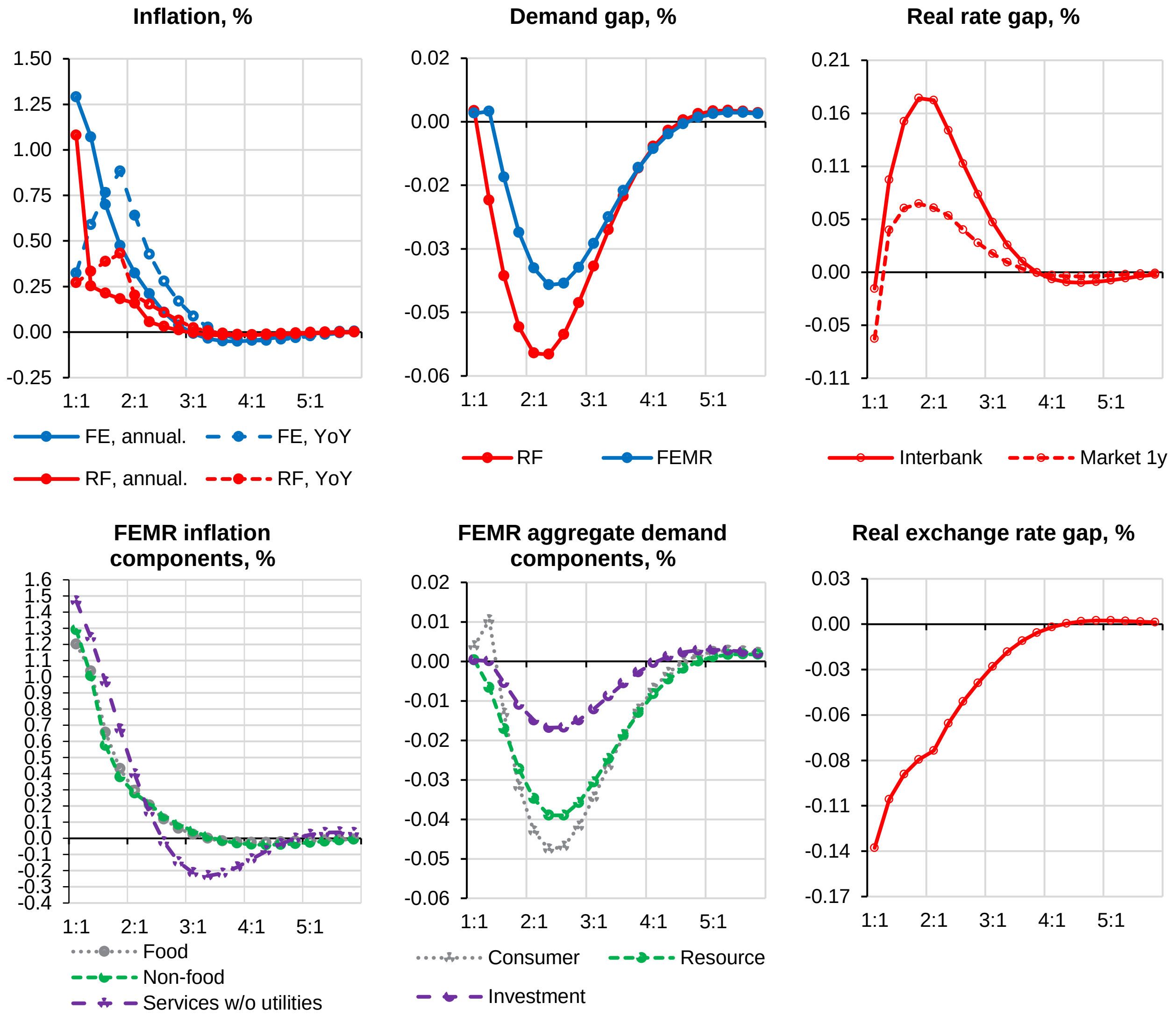

Figure 10. Russia's cost-push shock

FEMR fiscal policy shock. The fiscal policy shock in the FEMR causes aggregate demand in the macroregion to grow and creates a positive demand gap. This leads to higher inflation in the FEMR (Figure 11). However, due to the small share of the FEMR economy in the Russian economy, the 1 pp FEMR fiscal policy shock does not have a significant impact on the countrywide macroeconomic variables. As the fiscal impulse is exhausted, economic activity and inflation return to equilibrium without any reaction from monetary policy. However, if the fiscal policy shock in the FEMR is significant at the countrywide level, it leads to the formation of a significant positive gap in countrywide aggregate demand over the horizon of eight quarters, and to the growth of the countrywide inflation. As a consequence, a rate increase is required to bring inflation back to the target. According to model estimates, the fiscal policy shock of the FEMR should amount to 125 pp within four quarters, so that the Bank of Russia responds to it by increasing the rate by 0.25 pp at the horizon of 12 quarters.

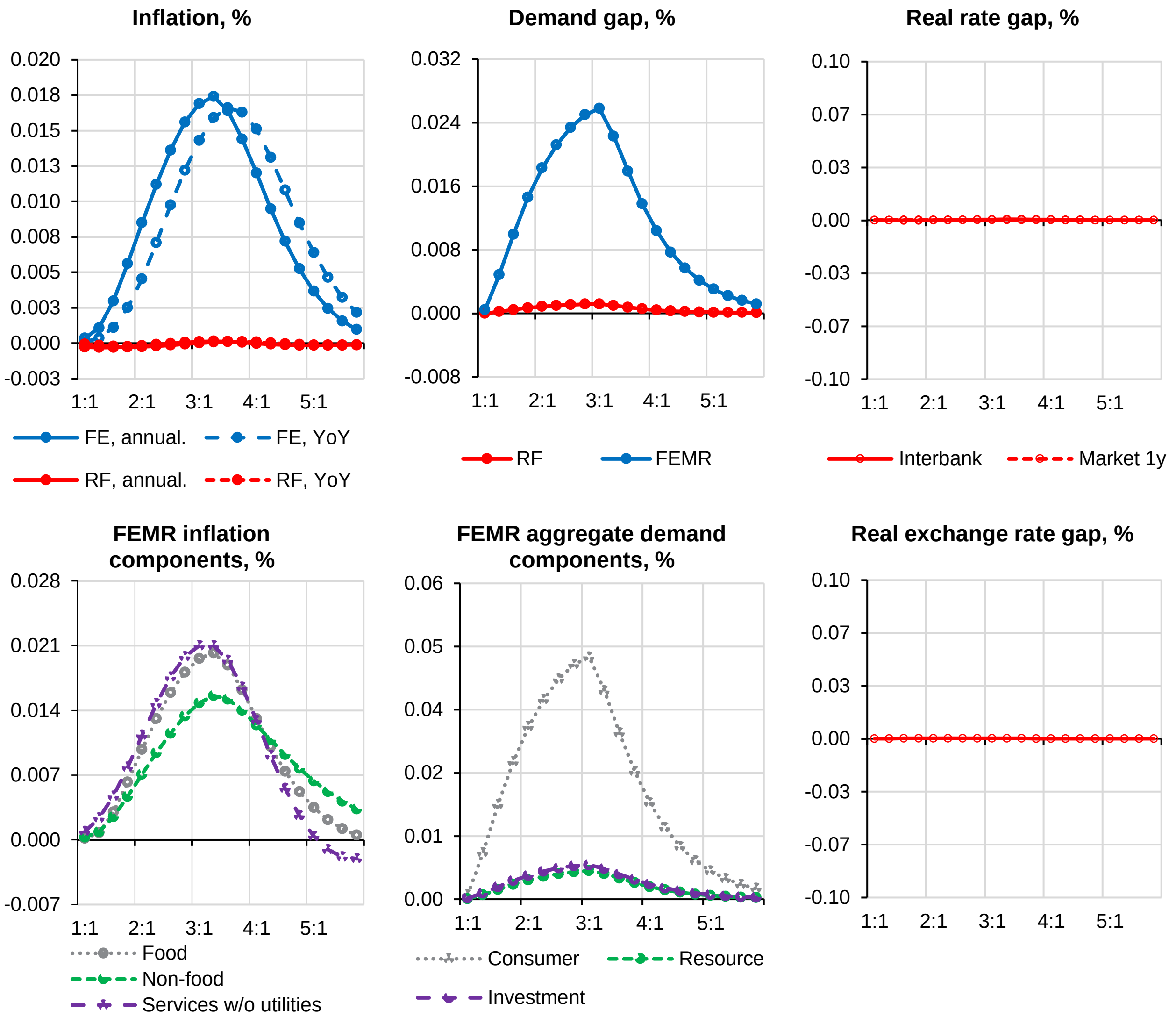

Figure 11. FEMR fiscal policy shock

Monetary policy shock. The monetary policy shock has a restraining effect on aggregate demand (Figure 12). FEMR consumer and resource demand responds to the monetary policy shock to a greater extent, while investment demand responds to this shock to a lesser extent. This leads to a smaller response of the aggregate demand of the FEMR relative to Russia as a whole to the monetary policy shock. The smaller reaction of investment demand compared to consumer and resource demand is explained by the high dependence of investment demand on the federal budget deficit gap, which does not react meaningfully to changes in the key rate. The monetary policy shock also leads to a stronger domestic currency. This is due to a reduction in demand for imports and, consequently, an excess supply of foreign currencies.

Both appreciation of the domestic currency and subdued consumer activity contribute to a slowdown in inflation. At the same time, price adjustment in the FEMR takes longer than in Russia as a whole. This is due to the fact that delivery of consumer goods from other regions takes a long time, and the share of such goods is high in the expenditures of the population.

As the key rate returns to neutral, the real exchange rate gap and economic activity revert to equilibrium, and inflation returns to the target level.

