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HETEROGENEITY OF THE IMPACT OF THE RUBLE EXCHANGE RATE ON OUTPUT IN THE REGIONAL CONTEXT

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Summary

This research examines the regional heterogeneity of the impact of the ruble exchange rate dynamics on output. The empirical assessment of the relationship between the exchange rate and the output of Russian regions has been carried out using models of structural vector autoregression based on data from January 2010 to December 2019 in the context of two periods: prior to the Bank of Russia's introduction of the free-floating regime of the ruble and thereafter. The research shows the regional heterogeneity of the impact of the exchange rate on the output, notes the possibility of both preserving and changing the nature of the said impact, depending on the general economic conditions.

Keywords: exchange rate, gross regional product, Russian regions, structural vector autoregression, impulse response functions.

JEL-classification: C3, C32, E23, R11.

1. Introduction

Open economies, of which Russia is one, development depends heavily on the international environment. Currency exchange rate plays a key role in the impact of external factors on the national economy. Monetary and fiscal authorities can influence the exchange rate to some extent through reserve accumulation, public external debt management, establishing fiscal and other rules providing for interventions in the currency market. The national currency depreciation tends to accelerate inflation due to increased prices of imported goods. On the other hand, the direction of the relationship between the exchange rate and the economic activity is not that obvious. Existing research demonstrates that the effect of currency depreciation on the economy is far from certain.

The regional heterogeneity of the impact of the exchange rate on the output is of further interest. The Russian Federation consists of 85 regions, varying in terms of economic development, sectoral specialisation, dependence on exports and imports. This results in the heterogeneous response of indicators of economic activity in various regions to the same external shock. However, with a set of specific internal characteristics, the regions are not fully independent economic systems: several macroeconomic factors that have formed for the country as a whole (interest rates, exchange rate, etc.) have impact on them.

The academic novelty of this research is that the assessment of the impact of the exchange rate on output has been carried out for the regions of the Russian Federation, unlike most research, where the authors tend to examine the impact of the exchange rate for the country as a whole. Understanding how the exchange rate impacts the economy in the regional context will allow a finer assessment of the effect of currency shocks on Russia's economic growth, and shall enhance the calibration of monetary policy aimed at meeting the nation-wide inflation target objective.

2. Review of studies on the relationship between the exchange rate and output

The impact of the exchange rate dynamics on the economic activity is considered in literature rather thoroughly, while the issue remains contentious and important subject of research. In many research works, their authors, using the example of certain countries, indicate the presence of a negative correlation between the exchange rate dynamics and economic growth, paying attention to the correlation between the 'weak' exchange rate and economic development [18; 23; 22; 16]. Several research works have noted a positive correlation between the exchange rate and economic growth, and questioned the appropriateness of measures aimed at the undervaluation of the exchange rate [2; 35]. A group of research works can be distinguished where the authors indicate that the effect of the exchange rate on output depends on the deviation of the exchange rate from some 'equilibrium level'; it is understood that excessive undervaluation or overvaluation of the national currency adversely affects the economy [32; 13; 26]. And finally, in some research, the authors do not find a statistically significant relationship between the exchange rate and output [5; 34; 7; 12].

The inconsistency of the results derives from the complexity of the impact of the exchange rate on the output, and each specific case requires detailed consideration. In this regard, many research works are conducted on data for a group of countries, where the authors focus on comparing a certain set of economic indicators that explain the differences. Another approach that allows to identify the key factors and channels of the impact of the exchange rate on the output is to study the economy of a particular country in the context of industries, regions or time periods.

The research of the European Central Bank experts [20] assesses the impact of changes in the real exchange rate on output in 150 countries over 40 years. As a result of such an extensive research, the authors confirm the presence and significance of the exchange rate pass-through effect on the output, while it is noted that developing countries, unlike the advanced economies of the world, are more vulnerable to the impact of the depreciation/appreciation of the national currency on the dynamics of economic growth per capita.

For a long time, the dominant point of view in the economic literature has been that there is a negative correlation between the exchange rate dynamics and output (i.e. it was assumed that the depreciation of the national currency leads to an increase in output and vice versa). This point of view was based on the Mundell – Fleming model of an open economy [30]. Under this model, the depreciation of the national currency leads to an increase in net exports and,

as a result, in total output. However, some factors can reduce a positive impact of currency depreciation/devaluation. The final impact of changes in the exchange rate on the trade balance depends on the price elasticity of demand for exports and imports. Furthermore, the economy should have free production resources so that the rise in the cost of imported goods can encourage import substitution and the growth of domestic output. Otherwise, currency depreciation will accelerate inflation. Calvo, G. and Reinhart, C. [14], based on the analysis of 96 cases of devaluation, conclude that it often has a negative impact on economic growth, especially in developing countries. The reason for such an impact, according to the authors, is a reduction in domestic demand and losses caused by an increase in the real value of existing liabilities denominated in foreign currency. As a result, the countries whose economy and production largely depend on imported equipment, technologies and raw materials are more vulnerable to the negative impact of devaluation. In their research, Eichengreen, B. and Hausmann, R. [19] draw attention to the imperfection of the financial markets of developing countries: the lack of opportunities to borrow domestically for a long term and to borrow in national currency abroad leads to a mismatch in the currency of assets and liabilities. The underdevelopment of national financial markets also prevents entrepreneurs from effectively insuring currency risks. In this regard, the impact of the exchange rate on economic growth through the debt channel is of particular relevance to developing economies. Mohamed, O. et al. [29] analyse the relationship between output and the exchange rate in seven developing countries: Ghana, Mexico, Malaysia, Pakistan, Philippines, Singapore, and South Africa. All the selected countries have gone through devaluation. Based on the results of the research, the authors conclude that the devaluation has a generally negative long-term impact on economic growth in all the countries analysed, except Mexico. The research explains the positive effect for Mexico by the low level of external debt in foreign currency relative to GDP. In addition to the growth of debt burden, the authors identify two more reasons for the negative impact of devaluation on economic development in the countries considered:

- the inability to increase exports due to the lack of goods of proper quality;
- the lack of their own full substitutes for imported raw materials and goods.