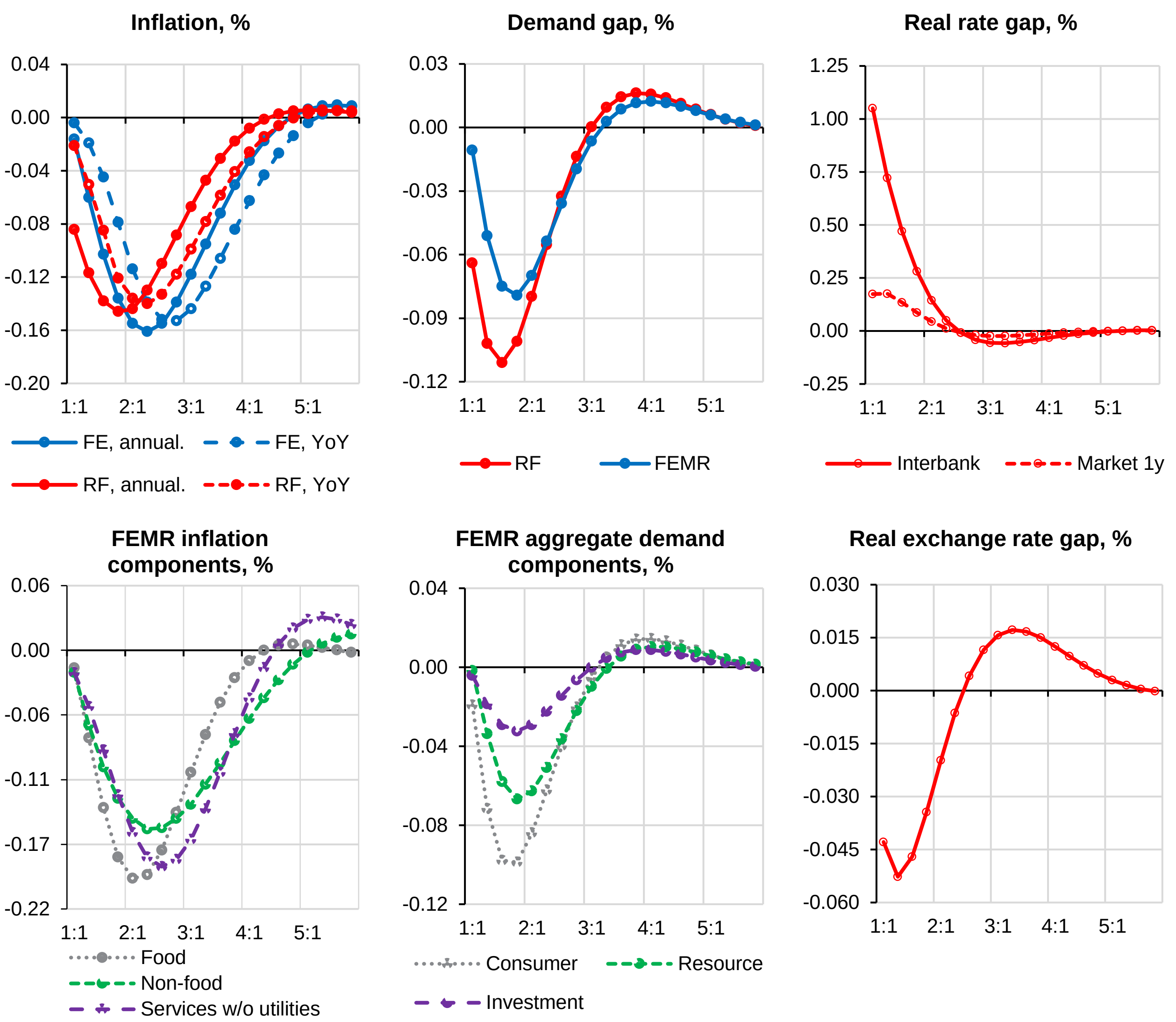

Figure 12. Monetary policy shock

Exchange rate shock. The exchange rate shock has direct and indirect effects on inflation (Figure 13). In the short term, the growth rate of the prices of imported goods increases. This also leads to a rise in demand for Russian producers' goods and an increase in the competitiveness of domestic products compared to imports due to a decrease in the cost of domestic products on the world market These factors stimulate the growth of net exports and aggregate demand. Rising aggregate demand and costs of imported goods lead to higher inflation. In response to higher growth in economic activity, and current and expected inflationary pressures, monetary policy tightens, which contributes to both a slowdown in inflation and a return of the aggregate demand gap to equilibrium. In the short term, FEMR inflation and demand respond to exchange rate shocks with a lag of one quarter due to the fact that delivery of goods from other regions of the country takes a long time. Despite the deviations in the countrywide and FEMR inflation dynamics, the accumulated response is not meaningfully different. The aggregate demand response is smaller due to high integration into the markets of Asia-Pacific countries with stable demand for raw materials.

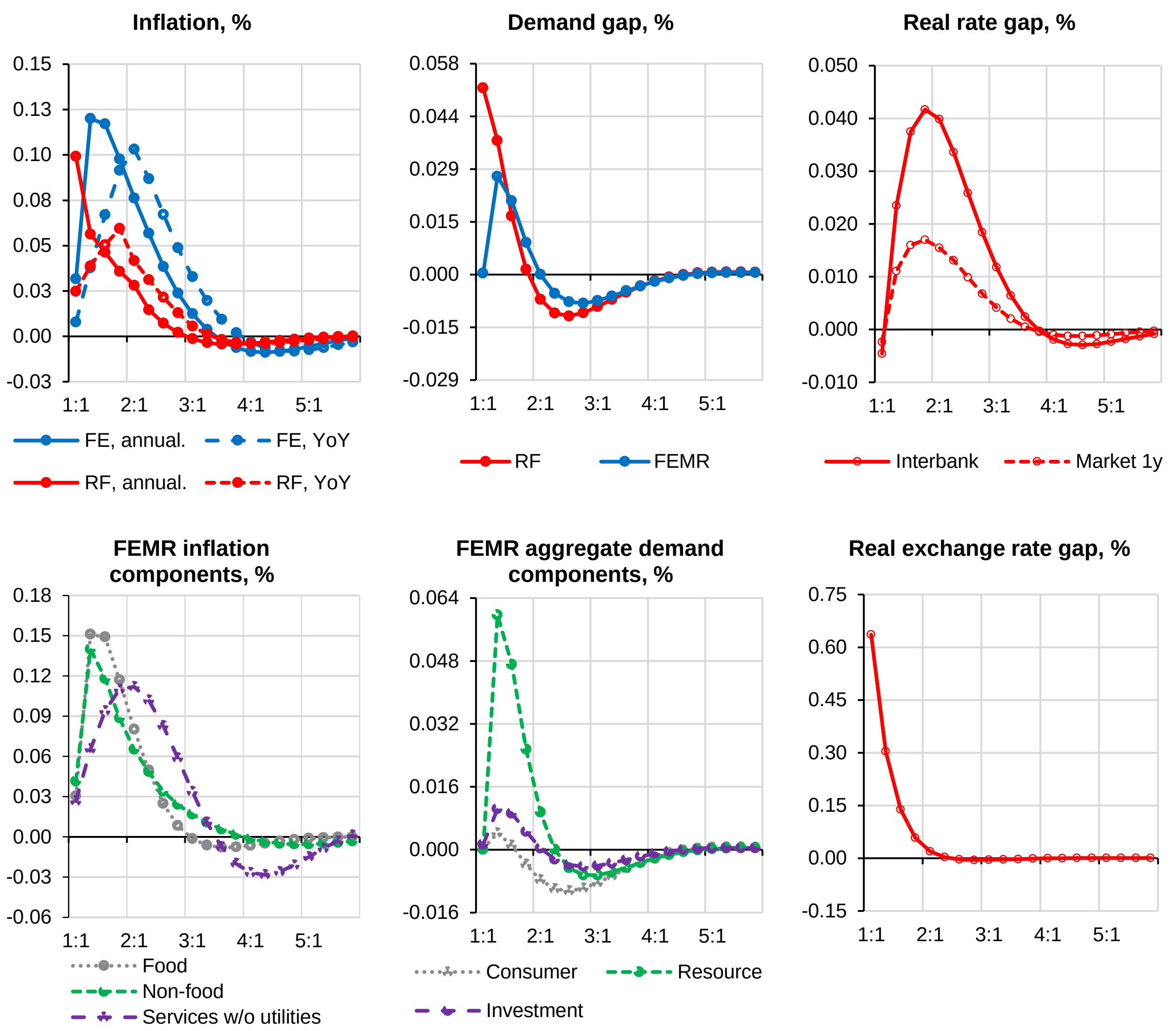

Figure 13. Exchange rate shock

In summary, the results of analysing the properties of the model based on impulse response functions indicate that in the case of a single shock to the FEMR economy, the Bank of Russia will not respond by changing the interest rate. The reason for this is the small contribution of the FEMR to the national variables. However, in the event of a large (demand, cost-push or fiscal policy) shock in the FEMR, which will lead to a significant deviation of nationwide macroeconomic variables from equilibrium, the regulator may have to react and adjust the key rate.

Analysis of the impulse response function reveals differences in the response of the main macroeconomic variables of the FEMR and Russia to countrywide shocks.

The all-Russian **aggregate demand** shock has a significant impact on both macroregional and countrywide inflation. The impact on FEMR inflation occurs with a lag of one quarter due to the fact that the delivery of consumer goods from other regions of the country takes a long time. In addition, the price response to this shock in the FEMR is lower than in the country as a whole due to the greater contribution of logistics costs to the final prices of consumer goods, which partially offsets the impact of this shock on prices in the macroregion.

The all-Russian **cost-push shock** is accelerating inflation in both Russia as a whole and the FEMR. Similar to the Russian aggregate demand shock, this shock affects FEMR inflation with a lag. We should note that due to a smaller response of investment demand to this shock (compared to other components of aggregate demand), the response of aggregate demand in the FEMR is smaller than in the entire country.

The **monetary policy shock** has a smaller impact on FEMR aggregate demand relative to Russia as a whole. This is due to a larger decline in consumer and resource demand compared to investment demand in response to the monetary policy shock. At the same time, price adjustment in the FEMR takes longer than in the entire country.

4.4. Predictive performance

A description of the data used to build the model is given in Table A5 of Annex 6.

Assessing the accuracy of model predictions is one of the tools for diagnosing the quality of calibration. To test the predictive performance of the model, the sample (2013 Q1 – 2023 Q3) was divided into a training sample (2013 Q1 – 2018 Q4) and a test sample (2019 Q1 – 2023 Q3). After assessing the model on the training sample, out-of-sample dynamic forecasts of endogenous variables were conducted on a moving eight-quarter window within the test sample.

To assess the accuracy of the forecast, the root mean square errors (RMSE) of the forecast for the second year (medium-term period, from the 5th to the 8th forecast quarter inclusive) were calculated. The forecast was obtained using the estimated model (FEMR semi-structural model) and the Reference Model. The accuracy of the model was assessed for five variables: FEMR GRP, FEMR CPI, Russian GDP, Russian CPI, and the RUB/USD exchange rate.

The ARMA(1,0) model is used to forecast output, inflation, and exchange rate as the Reference Model for comparison. To assess the accuracy of the model, we use the period from 2020 Q1 to 2021 Q4 for the output and the period from 2020 Q2 to 2023 Q3 for inflation and the exchange rate.

Table 6. RMSE of out-of-sample forecast of main macroeconomic variables

RMSE	FEMR GRP, YoY	FEMR CPI, YoY	RUB/USD exchange rate	Russian GDP, YoY	Russian CPI, YoY
FEMR semi-structural model	3.3	4.8	8.1	5.17	6.28
Reference	4.6	5.6	12.5	5.20	6.91

Source: authors' calculations.

Figure 14 shows the sets of out-of-sample forecast paths for output, inflation, and the RUB/USD exchange rate, which were used to assess the quality of the model.

It can be visually determined that the forecasts are not systematically concentrated above or below the actual path, with the exception of the GRP and inflation forecasts generated for 2020 Q2 and 2022 Q4, respectively. The spread of the forecast paths can be considered insignificant.

The RMSE of forecasts of the main macroeconomic variables are smaller for the estimated model (Table 6). More accurate estimates help improve the decomposition of the historical dynamics of the main macroeconomic variables into contributions of components and factors, identification of shocks, and construction of a theoretically sound forecast of economic development in the Far Eastern macroregion, considering its regional characteristics.

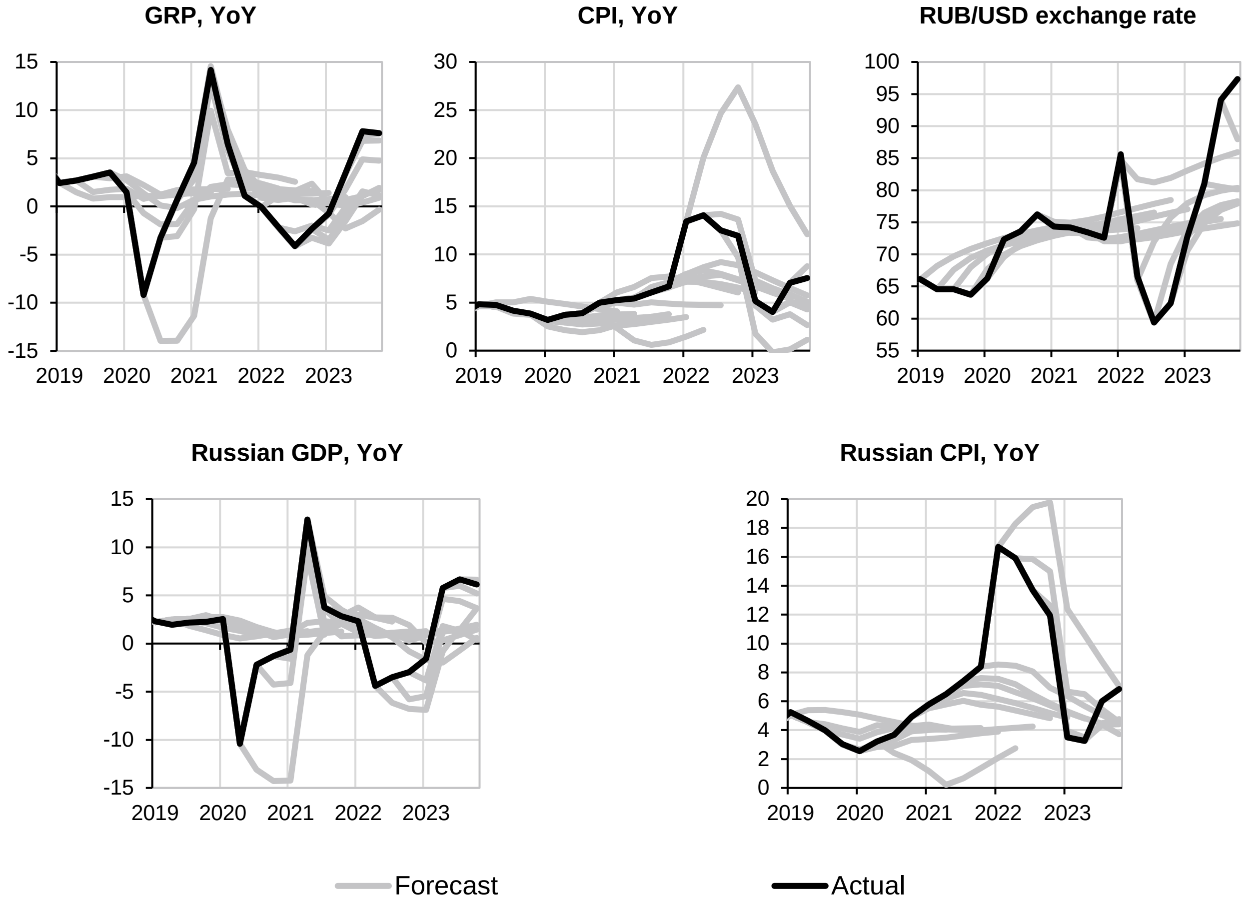

Figure 14. Out-of-sample dynamic forecasts of GRP, CPI, and RUB/USD exchange rate on a moving 8-quarter window

To analyse robustness, several models with different coefficient variations in the main behavioural equations were estimated (Table A3 contains the RMSE of the forecast and Table A4 contains the sets of coefficients). The RMSE of the out-of-sample forecast of GRP, CPI, and the RUB/USD exchange rate was calculated for each specification. In terms of forecast accuracy, the Reference specification was found to be the optimal compared to other variations of the model.

5. Output and inflation drivers in the Far Eastern macroregion

To compare the impacts of shocks of a different nature (domestic and external in relation to the macroregion), we decompose the main macroeconomic variables (output and inflation gaps) into shocks and the contributions of individual components.

Following the transition to inflation targeting, the macroregion's average growth between 2016 and 2022 was slightly above the nationwide; its average price growth also tracked the national average. The macroregion's economic development passed several stages in the period, namely stagnation (2016–2017), growth (2018–2019), coronaviris pandemic (2020–2021), and structural transformation (2022 – 2023 3Q).

Stagnation (2016–2017). In 2016–2017, the macroregion's GRP grew at near-zero rates (compared to the national average of about 1%). First, the macroregion's economy came under constraining pressure from countrywide factors – as the national economy was adjusting to new external conditions (low export commodity prices, financial sanctions and technology exchange restrictions) – and domestic developments (such as shrinking consumer demand and low investment activity of private business). Second, the economy was affected by the local factor: investment fell following the completion of major investment projects in the macroregion. In recent decades, the Far Eastern regions have been implementing major investment projects, which drove high volumes of construction. However, with the construction of the Eastern Siberia – Pacific Ocean pipeline past its principal stage and no other project launches scheduled, construction slowed in 2013–2018. This led to investment, alongside consumer, demand making a negative contribution to the macroregion's emerging negative output gap, which is described by the volume of construction (Figure 15). Meanwhile, resource demand made a positive input into the output gap. At the time, the macroregion recorded growing volumes of mineral extraction, the bulk of which were exported. Nonetheless, adverse market conditions for several types of exports, Western sanctions including equipment and technology restrictions, and a ban on foreign loans (*Prokapalo et al. (2017)*), had combined to make a constraining effect on production growth. This resulted in this component having barely a minor impact on the output gap, partially offsetting the negative effects of consumer and investment demand.

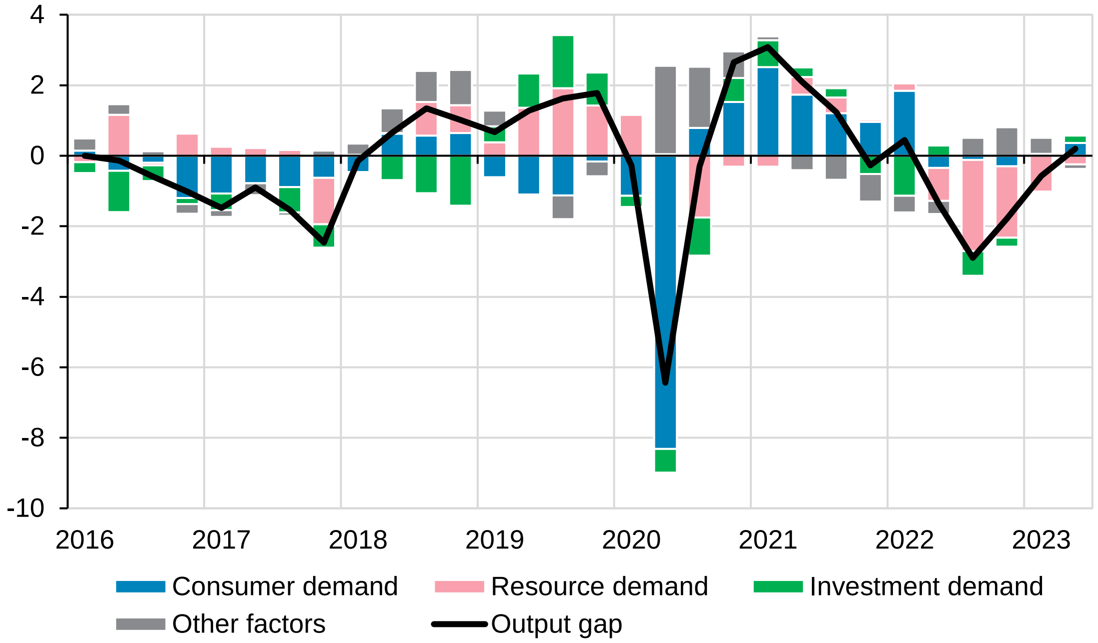

Figure 15. FEMR output gap decomposed by component, %

Among factors having a constraining effect on economic activity up to mid-2017, both at the regional and federal levels, was a tight monetary policy stance (Figure 16). For all its reduction, the Bank of Russia key rate held above its neutral value at the time. This was offset by a weak exchange rate of the ruble. From 2016 Q4 to 2020 Q1, a positive contribution to output in both the macroregion and the overall country came from improvements in global terms of trade (the approximation for rising oil prices). At the same time, an expanding supply of foreign currency revenue from Russian exports, which enjoyed higher prices, led the ruble to strengthen, which in 2017 put constraining pressure on output.

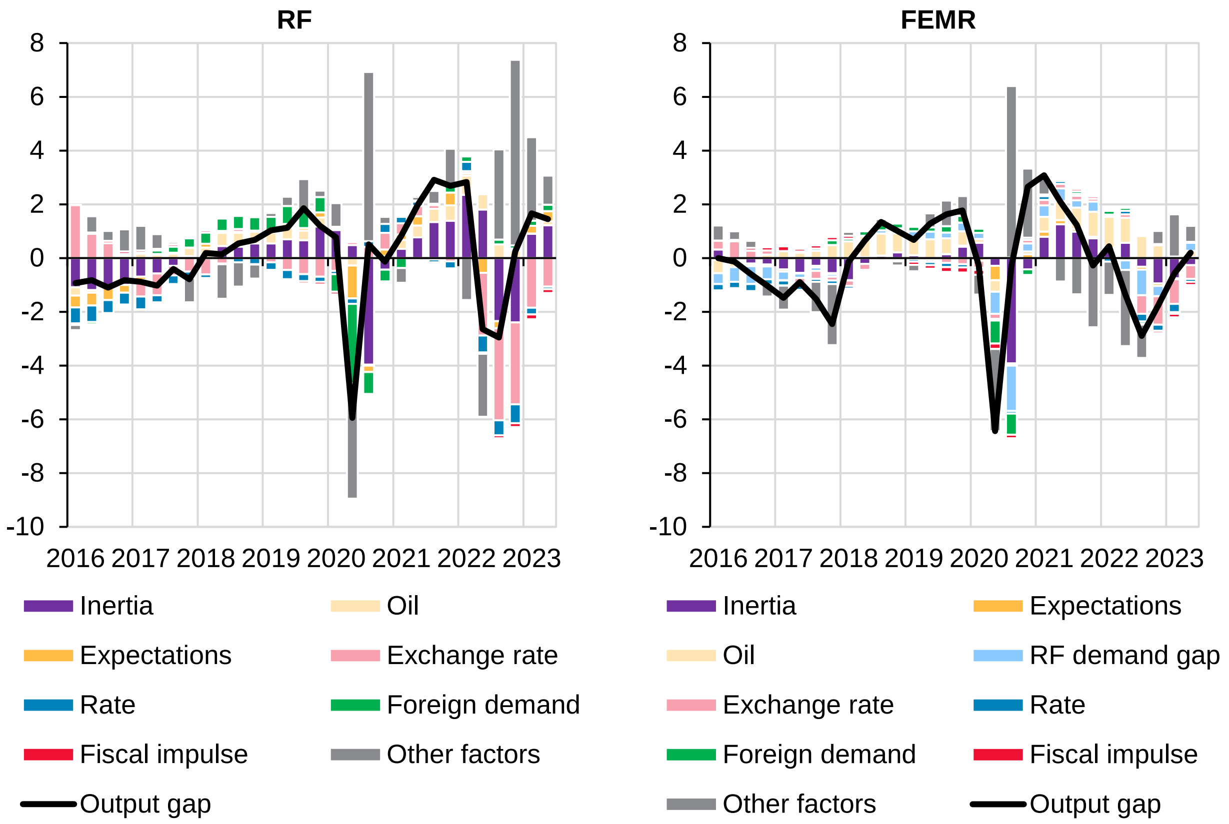

Figure 16. Russian and FEMR output gap decomposed by factor, %

Weak economic activity combined with muted consumer demand, including as a result of a tough monetary stance, drove inflation in 2016–2017 down to an all-time low for both the macroregion and Russia as a whole (Figure 17). The disinflationary effect also came from the expanding supply of affordable domestic food products on the back of progress in import substitution, which Russia initiated as counter-sanctions in the food industry (*Prokapalo et al., 2017*). In 2015, the weakening of the ruble drove the share of retail products sharply down; as regards food, the decline of its share continued into 2016 (*Golyashev et al., 2017*).