Thus, the effect of the exchange rate in a particular country is determined by the specifics of its economy: the composition of exports and imports, the development of financial markets, the debt burden in foreign currency, and the availability of unused production resources. It should also be taken into account that economic environment is not static: the nature and degree of the impact of the exchange rate pass-through effect can change significantly under the influence of structural changes, for example, as a result of economic reforms (change of

the exchange rate regime, introduction of fiscal rules, etc.), as well as under the influence of external factors (sanctions, interaction with economic unions). Thus, in their research of the impact of the exchange rate on the export industry of Turkey, Dincer, N. and Kandil, M. [17] conclude that following the structural reforms in the Turkish economy, there is no positive effect of the currency devaluation on exports and economic growth, which was found earlier. Kartaev, F.S. [9], based on the data for 176 countries, evaluates the efficiency of the implementation of the inflation targeting policy and draws attention to the significance of the current exchange rate regime: a hybrid version of inflation targeting, under which the monetary authorities manage the exchange rate, is more effective for encouraging output than pure inflation targeting, which assumes the regime of free floating of the national currency exchange rate.

The heterogeneity of the impact of the exchange rate pass-through effect between countries raises the question of whether there is a similar differentiation within the country, in the regional context. Research works concerning the Chinese economy [15; 24] note the lack of convergence of regional economies in the perception of changes in the exchange rate. Dividing geographically the provinces of China into ‘coastal’ (export-oriented) and ‘mainland’ (more focused on the domestic market), the authors point out that the impact of the strengthening of the yuan exchange rate is heterogeneous in the two regional segments examined due to differences in the size of the tradable sector, employment, government policy preferences, capital intensity, etc.

The discussion of the regional differentiation of economic processes is also found in Russian studies, but the research concerning the relationship between the exchange rate and the output in Russia pays more attention to sectoral differences. Badasen, P.V. et al. [1] (based on data from 2005 to 2014) and Evdokimova, T.V. et al. [7] (based on data from 1999 to 2011) show that there is no clear dominant influence of changes in the exchange rate in Russia: groups of industries that benefit and lose from the weakening of the exchange rate, as well as those that do not depend on this factor have been identified (the main results of these research works, as well as other similar studies concerning Russia, are given in Annex 1).

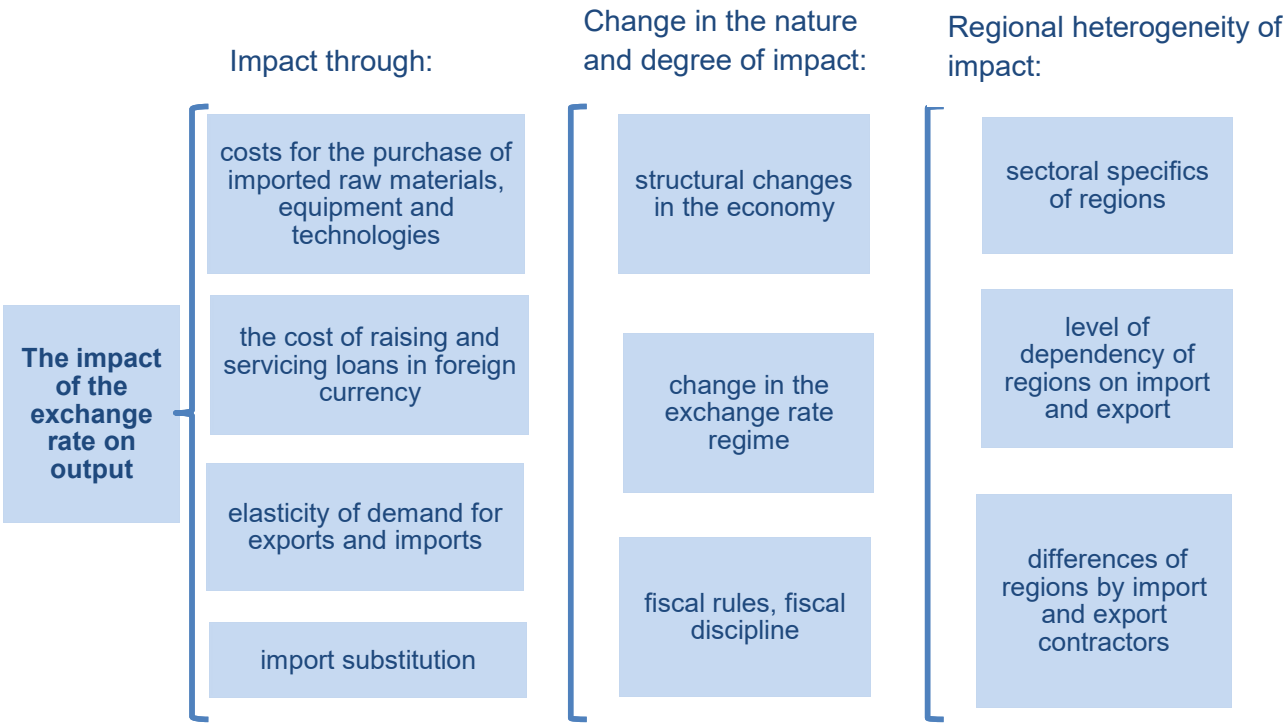
In another Russian research, Smirnov, S. et al. [11] analyse in detail the foreign trade orientation of industries. The authors have calculated the industry’s real effective exchange rates (the structure of the currency basket is determined on the basis of data not on the total foreign trade turnover, but on the foreign trade turnover within the industry analysed). As a result, the authors show a significant intersectoral difference in real effective exchange rates.