Growth in the macroregion's consumer prices was consistent with countrywide data.

Growth (2018–2019). The 2018–2019 period is marked by strong economic growth, with the macroregion's economy expanding at a pace above the national average. The positive output gap in the FEMR in those years owes its existence mainly to resource demand driven by rising volumes of mineral production as the global environment improved and external demand went up. A further impactful contribution came from several major investment projects, which were partially completed in 2019. For example, a section of the Power of Siberia gas pipeline was put into operation in 2019. The construction of the pipeline, which exports gas from Yakutia to China, began in 2014. The first supplies to China began in 2019 Q4 and gave impetus to resource demand in the period.

In 2018–2019, the influence of external demand on economic activity in Russia as a whole proved slightly higher than in the FEMR.

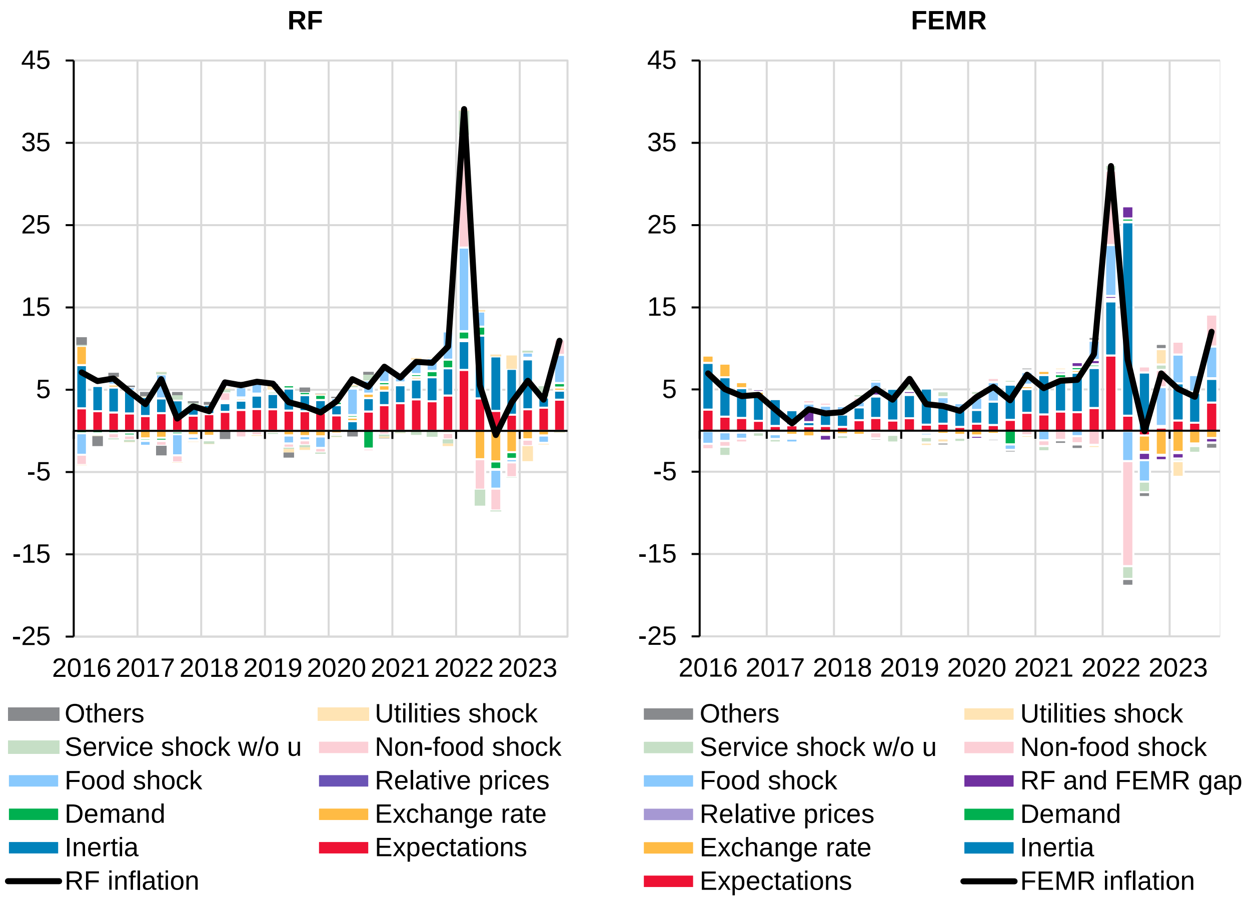

Figure 17. Russian and FEMR inflation decomposed, QoQ,[15] seasonally adjusted, annualised, %

Consumer demand in the overall FEMR remained muted with negligible effects on growth and inflation. In 2018, inflation accelerated in the entire country and in the FEMR alike. Beyond expectations and inertia, consumer price shocks – emanating from the expected VAT rise to as high as 20% – made a significant contribution to the acceleration of inflation. As this factor ran its course in 2019 Q2, inflation was increasingly showing a downward trend. Also, the disinflationary effect was brought by an ample harvest and expanding supply in individual food markets (food inflation shocks in 2019 were overall negative). For all the weakening of the ruble throughout 2018–2019, this factor had a disinflationary effect in Russia as a whole and FEMR alike given that the pace of weakening was below the equilibrium level and the real exchange rate gap was negative.

Coronavirus pandemic (2020–2021). The downturn in 2020 Q2 in both Russia as a whole and the macroregion owes its existence to the exogenous factors the model strips out, that is the tight anti-coronavirus restrictions intended to limit social contact. The restrictions on the freedom of movement combined with a drop in incomes to drive down consumer demand, which was the key factor behind the negative output gap emerging in the FEMR at the time. The pandemic-induced downturn in partner economies alongside the closure of borders disrupted established economic interactions. As a result, a significant contribution to the negative output gap, country- and macroregion-wide, was made by negative output gaps in partner countries, which had more substantial implications for countrywide output gap: all-Russia's partner countries posted a much stronger negative output gap (-2.95%, according to our calculations) than the FEMR's partner countries (-

[15] QoQ growth, %

0.86). As a number of businesses suspended operations, the economic potential of both the Russian economy as a whole and the FEMR posted a temporary contraction.

Starting from the second half of 2020, all-Russia's and the FEMR's economies took a dynamic recovery path following the lifting of non-market restrictions. The response of economic activity to the imposition and lifting of restrictions cannot be described by the set of factors we consider. Accordingly, 2020 Q2 saw a significant reduction in the output gap of both Russia as a whole and the FEMR, while Q3 and Q4 were marked by an unusually swift recovery as restrictions were lifted, largely on the back of the unexplained part or other factors. A downturn of a market nature would very unlikely have been followed by so swift a recovery.

The economies of countrywide and the FEMR both report a positive output gap in this period. Overall, the drop in output at year end 2020 in the macroregion (-2.6% YoY)[16] was slightly less strong than in Russia as a whole (-2.7% YoY)[17] thanks to a more moderate shrinkage in external demand.

In the first half of 2021, all-Russia's and the macroregion's output were back on course to grow above pre-pandemic rates. This was helped by high consumer demand (chiefly responsible for the emergence between 2020 Q4 and 2021 Q2 of a positive output gap in the macroregion) and demand from the rest of Russia, spurred by a soft monetary stance as well as benign foreign trade conditions, in particular high oil prices. (Throughout 2021, positive oil price shocks made a significant contribution to the output gap in the FEMR.) In the second half of 2021, growth in FEMR output was decelerating, with the output gap having dipped into negative territory by late 2021, whereas the overall national economy continued to expand. The deceleration was mainly due to slower growth in **resource demand** following lower production in several oilfields as well as slower growth in the FEMR's key foreign trade partner economies. The deceleration in the macroregion's economy was also due to a fall in investment demand once the construction of the Amur Gas Processing Plant was past its first stage. These changes cannot be described by aggregate demand factors since they relate to the supply side. Therefore, 'other factors' were introduced to account for their impact on aggregate demand in the model path.

Starting from 2020 Q2, inflation switched to acceleration both in Russia as a whole and the macroregion, driven by a supply squeeze (partially suspended or discontinued business operations, a poor harvest across several regions of the world, supply chains disrupted by anti-pandemic measures, and rising costs of logistics). By late 2020, prices further accelerated growth as the mismatch between supply and demand was mounting. (Demand was recovering faster than supply.) Overall price growth in the FEMR in 2020 was close to all-Russia's indicators, owing to the impact of common factors. In 2021, the macroregion's growth was below the national average. At the time, inflation in Russia as a whole was fuelled by high inflation expectations and food inflation shocks. This is explained by, first, the higher inertia of inflationary processes in the macroregion relative to the rest of the country and, second, the stronger impact on prices of transport costs, whose growth lagged behind growth in consumer prices.

Start of structural transformation (2022). 2022 Q2 saw a significant reduction in national output, mainly due to exogenous factors including restrictions on Russian imports by hostile countries, production and supply chain disruptions, and settlement difficulties among others. However, as soon as 2022 Q4, as alternative markets and suppliers emerged alongside new logistics and schemes of settlement, the economy began to rebound and the negative output gap of Q2 and Q3 was contracting.

[16] Authors' calculations.
[17] Rosstat.

FEMR output continued to decline up to 2022 Q3. The fallout of sanctions for the FEMR was slightly stronger than for Russia as a whole. This is mainly explained by the economic structure of the macroregion, with mining accounting for a third of GRP. The macroregion’s economic trends of the period were chiefly defined by oil output. Specifically, the cancellation of insurance for tankers transporting crude to Sakhalin Island brought oil shipments to a halt, and oil had to be sent to storage facilities. In 2022 Q3, crude production was essentially put on hold due to the absence of spare storage facilities and ongoing shipment problems. More so, following the exit of foreign companies from the Russian market, the real sector lost access to a number of critical technologies and faced problems with equipment and spare parts supplies. These factors were mainly responsible for a decline in potential growth of the macroregion’s economy in 2022. The emergence of a negative output gap in the macroregion in 2022 was mainly accounted for by exogenous factors. These include the ban on commodity exports imposed by hostile counties and the tightening of lockdown in China, resulting in problems with imports. The other major factors included a drop in countrywide demand, a strengthening of the ruble, and a tight monetary stance.

Prices rose in 2022 Q1 at a significantly accelerated pace both in Russia as a whole and the FEMR, propelled by mounting household inflation expectations following the substantial weakening of the ruble in March and the ensuing rush of panic purchases in the markets for individual products. However, this acceleration in the FEMR was slightly below the national average. (Seasonally adjusted annualised price growth in 2022 Q1 was 32.2% in the FEMR and 39.1% in Russia). Specifically, food, non-food and service price shocks in the FEMR were weaker than in Russia as a whole due to government-subsidised railway shipments of petroleum products bound for the Far East, a measure intended to scale back the growth of producer and supplier costs.

Since the real exchange rate gap feeds through to FEMR inflation with a one-quarter lag, the minor positive contribution of the real exchange rate gap in this period comes as a result of a lower real exchange rate gap in 2021 Q4. It is explained by a decline in the real exchange rate due to the nominal strengthening of the ruble and growth in the national rate of inflation.

In 2022 Q2–Q3, price growth slowed down, propelled by lower inflation expectations, demand adjustments and a stronger ruble. At the same time, the slowdown in Russia as a whole proved stronger than in the FEMR. The more moderate slowdown in the FEMR was due to the lags related to long delivery times for product supplies to the FEMR. These supplies were up in 2022 significantly on the back of higher load rates in transport infrastructure and less contraction in demand compared to overall Russia as a whole (attributable to differences in the supply and consumer demand structure). Specifically, a major input into inflation movements during this period was made by car prices. In the FEMR, the structure of demand for this product group is dominated by used cars mainly originating from Asian countries. Nationwide, the structure of demand is dominated by new cars. Beginning in the second quarter, demand for used cars from Asia showed an upward trend as new cars of European and American origin were in short supply in view of sanctions. The rise in their prices was held back by a strengthening of the ruble and a weakening of the Japanese yen against the US dollar. This led to prices for used cars imported into the region rising more slowly than for new cars.

As is shown by the structure of the model, the positive contribution of the real exchange rate gap to FEMR inflation In 2022 Q2 was due to the positive value of the real exchange rate exchange gap in 2022 Q1, driven by the upward trend of the real exchange rate thanks to the nominal weakening of the ruble and mounting global inflation. The negative contribution of real rate exchange gap in 2022 Q3 in FEMR inflation was the product of downward trends in the real exchange rate in 2022 Q2, triggered by the nominal strengthening of the ruble and the growth of inflation nationwide.

In 2022 Q4, price growth accelerated both in Russia as a whole and the macroregion, where it was higher than the national measure. This is mainly explained by the impact of exogenous factors, with increased logistics costs entailing stronger inflationary pressures in the FEMR than in the entire country, given their contribution to end-user prices.

In general, in the course of the transition to inflation targeting, the following differences were specific to the structure of **output gap shocks** in the FEMR and Russia as a whole:

- the contribution of the **output gap of the external sector** to the FEMR's output gap is lower than the national average for the entire period under study. This is determined by, first, less volatile output in the FEMR's trading partner countries compared to all-Russia's trading partners in the period we consider. Second, since the FEMR's commodity structure of exports and imports is less diversified compared to all-Russia's, it is reliable on industrial production in individual sectors, rather than on business cycles;

- the input of the **terms of trade** – determined by oil prices – into the output gap of the FEMR is above the nationwide average. Oil production has a significant share of the macroregion's economy, which explains the greater weight of the terms of trade in the FEMR's aggregate demand equation compared to the country as a whole;

- for the FEMR, the input of **fiscal stimulus** is also above the countrywide. This owes to a high reliance of the FEMR on federal budget transfers as well as the high proportion of federally funded investment projects.

- changes in **interest rates** make less impact on the output gap of the FEMR than on Russia as a whole, which is due to the dependence of aggregate demand in the macroregion on the implementation of investment projects (the input of investment demand to aggregate demand is 10%; however, it is markedly up at times when investment projects are in motion and construction volumes are rapidly growing). Investment demand, in turn, gives a weak response to interest rate changes in the economy, showing a heavier reliance on the federal budget;

- during the 2020–2021 crisis, the impact of **other factors** on the FEMR's output gap was larger than the national average measure. This comes as a result of exogenous regional factors, that is problems with logistics and shipments from Asian countries alongside China's import and export restrictions targeting Russian goods. In 2022, the average impact of other factors was higher for the country as a whole due its deeper integration into the global economy and Western trade sanctions against Russia.

As compared to the national average, FEMR **inflation** was marked by the following:

- a smaller input of inflation **expectations** into inflation changes, and a larger contribution of **inertia**. Put it differently, inflation in the FEMR is characterised by a stronger dependence on its values in past periods compared to national inflation, that is to say, expectations are more adaptive. This is due to the long delivery times of individual consumer goods entering the macroregion either from producing or central (handling the bulk of imports) regions. This also determines the dependence of FEMR inflation on the national inflation rate;

- **consumer demand** shocks are less relevant to the macroregion's inflation than to Russia as a whole due to the higher inertia of FEMR inflation;

- **food price** shocks have lower influence over FEMR inflation compared to inflation in Russia as a whole. The reason is the macroregion's inadequate self-sufficiency in food products. With a substantial amount of food shipments coming from other regions of the country, their price structure is highly dependent on logistics costs, which in some periods acted to partially offset the high volatility of food prices;

- **service price** shocks have overall a stronger impact on inflation in the FEMR than in Russia as a whole, due to differences in the structure of consumer spending. For example, the structure of the FEMR's CPI is characterised by a larger contribution of air fares, which are usually highly volatile.

- the effects of **exchange rate** shocks on inflation movements in 2016–2022 were similar in the FEMR and Russia as a whole. This finding confirms the results of previous research that established significant differences between Russian regions in terms of the exchange rate pass-through effect (*Zhurakovsky et al., 2021*).

Therefore, following the transition to inflation targeting, the FEMR's economic growth was slightly below the national average. The reason is the differences in the structures of the economies, the high dependence of the macroregion's economy on external demand, and the speed of delivery of major investment projects, as well as on exogenous – unaccounted for in the model – regional and external factors. For example, oil price and fiscal spending shocks have stronger impacts on the FEMR's output than on all-Russia's. At the same time, the high dependence of the FEMR on economic relationships with Asian countries (e.g. China, Japan, and South Korea) and external demand shocks over the course of the pandemic had less impact on output in the macroregion than in Russia as a whole. The reason was that at the time business activity in Asian countries proved less volatile relative to, for example, EU countries and the US. The stronger dependence of the FEMR's economy on external demand and investment projects is also behind the lower response of aggregate output monetary policy shocks in the macroregion compared to Russia as a whole.

The average growth of prices in the FEMR over the period was close to the national average. The differences in inflation dynamics in individual periods are explained by different contributions of the shocks. Specifically, FEMR inflation is marked by more inertia than in Russia as a whole, while expectations are more adaptive. At the same time, inflation in the FEMR is less exposed to food price shocks than in Russia, but shows a heavier dependence on service price shocks. The response of FEMR inflation to monetary policy shocks is similar to that of nationwide inflation. Among differences are the longer time (by one quarter on average) that the macroregion's inflation takes to return to target after a change in the key rate.

Overall, the results of this research indicate that a single monetary policy, grounded in analysis and projections of all-Russia's macroeconomic indicators, does not cause FEMR inflation to systematically deviate from target, or output from its potential level.

6. Conclusion

The model presented in this paper is a modification of the neo-Keynesian model of a small open economy, which takes into account the particularities of the Far Eastern macroregion. These particularities include: first, the region's small contribution to the dynamics of Russia's main macroeconomic indicators and less spatial connectivity with other regions of the country; second, greater economic integration with the Asia-Pacific countries compared to the country as a whole; third, a high share of external demand-oriented industries in output; and fourth, the economy's dependence on transfers from the federal budget to implement large investment projects. These particular features shape the main properties of the model:

- smaller shocks of demand and costs in the FEMR have a limited impact on the dynamics of output and inflation in Russia as a whole and, consequently, on the monetary policy. Meanwhile, in case of greater demand shocks in FEMR (for example, the amount of government investment), cost-push shocks (for example, transportation costs) that induce a significant deviation of all-Russian macro variables from their equilibrium values, will require the Central Bank's monetary policy response;

- demand and cost-push shocks arising in other regions of Russia lead to acceleration of inflation in the FEMR with a lag (one quarter on average). Inflation in the macroregion reacts less to countrywide shocks than inflation in Russia as a whole. This is due to the greater dependence of inflation in the macroregion on past values (inertia);

- the response of FEMR inflation to exchange rate shocks is generally similar to that of countrywide inflation. However, FEMR inflation reacts to such shocks with a lag of one quarter, and the effect persists longer than in Russia as a whole. This is due to the greater inertia of inflationary processes in the macroregion;

- the magnitude of the inflation response in the FEMR to monetary policy shocks corresponds to that in Russia. However, the response in the FEMR is characterised by a lag relative to the countrywide response (on average one quarter).

By comparing the contribution of shocks to output and inflation in 2016–2022, we show that oil price shocks and fiscal policy shocks contributed more to the development of the output gap in the Far Eastern macroregion than in Russia as a whole in this period. This is due to the heavy dependence of the Far East economy on the export of raw materials, in particular oil, and the implementation of large projects financed from the federal budget. The greater focus of the Far East's foreign trade relations on Asian markets, where business activity in the period under study was less volatile than in G20 countries, is the reason why external sector shocks contributed less to the dynamics of the macroregion's output gap compared to Russia as a whole. For this reason, the decline in the FEMR economy during the coronavirus pandemic was smaller than in the entire country.

During this period, the average rate of price growth in the FEMR was in line with the national rate, but in some periods there were significant differences in the dynamics of inflation in the macroregion and in Russia as a whole. This was due to differences in the contributions of individual shocks. Compared to Russia as a whole, inflation in the Far Eastern macroregion has greater inertia and a stronger dependence on service price shocks but less contribution from food price shocks. A significant share of food products is imported from other regions of the country. So the structure of their prices includes a high share of logistics costs, which in some periods partially offset the high volatility of food prices.

Bibliography

Andreyev M. Adding a fiscal rule into a DSGE model: How much does it change the forecasts? // Working paper series No. 64. – November 2020. URL: https://www.cbr.ru/StaticHtml/File/117490/wp-64_e.pdf.

Benigno P. Optimal monetary policy in a currency area // Journal of International Economics. 2004. Vol. 63, pp. 293–320.

Benigno P., Lopez-Salido J. D. Inflation persistence and optimal monetary policy in the euro area // Journal of Money, Credit and Banking. 2006, pp. 587–614.

Bennett P. The influence of financial changes on interest rates and monetary policy: a review of recent evidence // Federal Reserve Bank of New York Quarterly Review. 1990, pp. 8–30.

Berg A., Karam P.D., Laxton D. A Practical Model-Based Approach to Monetary Policy Analysis – Overview // IMF Working Papers 06/80 – 2006b.

Berg A., Karam P.D., Laxton D. Practical Model-Based Monetary Policy Analysis - A How-To Guide // IMF Working Papers 06/81. - 2006a.

Bokan N., Ravnik R. Quarterly Projection Model for Croatia // CNB Surveys. – 2018.

Bouvet F., King S. Do National Economic Shocks Influence European Central Bank Interest Rate Decision? // Journal of Common Market Studies. 2013. Vol. 51:2, pp. 212–231.

Carlino G. A., DeFina R. Monetary policy and the US states and regions: Some implications for European Monetary Union // Regional aspects of monetary policy in Europe. – Springer, Boston, MA, 2000, pp. 45–67.

Carlino G., DeFina R. The differential regional effects of monetary policy //Review of economics and statistics. 1998. Vol. 80. No. 4, pp. 572–587.

Cristadoro R., Saporito G. and Venditti F. Forecasting inflation and tracking monetary policy in the euro area: does national information help? // Empirical Economics. 2013. Vol. 44:3, pp. 1065–1086.

Gächter M., Riedl A., Ritzberger-Grünwald D. Business cycle synchronization in the euro area and the impact of the financial crisis // Monetary Policy & the Economy. 2012. Vol. 2. No. 12, pp. 33–60.

Gertler M., Gilchrist S. Monetary policy, business cycles, and the behavior of small manufacturing firms //The Quarterly Journal of Economics. 1994. Vol. 109. No. 2, pp. 309–340.