The results of the research by domestic authors suggest that there is a regional heterogeneity in the relationship between the exchange rate and the output in Russia due to

the sectoral specialisation of the regions, different involvement of the regional economy in foreign trade operations.

Based on the research works considered, the mechanism of the impact of the exchange rate on economic activity can be represented as a diagram (Fig. 1).

Figure 1. The main channels and factors of the impact of the exchange rate on the output



3. Assessment of the regional heterogeneity of the relationship between the exchange rate and the output in Russia

3.1. Research objective

This research evaluates the regional differentiation of the impact of the exchange rate on economic activity in the context of the federal districts and regions of Russia. In this regard, it is necessary to take into account the overall macroeconomic environment specific to Russia in general, and the economic specifics of each individual region. Furthermore, when starting to analyse the relationship between the exchange rate and the output, it is worth paying attention to the significant changes in recent years and the emerging trends in the economy. It is this component that can adjust addressing the task at the current stage and make it possible to identify factors that were not noted in previous research.

The period from 2010 to 2014 is characterised for Russia by economic growth, which was

in line with the global trend – a recovery from the global financial crisis of 2008–2009. In the second half of 2014, there was a significant depreciation of the exchange rate of the Russian currency, at the same time, at the end of 2014, the Bank of Russia decided to stop managing the ruble exchange rate and switched to an inflation targeting policy. In this regard, it is advisable that this research consider the impact of the ruble exchange rate on the regional output in the context of two periods: 2010–2014 and 2015–2019.

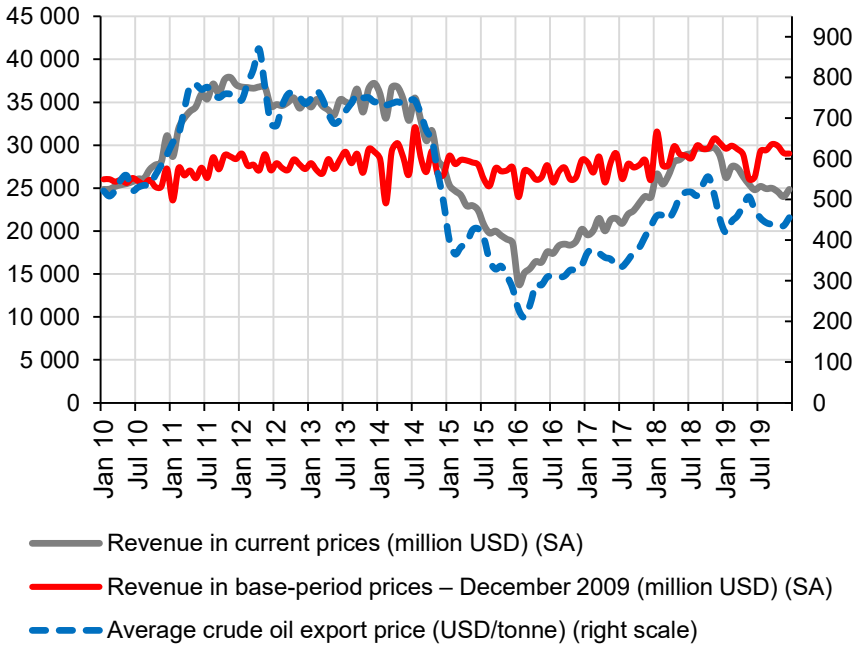
The period since 2015 was also marked by a number of new macroeconomic conditions for the Russian economy – a gradual reduction in interest rates and inflation: the weighted average actual overnight rate of the Russian interbank loans market (MIACR) dropped from 17.0% in January 2015 to 6.1% in December 2019, annual inflation in Russia for the same period fell from 15.0 to 3.0%, while the foreign currency reserves of the Russian Federation reached a new maximum, amounting to about USD 554 billion as of 1 January 2020. In February 2017, fiscal rule-based operations started. Under the Fiscal Rule, the Ministry of Finance purchases foreign currency with oil and gas revenues received when oil prices are above the reference value. The reference value, initially set at USD 40 per barrel of Urals crude oil, is subject to annual adjustment by 2%, starting from 2018. The essence of the Fiscal Rule is that not all oil and gas revenues are directed to the country's budget for current expenses, but only a calculated amount that is based on the reference value. Additional oil and gas revenues (windfall revenues) are sent to the National Wealth Fund. Similarly, when oil prices fall below the base price, the Fiscal Rule provides for the sale of the currency accumulated in the National Wealth Fund in order to support the Russian ruble and the sending of accumulated reserves to compensate for falling budget revenues. On the one hand, the Fiscal Rule has created a favourable environment for oil and oil products exporters in a situation of rising oil prices: before that, the correlation of oil prices and the ruble exchange rate partially mitigated the positive effect for exporters due to the increased revenue from high oil prices through the strengthening of the national currency. On the other hand, in the event of a significant drop in oil prices, the losses of exporters were less compensated due to the restrained weakening of the ruble exchange rate. For the economy in general, the Fiscal Rule and the inflation targeting policy made it possible to smooth exchange rate fluctuations and weaken the impact of the oil price on price stability.

However, it should be noted that after 2017, the Russian economy, according to a number of domestic economists, approached full employment and a high level of industrial production capacity utilisation [10]. In this context, monetary methods of stimulating the economy are more likely to have only a short-term positive effect, leading to an increase in inflation in the long

term.

As it was indicated in the literature review, the relationship between the exchange rate and output in a particular country is largely determined by its exports and imports composition. The Russian economy is characterised by high dependency on fluctuations in world oil prices, which have a significant impact on the total nominal export revenue, the amount of foreign exchange earnings, and as a result, affect the exchange rate. As shown in Figure 2, the revenue from the sale of the basic Russian export products[1] correlates with the current oil price and is subject to strong fluctuations over a long period, while the export quantities (exports in base prices) have less volatility and an observable trend.

Figure 2. Revenue from exports of basic products in Russia



Sources: Rosstat, author's calculations.

The economy of the Russian regions largely depends on the cost of oil, both directly through the impact on regional exporters, and indirectly through the interregional redistribution of budget and corporate finance, the revitalisation of oil-related industries, changes in domestic prices for oil products.

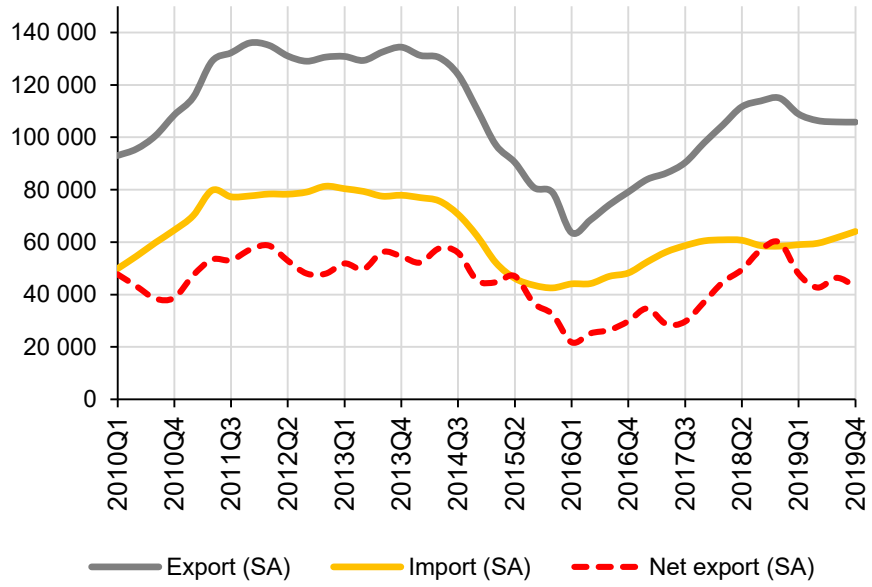
An important effect of changes in the exchange rate on the economy is its impact on domestic demand – through a change in the ratio of demand for domestic and imported products. In contrast to exports, Russian imports consist mainly of highly processed finished products: equipment, machinery, vehicles and medical supplies, and imported food is partially

[1]The list of the basic Russian export products used for the calculation is specified in Annex 7.

represented by goods without competitors in the domestic market due to climatic and other conditions. This means that imports are only partially replaced by domestic products due to the lack of substitute goods, and the demand for some imported goods is not elastic in price. The weakening of the ruble exchange rate increases the relative prices of imported goods, making them less attractive, but this will not necessarily stimulate a significant decrease in the import quantities and an increase in demand for domestic products (a substitution effect). At the same time, the strengthening of the exchange rate may lead to a decrease in the total costs of imported goods in ruble equivalent, and part of the released funds will be used to purchase goods of domestic origin (an income effect).

The dynamics of nominal import and export volumes in Russia are characterised by a high correlation (Figure 3). The nominal exports are largely determined by global commodity prices, and imports are determined by the effective demand at a given exchange rate.

Figure 3. Export, import and net export of Russia (million USD)



Sources: Rosstat, author's calculations.

One of the ways to evaluate the relationship between the exchange rate and foreign trade in economic research is to use indicators of import and export quantities in models, for example, in [17; 31; 36], which allows excluding the impact of price environment on the turnover of tradable goods. Unfortunately, it is difficult to use Russian data on import and export volumes at the regional level. Firstly, this is due to the accounting methods in foreign trade – the revenue from the export-import operations is recorded at the place of tax registration of entities (in this regard, the foreign trade turnover of many major companies operating in the regions is

recorded in Moscow, St Petersburg, etc.[2]), and secondly, the calculation of the volume of trade has some shortcomings, especially for the import of finished products (equipment, machinery and medical supplies), where the translation of the nominal volume in the physical quantity would not necessarily take into account changes in the quality characteristics of the products. This research uses an alternative approach to assess the impact of the exchange rate on the output in Russian regions: variables characterising monetary conditions, the influence of the global market environment are used, and a control variable on the domestic demand is added.