Gertler M., Gilchrist S. The role of credit market imperfections in the monetary transmission mechanism: arguments and evidence //The Scandinavian Journal of Economics. 1993. pp. 43–64.

Hodrick R.J., Prescott E.C. Postwar US business cycles: An empirical investigation // Journal of Money, Credit, and Banking. 1997. Vol. 29. No. 1, pp. 1–16.

Kashyap A. K., Stein J. C. The role of banks in monetary policy: A survey with implications for the European monetary union //Economic Perspectives-Federal Reserve Bank of Chicago. 1997. Vol. 21, pp. 2–18.

Marcellino M., Stock J. H., Watson M. W. Macroeconomic forecasting in the euro area: Country specific versus area-wide information //European Economic Review. 2003. Vol. 47. No. 1, pp. 1–18.

Musil K., Pranovich M., Vlcek M. J. Structural quarterly projection model for Belarus / International Monetary Fund, 2018.

Pedemonte M., Herreño J. D. The Geographic Effects of Monetary Policy // Working Papers 22-15, Federal Reserve Bank of Cleveland. – 2022. URL: https://doi.org/10.26509/frbc-wp-202215.

Pizzuto P. Regional effects of monetary policy in the US: An empirical re-assessment // Economics Letters. 2020. Vol. 190, P. 1-6. URL: https://doi.org/10.1016/j.econlet.2020.109062.

Quint D. Is it really more dispersed? Measuring and comparing the stress from the common monetary policy in the euro area // International Economics and Economic Policy. 2016. Vol. 13(4), pp. 593–621. http://dx.doi.org/10.17169/FUDOCS_document_000000020335.

Vlček J. et al. Quarterly Projection Model for the National Bank of Rwanda // IMF Working Paper No. 2020/295. – 2020.

Winkelried D., Gutierrez J. E. Regional inflation dynamics and inflation targeting. The case of Peru //Journal of applied economics. 2015. Vol. 18. No. 2, pp. 199–224. https://doi.org/10.1016/S1514-0326(15)30009

Averina D.S., Gorshkova T.G., Sinelnikova-Muryleva E.V. Phillips Curve Estimation on Regional Data // The HSE Economic Journal. 2018. Vol. 22, No. 4, pp. 609–630 (in Russian).

Glushchenko K.P. Spatial integration of the Russian goods market // Spatial development of modern Russia: trends, factors, mechanisms, institutions / edited by E.A. Kolomak. Novosibirsk, Institute of Economics and Industrial Engineering of the Siberian Branch of the RAS. 2020, pp. 53–76 (in Russian).

Golyashev A.V., Grigoryev L.M., Lobanova A.A., Pavlyushina V.A. Features of Recession Recovering: Income and Inflation // Spatial Economics. 2017. No. 1, pp. 99–124. DOI: 10.14530/se.2017.1.099-124 (in Russian).

Demidenko M., Hrebicek H., Karachun O., Korshunov D., Lipin A. Forecasting System for the Eurasian Economic Union // Joint Report by the Eurasian Economic Commission and the Eurasian Development Bank. 2016. 116 p. (in Russian). URL: https://eec.eaeunion.org/upload/medialibrary/59f/EEC_Model_RUS.pdf

Deryugina E., Karlova N., Ponomarenko A., Tsvetkova A. The role of regional and sectoral factors in Russian inflation developments // Bank of Russia Working Paper Series. No. 36. July 2018 (in Russian). URL: https://www.cbr.ru/Content/Document/File/47509/wp_36.pdf

Monetary Policy Report. No. 2 (38). May 2022 (in Russian).

Zhemkov M.I. Regional effects of inflation targeting in Russia: Factors of heterogeneity and structural inflation rates // Voprosy Ekonomiki. 2019; (9):70-89 (in Russian).

Zhurakovsky V.P., Novopashina A.N., Tarantaev A.D. Regional heterogeneity of the effect of exchange rate transfer on inflation // Bank of Russia Working Paper Series. January 2021 (in Russian). URL: https://www.cbr.ru/Content/Document/File/118010/wp_dgu_jan.pdf

Kolomak E. A. Estimation of the Spatial Connectivity of the Economic Activity of Russian Regions // Spatial development of modern Russia: trends, factors, mechanisms, institutions / Edited by E.A. Kolomak. Novosibirsk: Institute of Economics and Industrial Engineering of the Siberian Branch of the RAS. 2020, pp. 45–53 (in Russian).

Korshunov D., Nelyubina A. Forecasting Regional Indicators Based on the Quarterly Projection Model // Bank of Russia Working Paper Series. No. 87, December 2021 (in Russian). URL: https://www.cbr.ru/StaticHtml/File/131989/wp_87.pdf

Kreptsev D., Seleznev S. DSGE models of the Russian economy with a small number of equations // Bank of Russia Working Paper Series. No. 12, May 2016 (in Russian). URL: http://www.cbr.ru/Content/Document/File/119373/sDSGE.pdf

Kreptsev D., Seleznev S. DSGE Model of the Russian Economy with the Banking Sector // Bank of Russia Working Paper Series. No. 27, December 2017 (in Russian). URL: http://www.cbr.ru/Content/Document/File/119374/bDSGE.pdf

Kryzhanovskiy O., Zykov A. DEMUR: A Regional Semi-structural Model of the Ural Macroregion // Russian Journal of Money and Finance. 2022. Vol. 81(4), pp. 52–85 (in Russian).

Kryukov V.A., Kolomak E.A. Spatial development of Russia: main problems and approaches to the solution // Scientific Works of the Free Economic Society of Russia. 2021, Vol. 227. No 1, pp. 92–114 (in Russian). DOI: 10.38197/2072-2060-2021-227-1-92-114.

Napalkov V., Novak A., Shulgin A. (2021). Variations in the Effects of a Single Monetary Policy: The Case of Russian Regions // Russian Journal of Money and Finance. 2021. Vol. 80(1), pp. 3–45 (in Russian).

Nelyubina A. Forecasting Regional Indicators Based on the Quarterly Projection Model // Russian Journal of Money and Finance. 2020. Vol. 80(2), pp. 50–75 (in Russian).

Novak A., Shulgin A. Monetary policy in the economy with regional heterogeneity: approaches based on aggregated and regional information // Bank of Russia Working Paper Series. March 2020 (in Russian). URL: https://www.cbr.ru/Content/Document/File/108035/wp_2003.pdf

Orlov A. Quarterly Projection Model of Russia // Bank of Russia. 2021 (in Russian). URL: http://www.cbr.ru/content/document/file/118791/inf_note_feb_2521.pdf

Perevyshin Yu.N., Sinelnikov-Murylev S.G., Trunin P.V. Factors of price differentiation in Russian regions // HSE Economic Journal. 2017. Vol. 21, No. 3, pp. 361–384 (in Russian).

Perevyshin Y., Egorov D. Influence of All-Russian Factors on Regional Inflation // Russian Economic Development. 2016. Vol. 23, No. 10, pp. 44–50 (in Russian).

Prokapalo O.M., Bardal A.B., Isaev A.G., Mazitova M.G., Suslov D.V. Economic Situation in the Far Eastern Federal District in 2020 // Spatial Economics. 2021. No. 2, pp. 81–126 (in Russian). URL: https://dx.doi.org/10.14530/se.2021.2.081-126

Prokapalo O.M., Bardal A.B., Isaev A.G., Mazitova M.G., Suslov D.V. Economic Situation in the Far Eastern Federal District in 2019 // Spatial Economics. 2020. No. 2, pp. 142–184 (in Russian). URL: https://dx.doi.org/10.14530/ se.2020.2.142-184

Prokapalo O.M., Bardal A.B., Isaev A.G., Mazitova M.G., Suslov D.V. Economic Situation in the Far Eastern Federal District in 2018 // Spatial Economics. 2019. No. 2, pp. 110–149 (in Russian). DOI: 10.14530/se.2018.2.110-149.

Prokapalo O.M., Bardal A.B., Isaev A.G., Mazitova M.G., Suslov D.V. Economic Situation in the Far Eastern Federal District in 2021 // Spatial Economics. 2022. Vol. 18, No. 2, pp. 135–182 (in Russian). URL: https://dx.doi.org/10.14530/se.2022.2.135-182

Prokapalo O.M., Bardal A.B., Isaev A.G., Mazitova M.G., Suslov D.V. Economic Situation in the Far Eastern Federal District in 2016 // Spatial Economics. 2017. No. 2, pp. 138–173 (in Russian). DOI: 10.14530/se.2017.2.138-173.

Annex 1. Matrix of interregional trade flows

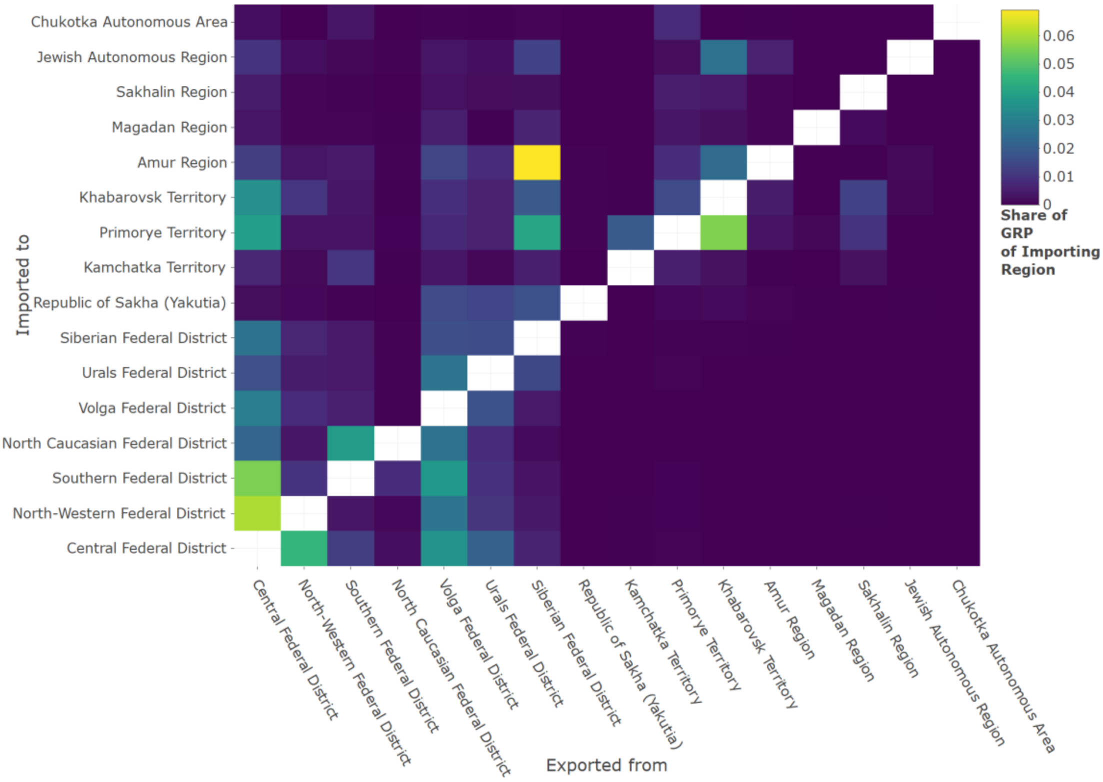

Figure A1. Imports and exports in rubles normalised by GRP of importing regions, in 2016