3.2. Data description

This research provides models for Russia as a whole, and for federal districts and regions. Calculations have been made only for 79 regions of Russia due to the lack of complete statistical data series for calculating the indicators for some regions (calculations for the Khanty-Mansi, Yamalo-Nenets and Nenets Autonomous Regions were carried out as part of the relevant regions – the Tyumen and Arkhangelsk Regions, calculations for the Republic of Crimea, Sevastopol and the Republic of Ingushetia were not made).

All model specifications are based on the monthly data (month-on-month growth rate as a percentage – MoM); the set of variables used to build the specifications is as follows:

1. Endogenous variables (monthly increases – MoM %):

• VRP – real output – proxy-GRP calculated on the basis of leading indicators of Rosstat, according to the methodology of the Ural Main Branch of the Bank of Russia [4];

• CPI – consumer price index (source: Rosstat);

• W – real wages (source: Rosstat);

• ruble exchange rate:

  ○ REER – real effective exchange rate of the ruble (source: Bank of Russia);

  ○ NEER – nominal effective rate of the ruble (source: Bank of Russia);

• RUONIA – weighted interest rate of one-day unsecured interbank loans (deposits) provided by the largest Russian credit institutions (source: Bank of Russia);

2. Exogenous variables (monthly increases – MoM %):

• Brent – dynamics of Brent Crude oil prices (source: Pink Sheet World Bank).

Seasonal data series (regional output, real wages, inflation) have been cleaned using the

[2]For example, according to the Federal Customs Service of Russia, in 2018 and 2019, Moscow represented about 43% of Russia's total export revenue.

Tramo/Seats method.

All models were calculated based on data for two periods:

• January 2010 – October 2014 (58 observations) – the period prior to the transition of the Bank of Russia to inflation targeting policy and refusal to manage the ruble exchange rate;

• March 2015 – December 2019 (58 observations) – the period of inflation targeting policy.

The periods from November 2014 to February 2015, as well as the beginning of 2020, are not included in the models due to significant volatility in the currency market (the imposition of sanctions on Russia and the transitional period – in the first case; the coronavirus pandemic and the change in OPEC+ arrangements – in the second case). The inclusion of these periods in a relatively short time series can significantly distort the results.

3.3. Method description

The econometric approach used in this research is to build a structural vector autoregression model – VAR, based on the approach initially described in Sims, S. [33]. The model is a system of equations that takes into account the correlation between various macroeconomic variables and assumes the existence of a certain dynamic structure of relations between them in accordance with economic theory. The advantage of this approach is the simultaneous solution of equations for each endogenous variable expressed with a certain number of lags, both through its own values and through the values of other variables. This becomes more relevant when studying economic relationships, for example: output impacts both inflation and wages, but the latter, in turn, can also impact output with a certain lag. The use of vector autoregressions is a fairly common approach for assessing the relationship between the exchange rate and output in domestic and foreign research works [e.g. 1; 5; 7; 21; 22; 25; 27; 31].

The general form of the VAR model used in this research, which does not take into account the restrictions imposed, is as follows:

$$REER_t = a_{10} + \sum_{j=1}^{p} a_{11j}\, REER_{t-j} + \sum_{j=1}^{p} a_{12j}\, VRP_{t-j} + \sum_{j=1}^{p} a_{13j}\, CPI_{t-j} + \sum_{j=1}^{p} a_{14j}\, W_{t-j} + \sum_{j=1}^{p} a_{15j}\, RUONIA_{t-j} + a_{16} Brent_t + e_{1t}$$

$$VRP_t = a_{20} + \sum_{j=1}^{p} a_{21j}\, REER_{t-j} + \sum_{j=1}^{p} a_{22j}\, VRP_{t-j} + \sum_{j=1}^{p} a_{23j}\, CPI_{t-j} + \sum_{j=1}^{p} a_{24j}\, W_{t-j} + \sum_{j=1}^{p} a_{25j}\, RUONIA_{t-j} + a_{26} Brent_t + e_{2t}$$

$$CPI_t = a_{30} + \sum_{j=1}^{p} a_{31j}\, REER_{t-j} + \sum_{j=1}^{p} a_{32j}\, VRP_{t-j} + \sum_{j=1}^{p} a_{33j}\, CPI_{t-j} + \sum_{j=1}^{p} a_{34j}\, W_{t-j} + \sum_{j=1}^{p} a_{35j}\, RUONIA_{t-j} + a_{36} Brent_t + e_{3t}$$

$$W_t = a_{40} + \sum_{j=1}^{p} a_{41j}\, REER_{t-j} + \sum_{j=1}^{p} a_{42j}\, VRP_{t-j} + \sum_{j=1}^{p} a_{43j}\, CPI_{t-j} + \sum_{j=1}^{p} a_{44j}\, W_{t-j} + \sum_{j=1}^{p} a_{45j}\, RUONIA_{t-j} + a_{46} Brent_t + e_{4t}$$

$$RUONIA_t = a_{50} + \sum_{j=1}^{p} a_{51j}\, REER_{t-j} + \sum_{j=1}^{p} a_{52j}\, VRP_{t-j} + \sum_{j=1}^{p} a_{53j}\, CPI_{t-j} + \sum_{j=1}^{p} a_{54j}\, W_{t-j} + \sum_{j=1}^{p} a_{55j}\, RUONIA_{t-j} +$$

$a_{56}Brent_t + e_{5t}$

Indicators VRP, CPI, W included into the model correspond to such region (federal district) with respect to which the model is made.

The specified equation can also be briefly written in matrix form:

$$Y_t = \sum_{j=1}^{p} A_j * Y_{t-j} + B * X_t + C + e_t,$$

where:

Y is a vector of endogenous variables,

X is a vector of exogenous variables,

A, B, C are matrices of coefficients where *C* is a vector of the constants,

e is a random error.

It is worth considering the logic of including the variables into the models as well as a number of established restrictions. The investigations of the interrelation between the exchange rate and the output commonly use the Real Effective Exchange Rate (REER) that represents the weighted average exchange rate of home currency against currencies in main foreign trade partner-countries as amended by the ratio of inflation rates between countries. An alternative approach in similar research is the use of a nominal exchange rate with respect to one or several foreign currencies. The disadvantage of this approach is that it does not take into account the 'natural' revaluation of the exchange rate against the inflation rate. On the other hand, economic agents are guided exactly by the nominal exchange rate when concluding transactions, therefore results with respect to the nominal exchange rate are easier to interpret. This work contains calculations both for the real and nominal effective exchange rates of the Russian ruble established by the Bank of Russia.

Lack of statistics on domestic regional product as an indicator of the real output prompts us to use in this study a proxy-GRP calculated in line with the methodology of the Ural Main Branch of the Bank of Russia [4] based on leading indicators of Rosstat (the Federal State Statistics Service) that constitute industry-based monthly indexes (industrial production, construction, retail trade turnover, turnover of paid services), taking into account weights of these indicators. The proxy-GRP reflects both the dynamics of the real sector of the economy and the state of the business activity indicators such as the services sector and trade.

The RUONIA rate is included in the model since it is necessary to identify the interest rate channel of influence on the economy and establish the response of output and other indicators to the change in the cost of borrowed funds and investments. The short-term lending rate of unsecured interbank loans contains the least risk and liquidity premiums, which makes it

possible to estimate fluctuations in the demand for money in the economy.

Dynamics of inflation and of real wages (average inflation-adjusted wages and salaries) helps us take into account the local demand conditions in Russia's regions. Moreover, including these variables into the model is conditioned by specific features of Russia's past years, where the recession was not accompanied by a major rise in unemployment, and the growth rate of wages and inflation were low or negative (due to the relative flexibility of wages). Changes in household income makes it possible to evaluate a business cycle phase. Similar approach where the wages indicator is included in the VAR-model, which helps bind together output, money market and labour market, is used in the research of the European Central Bank experts [25] to evaluate oil shocks impact on the economic growth in OECD countries.

The dynamics of Brent crude oil prices, influenced by the situation in the world economy, determine prices for other types of crude oil and oil products, which makes it valuable for explaining the Russian ruble exchange rate dynamics to represent an indicator of the external factors' impact on Russia's economy. As mentioned above, the Russian regions' economy depends a lot on oil prices: both directly through the influence on regional exporters and consumers of oil products and indirectly as part of the interregional distribution of funds of the budget and corporations and activities in oil-related industries.

Table 1. Restrictions in the regional model

Explanatory variables	**Dependent variables**				
	REER	VRP	CPI	W	RUONIA
REER	1	1	1	1	1
VRP	0	1	1	1	0
CPI	0	1	1	1	0
W	0	1	1	1	0
RUONIA	1	1	1	1	1
Brent	1	1	0	0	0

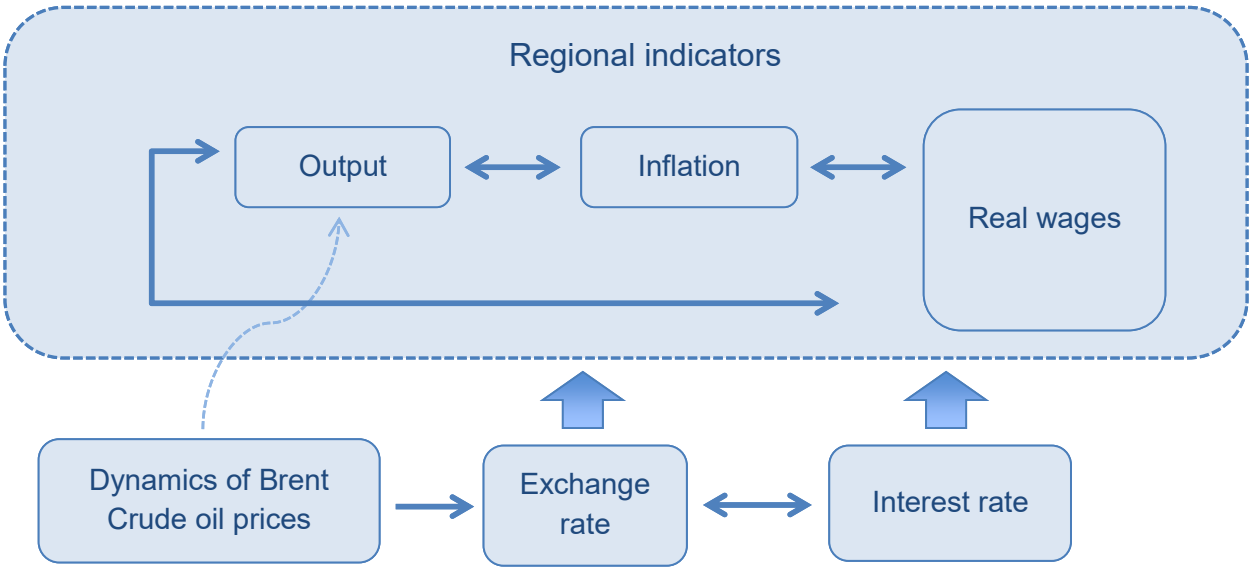
1/0 – assumption/restriction of the influence of the explanatory variable on the dependent one.