Annex 2. Parameters values in FEMR model

Table A1. Parameters values in FEMR model

Parameter	Description	Distribution	Value
ω_{d}^{dv}	Share of the FEMR consumer demand gap in the FEMR aggregate demand gap	Beta	0.5
ω_{prod}^{dv}	Share of the industrial production demand gap in the FEMR aggregate demand gap	Beta	0.4
ω_{proj}^{dv}	Share of the investment demand gap in the FEMR aggregate demand gap	Beta	0.1
α_{d0}^{dv}	Coefficient for the expected FEMR consumer demand gap in the FEMR consumer demand gap equation	Beta	0.1
α_{d1}^{dv}	Coefficient for the FEMR consumer demand gap in the previous period in the FEMR consumer demand gap equation	Beta	0.45
α_{d2}^{dv}	Coefficient for the real market rate gap in the FEMR consumer demand gap equation	Beta	0.2
α_{d3}^{dv}	Coefficient for the domestic demand gap of RoR in the FEMR consumer demand gap equation	Beta	0.15
α_{d4}^{dv}	Coefficient for the FEMR budget deficit gap (regional + federal + extra-budgetary funds) (average over the previous two years) in the FEMR consumer demand gap equation	Beta	0.06
α_{d5}^{dv}	Coefficient for the real oil price gap in the FEMR consumer demand gap equation	Beta	0.01
α_{d6}^{dv}	Coefficient for the deviation of the FEMR consumer demand gap from the FEMR aggregate demand gap in the consumer demand gap equation	Beta	0.2
α_{prod1}^{dv}	Coefficient for the FEMR industrial production gap in the previous period in the resource demand gap equation	Beta	0.27
α_{prod2}^{dv}	Coefficient for the output gap of RoR in the previous period in the FEMR resource demand gap equation	Beta	0.4
α_{prod3}^{dv}	Coefficient for the FEMR external sector output gap in the previous period in the FEMR resource demand gap equation	Beta	0.5
α_{prod4}^{dv}	Coefficient for the real effective exchange rate in the previous period in the FEMR resource demand gap equation	Beta	0.07
α_{prod5}^{dv}	Coefficient for the real oil price gap in the FEMR resource demand gap equation	Beta	0.03
α_{prod6}^{dv}	Coefficient for the deviation of the FEMR industrial production gap from the FEMR aggregate demand gap in the FEMR resource demand gap equation	Beta	0.2
α_{proj0}^{dv}	Coefficient for the expected FEMR investment demand gap in the FEMR investment demand gap equation	Beta	0.15

α_{proj1}^{dv}	Coefficient for the FEMR investment demand gap in the previous period in the FEMR investment demand gap equation	Beta	0.28
α_{proj2}^{dv}	Coefficient for the output gap of RoR in the previous period in the FEMR investment demand gap equation	Beta	0.1
α_{proj3}^{dv}	Coefficient for the Russia budget deficit gap (average over the previous two years) in the FEMR investment demand gap equation	Beta	0.3
α_{proj4}^{dv}	Coefficient for the deviation of the FEMR investment demand gap from the FEMR aggregate demand gap in the investment demand gap equation	Beta	0.2
d_1^{dv}	Coefficient for the FEMR structural budget deficit relative to GRP in the fiscal sector equation	Beta	0.65
d_2^{dv}	Coefficient for the deviation of FEMR equilibrium output from a steady state in the fiscal sector equation	Beta	0.3
d_3^{dv}	Coefficient for the FEMR budget system actual deficit relative to GRP in the fiscal sector equation	Beta	0.8
d_4^{dv}	Coefficient for the FEMR budget system actual deficit relative to GRP from the FEMR government's medium- and long-term targets in the fiscal sector equation	Beta	0.3
d_5^{dv}	Coefficient for the FEMR aggregate demand gap in the fiscal sector equation	Beta	0.3
c_{f1}^{dv}	Coefficient for the expected rate of increase in food prices in the FEMR food price growth rate equation	Beta	0.2
c_{f2}^{dv}	Coefficient for the real effective exchange rate in the FEMR food price growth rate equation	Beta	0.105
c_{f3}^{dv}	Coefficient for the FEMR consumer demand gap in the FEMR food price growth rate equation	Beta	0.161
c_{f4}^{dv}	Coefficient for the difference in the food price growth rates between the RoR and the FEMR in the previous quarter in the FEMR food price growth rate equation	Beta	0.3
c_{f5}^{dv}	Coefficient for the FEMR relative price gap in the food price growth rate equation	Beta	0.3
c_{nf1}^{dv}	Coefficient for the expected rate of increase in non-food prices in the FEMR non-food price growth rate equation	Beta	0.3
c_{nf2}^{dv}	Coefficient for the real effective exchange rate in the FEMR non-food price growth rate equation	Beta	0.08
c_{nf3}^{dv}	Coefficient for the difference in the non-food price growth rates between the RoR and the FEMR in the previous quarter in the FEMR non-food price growth rate equation	Beta	0.3
c_{nf4}^{dv}	Coefficient for the FEMR consumer demand gap in the FEMR non-food price growth rate equation	Beta	0.084

c_{nf5}^{dv}	Coefficient for the FEMR relative price gap in non-food price growth rate equation	Beta	0.3
c_{swu1}^{dv}	Coefficient for the expected rate of increase in unregulated service prices in the FEMR unregulated service price growth rate equation	Beta	0.4
c_{swu2}^{dv}	Coefficient for the FEMR consumer demand gap in the FEMR unregulated service price growth rate equation	Beta	0.049
c_{swu3}^{dv}	Coefficient for the real effective exchange rate in the FEMR unregulated service price growth rate equation	Beta	0.010
c_{swu4}^{dv}	Coefficient for the FEMR relative price gap in the FEMR unregulated service price growth rate equation	Beta	0.3
c_{u1}^{dv}	Coefficient for the rate of increase in regulated service (utilities) prices in the FEMR regulated service (utilities) price growth rate equation	Beta	0.8
$\omega_{\pi_f}^{dv}$	Coefficient for the weight of food products in the FEMR CPI in the equation of price growth rates for all goods and services in the FEMR	Beta	0.372
$\omega_{\pi_{nf}}^{dv}$	Coefficient for the weight of non-food products in the FEMR CPI in the equation of price growth rates for all goods and services in the FEMR	Beta	0.358
$\omega_{\pi_{swu}}^{dv}$	Coefficient for the weight of unregulated services in the FEMR CPI in the equation of price growth rates for all goods and services in the FEMR	Beta	0.205
$\omega_{\pi_u}^{dv}$	Coefficient for the weight of regulated services in the FEMR CPI in the equation of price growth rates for all goods and services in the FEMR	Beta	0.065
ω^{CC}	Tightness of capital controls in the uncovered interest rate parity (UIP) equation	-	0.75
k_1	Stability of the nominal interest rate	Beta	0.75
k_2	Coefficient for the deviation of expected inflation from the target level in the monetary policy rule	Gamma	1.52
k_3	Coefficient for the output gap in the monetary policy rule	Beta	0.5
k_4	Stability of the real interest rate trend	Beta	0.9
e_1	Coefficient of the expected nominal exchange rate in the UIP equation	Beta	0.9
μ	Coefficient of the real exchange rate gap in the UIP equation	-	0.8
θ	Coefficient of the trade gap in the UIP equation	-	0.2

Annex 3. Parameter values of semi-structural model in literature

Table A2. Parameter values of semi-structural model in literature

Parameter (from literature)	Description	Value in literature	Explanation	Source	Value for the FEMR in this paper
c_{44} c_{205}	Coefficient for expectations in the output gap equation	0.1 0.05	Typically, the sum of parameters for expectations and inertia is between 0.5 and 0.9. These parameters should reflect the relative scale, regional dominance, and openness of the Russian economy, as well as the high level of growth volatility. A specific feature of the Kyrgyz model is the high level of volatility of quarterly GDP indicators. This volatility is explained by fluctuations in production at the Kumtor mine	Demidenko et al. (2016) (Russia, Kyrgyzstan)	0.07 The value of the indicator ranges from 0.05 to 0.4 in the literature. The independent nature of monetary policy with respect to the FEMR macro variables is taken into account. Accordingly, the coefficient for the inertial part is significantly higher than the coefficient for forward-looking expectations
α_1^{cfo}	Coefficient for backward-looking lag in the output gap equation	0.4	The higher the value at the backward-looking lag, the more stable the output gap is. That is, the ratio of coefficients for expectations and inertia can be interpreted as the rate of return of the economy to equilibrium	Korshunov and Nelyubina (2021)	
α_2^{cfo}	Coefficient for the lag in the output gap equation (inertia)	0.3	A higher value of the parameter indicates greater stability of output dynamics. The volatility of output is taken into account on a retrospective basis	Korshunov and Nelyubina (2021)	0.36 The value of the coefficient reflects the instability of output dynamics, which is due to the high share of mining industry in output
c_{45}		0.6	The parameter reflects a high level of growth volatility.	Demidenko et al. (2016)	

β_2		0.3	Low level of output gap inertia. Interval accepted in the world practice: from 0.5 to 0.9	Borodin et al. (2008)	
β_{lag}		0.85	Interval: from 0.5 to 0.9	Berg et al. (2006)	
α_3^{cfo}	Coefficient for the interest rate gap in the output gap equation	0.1	The sum of coefficients for the interest and exchange rate gaps should be between 0.1 and 0.2, and not exceed the value of the output gap lag. The ratio of coefficients for the interest and exchange rate gaps reflects the greater importance of the interest rate channel compared to the exchange rate channel	Korshunov and Nelyubina (2021)	0.1 In this case, the larger coefficient for the interest rate gap compared to the parameter for the exchange rate gap shows the greater importance of the interest rate channel in the economy
β_3		0.1	The parameter reflects the low impact of interest rate on the output gap	Borodin et al. (2008)	
β_{RRgap}		0.1		Berg et al. (2006)	
α_4^{cfo}	Coefficient for the exchange rate gap in the output gap equation	0.05	The openness of the economy is reflected in the calibration of the parameter α_4^{cfo}, and its value should be less than α_3^{cfo} for developing economies	Korshunov and Nelyubina (2021)	0.028 The high share of mining industry, whose products are mostly exported, causes a lower sensitivity of output to the exchange rate of the national currency due to the fact that the situation on the world raw material markets is more important in this case. The economy is inert, so the sum of coefficients for the interest and exchange rate gaps is less the value of the parameter
c_{49}		0.12	The value of the parameter corresponds to the market economy	Demidenko et al. (2016)	
β_4		0.2	The value of the parameter shows a stronger influence of the exchange rate on the output gap, compared to the influence of the interest rate	Borodin et al. (2008)	