In the model of this study, the influence of the exogenous factor – the dynamics of Brent Crude oil prices – on endogenous factors is limited: oil prices influence only the exchange rate and output. At the same time, additional limitations on the interrelation between the endogenous variables are added for federal districts and regions of Russia (Table 1).

As it is demonstrated in Table 1, the model's specification denies the influence of the regional indicators (output, inflation, wages) on the dynamics of indicators of Russia as a whole (exchange rate and RUONIA interest rate), which excludes the corresponding variables (or zero coefficients of variables) from the VAR equation. The presence and significance of other

interrelations between the endogenous variables is determined in this model by solution of the system of VAR equations. If the influence of the dynamics of one variable on another is insignificant, the coefficient for the corresponding variable will be negligible. This approach avoids the imposition of the theoretically debatable limitations and prevents the loss of information. A schematic representation of the relationships established is depicted in Figure 4.

Figure 4. Scheme of the relationship between the variables in the model



When making the model, the advisability of adding other exogenous variables with various lags was tested: the dynamics of Russia's export commodities prices, the index of prices calculated by the World Bank for groups of non-energy products. However, these variables mainly failed to improve the models' quality criteria and did not significantly change the results, therefore, they were rejected.

This study contains three specifications of the models (Annex 2):

• specification 1 – basic (above);

• specification 2 which uses the real effective exchange rate rather than REER as in the basic specification;

• specification 3 where the exogenous variables of the basic model were complemented by a dummy variable dividing the period of 2015–2019 into two time slots – before and after the introduction of the new fiscal rule in Russia (the variable is equal to1 until February 2017 and to 0 from February to December 2019)[3].

[3]Similar dummy variable of the 'new fiscal rule' is used in the work of Bozhechkov, A.V., et al. [3] in the study of the factors of the Russian ruble exchange rate dynamics.

When making models, all data series were checked for stationarity (absence of unit roots). When choosing the number of lags of variables in the models, the Akaike, Schwarz, Hannan – Quinn criteria and the likelihood ratio test (LR test) were used. The maximum number of lags used in making the models is limited to four, since the results obtained on short time series with a large number of variables and lags may turn out to be inconsistent. It was discovered that in the context of the regions and time periods under consideration, a different number of lags (from one to four) is required to make the best models in terms of information criteria. This indirectly confirms the heterogeneous nature of the existing relationships in the regional context.

Each model was checked for stationarity and absence of autocorrelation in the residuals. When making the models, due attention was paid to testing for the normal distribution of residuals. If a significant outlier was found in the residuals, the feasibility of adding a dummy variable to the model was considered, since the outlier may significantly distort the results of a model made on short time series. Information on the number of lags and dummy variables in the models made, is presented in Annex 3.

3.4. Checking the results for robustness

The results of the models were interpreted using the Cholesky decomposition through the standard recursive identification of shocks. This procedure provides for the imposition of certain restrictions in accordance with the established order of the model's variables: the shock of a single variable has an immediate effect on the variable after it, and on other variables further in the order. At the same time, the immediate (in the same period) influence of the variables on the preceding variables is limited.

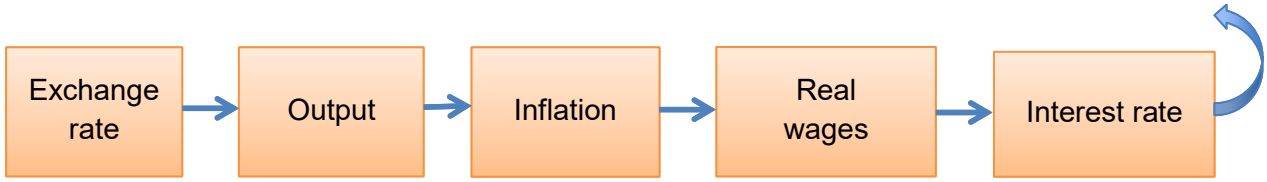
It is worth considering the four most common sequencing patterns for the endogenous variables in similar studies [e.g. 21; 25; 27].

1. Exchange rate – Output– Inflation – Real wages – Interest rate.

In this identification scheme of shocks (Figure 5), it is assumed that the impact of exchange rate shock affects output in the same period of time, the exchange rate and output in the same period affect inflation, which, in turn, affects the size of real wages. It is assumed that the interest rate (in our case, RUONIA) affects the previous variables only in the next period. A probable disadvantage of this approach is that there is no immediate effect of the interest rate shock on the exchange rate and other variables. However, given that the interest rate is short-term and its change will affect medium and long-term rates with a certain time delay (and hence the cost of borrowed resources for the real sector of the economy), this assumption can be

considered acceptable.

Figure 5. Identification scheme of shocks



2. Exchange rate – Interest rate – Output– Inflation – Real wages.
3. Interest rate – Exchange rate – Output – Inflation – Real wages.