			The interval $\beta_3 + \beta_4$ is from 0.1 to 0.3		for the output gap lag and lies in the interval from 0.1 to 0.2
β_{zgap}		0.05		Berg et al. (2006)	
α_5^{cfo}	Coefficient for the oil price gap in the output gap equation	0.02	The values of α_5^{cfo} and α_6^{cfo} reflects the dynamics of the real oil price and effective external demand on a retrospective basis	Korshunov and Nelyubina (2021)	0.017 The coefficient approximates the impact of global raw material market conditions on FEMR output. Despite the high share of mining industries, the efficient operation of the channel for the FEMR is ensured by its alignment with the phases of the economic cycles of APR countries, which are the main buyers of export commodities. As a result, the main weight is allocated to the coefficient for the foreign demand gap
c_{47}		0.06		Demidenko et al. (2016)	
α_6^{cfo}	Coefficient for the foreign output gap in the output gap equation	0.05		Korshunov and Nelyubina (2021)	0.2 The value of the indicator ranges from 0.05 to 0.25 in the literature. The high value is due to the close links between the FEMR economy and Asian countries (China, Japan, and South Korea), which have a steady demand for FEMR exports. The dynamics of external demand depends on the phases of the economic cycle of these countries
c_{48}		0.2	The value of the coefficient reflects the historical cross-correlation between the gaps of external and domestic output	The system of analysis and macroecono mic forecasting of the Eurasian Economic Union	
β_{USygap}		0.25		Berg et al. (2006)	
α_7^{cfo}	Coefficient for the output gap of the rest of Russia in the	0.25	The value of the parameter for foreign demand is smaller than for domestic demand, which reflects the greater influence of the	Korshunov and Nelyubina (2021)	0.245 The value is consistent with Korshunov and Nelyubina (2021)

	output gap equation		latter on the output gap of the Central FD		
α_8^{cfo}	Coefficient for fiscal impulse in the output gap equation	0.15	The parameter describes the characteristics if the region	Korshunov and Nelyubina (2021)	0.06 The value is lower than the values given in the literature due to the specific features of the FEMR: the expenditures of the FEMR budget system are systematically higher than revenues (a high share of transfers), which leads to a significant structural deficit and considerably increases the volatility of fiscal impulse trends The coefficient for the fiscal impulse was adjusted to optimise its contribution to aggregate demand
c_{290} c_{50} c_{158}		0.07 0.2 0.35		Demidenko et al. (2016) (Kazakhstan, Russia, and Belarus)	
$\alpha_{\pi ld}$	Coefficient for expectations in the aggregate Philips curve	0.2		Berg et al. (2006)	0.26 The coefficient corresponds to the value of the similar parameter in the literature (from 0.2 to 0.5). Inertia is high (from 0.1 to 0.6, closer to the lower boundary), and expectations are defined mostly as adaptive. FEMR inflation is more inertial compared to Russia as a whole, which is due to the fact that delivery of goods from other regions of the country takes a long time
c_{55}		0.35	The coefficient is set on the basis of Calvo's pricing model (only a limited number of customers may change prices during each period)	Demidenko et al. (2016)	
$\beta_1^{p\_cfo}$ $\beta_1^{np\_cfo}$ $\beta_1^{swu\_cf}$		0.5	The value lies in the range from 0.1 to 0.6. The high level of inertia relates to the transition of the Bank of Russia to the inflation targeting strategy	Korshunov and Nelyubina (2021)	
$1 - \alpha_1 - \alpha_2$	Coefficient for the real exchange rate gap in the aggregate	0.1	Low level of inflation elasticity of the exchange rate	Borodin et al. (2008)	0.07 The value corresponds to the interval in which the parameters lies in
α_z		0.1		Berg et al. (2006)	

$c_{56} * c_{57}$	Philips curve	0.05	The parameter reflects the openness of the Russian economy	Demidenko et al. (2016)	other studies (from 0.05 to 0.1). At the same time, the exchange rate affects FEMR inflation (unlike Russian inflation) with a lag of one quarter due to the fact that delivery of goods from other regions of the country takes a long time. According to empirical estimates, the largest price response to exchange rate shocks is observed within three month after the respective shock (*Zhurakovsky et al., 2021*). This is the reason for the differences in the paths of Russian and FEMR inflation impulse responses to exchange rate shocks
$\beta_2^{p\_cfo}$		0.3	A larger value of the coefficient indicates a larger amount of imported goods. The sum of parameters for the output and exchange rate gaps is in the interval from 0.1 to 0.5. The more production costs are transferred to prices, the greater the sum of these coefficients. In this case, it exceeds this interval, since the relative price component is added to the model with a negative sign. This component also takes into account the exchange rate dynamics	Korshunov and Nelyubina (2021)	
α_3	Coefficient for the output gap in the aggregate Philips curve	0.23	Low inflation elasticity with respect to output. Interval: from 0.25 to 0.5	Borodin et al. (2008)	0.07 Consumer demand makes a smaller contribution to inflation dynamics in the FEMR than in Russia as a whole due to the higher inertia of both inflation and demand
$\alpha_{\pi ld}$		0.3		Berg et al. (2006)	
$c_{56} * (1 - c_{57} - c_{58})$		0.04		Demidenko et al. (2016)	
β_4	Relative price gap in the aggregate Philips curve	0.3	In equilibrium, food inflation matches regional inflation in general; the dynamics of non-food and services inflation is described, among others, by the Balassa–Samuelson effect. The coefficient for this variable is designed to account for the dynamics of relative prices using historical data	Korshunov and Nelyubina (2021)	0.3

Annex 4. RMSE of out-of-sample forecast of variables for different calibration variations

Table A3. RMSE of out-of-sample forecast of main macroeconomic variables for different calibration variations

No.	Specification	Behavioural equation	GRP	CPI	Ex-change rate	Overall accuracy
1	Reference	-	3.302	4.797	8.060	4.119
2	Less response to exchange rate shocks	FEMR aggregate demand	3.321	4.797	8.060	4.130
3	More response to differences in inflation between the Russia and the FEMR	Food and non-food inflation equation	3.302	4.823	8.060	4.130
4	Less response to exchange rate shocks	Russian aggregate demand	3.307	4.823	8.012	4.131
5	More response to consumer demand	Food and services (w/o utilities) inflation equation	3.302	4.858	8.065	4.145
6	Less response to exchange rate shocks	Russian aggregate supply	3.294	4.875	8.026	4.145
7	Less response to exchange rate shocks	FEMR and Russian aggregate demand	3.337	4.824	8.012	4.147
8	Less response to exchange rate shocks	FEMR aggregate supply	3.302	4.880	8.059	4.153
9	Greater inertia	FEMR and Russian aggregate supply	3.243	4.982	7.966	4.160
10	Less response to exchange rate shocks	FEMR and Russian aggregate supply	3.292	4.966	8.011	4.182
11	Greater inertia	FEMR and Russian aggregate demand	3.777	5.656	8.143	4.737

Annex 5. Coefficients in behavioural equations for different calibration variations

Table A4. Coefficients in behavioural equations for different calibration variations

Coefficient		Specification										
		Refe-rence	2	3	4	5	6	7	8	9	10	11
Inertia in FEMR aggregate demand	Consumer demand	0.45	-	-	-	-	-	-	-	-	-	0.80
	Resource demand	0.27	-	-	-	-	-	-	-	-	-	0.65
	Investment demand	0.28	-	-	-	-	-	-	-	-	-	0.75
Inertia in Russian aggregate demand	Domestic demand	0.60	-	-	-	-	-	-	-	-	-	0.75
	Import demand	0.25	-	-	-	-	-	-	-	-	-	0.40
	Export demand	0.50	-	-	-	-	-	-	-	-	-	0.65
Expectations in FEMR aggregate supply	Food	0.20	-	-	-	-	-	-	-	0.10	-	-
	Non-food	0.30	-	-	-	-	-	-	-	0.10	-	-
	Services w/o utilities	0.40	-	-	-	-	-	-	-	0.10	-	-
Expectations in Russian aggregate supply	Food	0.60	-	-	-	-	-	-	-	0.30	-	-
	Non-food	0.60	-	-	-	-	-	-	-	0.30	-	-
	Services w/o utilities	0.60	-	-	-	-	-	-	-	0.30	-	-
Exchange rate lag in FEMR resource demand		0.07	0.05	-	-	-	-	0.04	-	-	-	-
Exchange rate growth in Russian aggregate supply		0.13	-	-	-	-	0.07	-	-	-	0.08	-
Exchange rate lag in Russian aggregate supply		0.08	-	-	-	-	0.04	-	-	-	0.04	-
Exchange rate lag in FEMR aggregate supply		0.07	-	-	-	-	-	-	0.04	-	0.04	-
Exchange rate in Russian aggregate demand	Import demand	-0.30	-	-	-0.15	-	-	-0.15	-	-	-	-
	Export demand	0.05	-	-	0.03	-	-	0.03	-	-	-	-
Difference between Russian and FEMR inflation rates		0.30	-	0.35	-	-	-	-	-	-	-	-
Consumer demand in FEMR aggregate supply		0.10	-	-	-	0.15	-	-	-	-	-	-

Annex 6. Preparation of data for modelling

Table A5. Preparation of data for modelling

Variable	Notation	Initial data	Transformation	Source
Consumer demand	d_t^{dv}	Retail turnover index	Weighted average[18] exponentially smoothed seasonally adjusted[19] benchmark index	Rosstat,[20] authors' calculations
		Index of the value of paid services to the public		
Resource demand	$prod_t^{dv}$	Industrial production index	Exponentially smoothed seasonally adjusted benchmark index	
Investment demand	$proj_t^{dv}$	Construction volume index	Exponentially smoothed seasonally adjusted benchmark index	
Food inflation	$\pi_t^{f\,dv}$ $\pi_t^{f\,RF}$	Consumer food price index	Seasonally smoothed growth, QoQ, annualised	Rosstat,[21] authors' calculations
Non-food inflation	$\pi_t^{nf\,dv}$ $\pi_t^{nf\,RF}$	Consumer non-food goods price index	Seasonally smoothed growth, QoQ, annualised	
Unregulated services inflation	$\pi_t^{swu\,dv}$	Consumer price index for services	Seasonally smoothed growth, QoQ, annualised	
Regulated services inflation	$\pi_t^{u\,dv}$	Consumer price index for services w/o utilities	Seasonally smoothed growth, QoQ, annualised	
Nominal interest rate	i_t	Bank of Russia key rate	-	Bank of Russia[22], authors' calculations
Nominal exchange rate	s_t	Nominal RUB/USD exchange rate	Weighted average of nominal RUB/USD and RUB/EUR exchange rates	Bank of Russia[23], authors' calculations
		Nominal EUR/USD exchange rate		Investing platform[24],

[18] Component weights are calculated based on the actual GRP structure as of the last reporting date.
[19] Seasonal adjustment is made using the X-13ARIMA-SEATS method.
[20] Information for monitoring the social and economic situation in the constituent entities of the Russian Federation. https://rosstat.gov.ru/folder/11109/document/13259
[21] Official statistical methodology for monitoring consumer prices of goods and services and calculating consumer price indices https://rosstat.gov.ru/statistics/price/methodology
[22] Bank of Russia key rate http://www.cbr.ru/hd_base/KeyRate/
[23] Dynamics of the official exchange rates http://www.cbr.ru/currency_base/dynamics/
[24] Investing https://ru.investing.com/currencies/eur-usd

				authors' calculations
Real oil price	q_t^{oil}	Monthly average price for Urals	Ratio of monthly average price for Urals to seasonally smoothed benchmark inflation index of trading partner countries	Russian Ministry of Economic Development,[25] authors' calculations
Actual deficit of the budget system relative to output	g_t^{dv} g_t^{RF}	Budget deficit	Seasonally adjusted budget deficit relative to nominal GDP/GRP	Russian Treasury,[26] authors' calculations
Output trading partner countries	y_t^{ROWdv}	China GDP index	Weighted average seasonally smoothed benchmark index	OECD,[27] authors' calculations
		Japan GDP index		
		South Korea GDP index		

[25] Situation in the global commodity markets https://www.economy.gov.ru/material/departments/d12/konyunktura_mirovyh_tovarnyh_rynkov/
[26] Russian Treasury official website https://roskazna.gov.ru
[27] Quarterly National Accounts https://stats.oecd.org/