The second and third orders of variables assume that the interbank market participants correctly form their expectations regarding development of the economy (which, however, is complicated practically by emergence of new statistical information with a certain delay).

4. Output – Inflation – Real wages – Interest rate – Exchange rate.

The fourth identification assumes that the exchange rate is subject to the influence of shocks of the remaining variables, while its shocks do not have a reciprocal effect in the same period. This order is more suitable for models made on large data frequencies (a quarter, a year). As a rule, short-term changes of the exchange rate are very quickly transferred to the prices of goods and influence the plans of business entities, but not vice versa.

This study tested all four shock identification schemes for each specification (Annex 4). It was found that schemes 1 and 2 produce the same results, and the results of scheme 3 differ slightly from those. Significant differences in the values of the output response to exchange rate shocks were found for Scheme 4; however, such a priority scheme is the least justified in this study. Identification scheme 1 was used to find a solution to the problem.

The models' robustness of the results when using identification scheme 1 was checked by comparing the specifications of the models. It is expected that the use of the nominal exchange rate in the second specification instead of the real one will lead to different results. However, with moderate inflation in the short run, the impact of the dynamics of the nominal and real exchange rates should not differ significantly. An additional check was made for the period from March 2015 to December 2019, to find out if it is necessary to allocate the time of the new Fiscal Rule being in force (from February 2017) by comparing the results of specification models 1 and 3. The data obtained (Annex 5) indicate an unsubstantial difference in the results of the specifications.

The results obtained with respect to federal districts and Russia as a whole were additionally checked arithmetically: by adding the results of the associated regions, multiplied by the

average share of each region in the total GRP. This check confirms that there are no significant errors both in federal districts and in Russia as a whole. Annex 6 shows the results of evaluating the impact of exchange rate dynamics on output for all regions, indicating the average weight of each region in Russia's GRP.

4. Analysis of the relationship between exchange rate dynamics and output

The results obtained indicate that there is no significant relationship between the ruble exchange rate dynamics and total Russia's output in 2010–2014 (Table 2), while for the period from 2015 to 2019 the inverse relationship was found between the strengthening of the Russian ruble real exchange rate and output (1% of the Russian ruble real exchange rate strengthening was responded by 0.05% output decrease within one year).

Thus, we can agree with a number of domestic authors who did not find unambiguous influence of the Russian ruble exchange rate dynamics on the Russia's total output based on the data up to 2015 [5, 7].

In the regional context, the first and second study periods represent both positive and negative effects of the exchange rate strengthening on output.

Table 2. 12-month accumulated impulse response of output to 1% strengthening of the Russian ruble real effective exchange rate (%)

	2010–2014	**2015–2019**
Russian Federation	**0.02**	**-0.05****
Central Federal District	0.02	-0.10**
North-Western Federal District	0.03	-0.01
Southern Federal District	0.01	0.00
North Caucasian Federal District	0.16*	0.00
Volga Federal District	0.15*	-0.07
Urals Federal District	-0.01	-0.05
Siberian Federal District	0.14*	-0.06
Far Eastern Federal District	-0.11*	0.11*

* and ** denote statistical significance at 10- and 5%, respectively.

2010–2014 found statistically significant direct relationship between the exchange rate strengthening and output (output growth of about 0.15% in response to 1% of the Russian ruble real exchange rate strengthening) in the Volga, Siberian and North Caucasian Federal Districts. This fact can be explained by the economic recovery after the 2008–2009 crisis being accompanied by the renewal and expansion of production capacities, while the Volga and

Siberian Federal Districts have the largest share of the manufacturing industry in the gross regional product (Annex 3), and the North Caucasian Federal District has the highest share of the construction industry in the GRP. The manufacturing industry and construction tend to experience the greatest need for imported equipment and raw materials, which explains the relationship found in this period.

At the same time, it should be noted that in 2010–2014, for the Far Eastern Federal District, where gross regional product has a significant share of the mining industry (Sakhalin Region, Chukotka Autonomous Region, Republic of Sakha (Yakutia)), there is an inverse relationship between the strengthening of the exchange rate and output (a decrease in output by about 0.1% in response to 1% strengthening real exchange rate of the Russian ruble). At the same time, each federal district of Russia has regions with both direct and inverse dependence of output on the exchange rate strengthening.

The results obtained confirm the structural changes in the Russian economy that occurred at the turn of 2014–2015 led to a change in the exchange rate pass-through effect on output in many regions. This can be explained by transformation of business processes in the manufacturing industry in the current environment. A substantial depreciation of the Russian ruble exchange rate at the end of 2014, as well as the subsequent high inflation and growth of bank interest rates, forced many enterprises to abandon investment plans, especially those related to the import of equipment. However, enterprises with competitive products for domestic or foreign markets got certain advantages from the national currency depreciation. Adaptation to new conditions was accompanied by a forced reduction in the import component in the costs of enterprises and an increase in the production of import-substituting products.

Table 3. Russia's import and export of certain commodities (million USD)

Commodity group	**Import**			**Export**		
	2014	2019	Change, %	2014	2019	Change, %
Machinery, equipment and vehicles	136,318	112,659	-17	26,411	27,845	+5
Wood, and pulp and paper products	5,905	3,701	-37	11,625	12,797	+10
Food products and agricultural raw materials	39,905	29,964	-25	18,981	24,830	+31

The Federal Customs Service of Russia statistics show that 2019, compared to 2014, saw a decrease in imports accompanied by an increase in exports for a number of foreign trade

commodity groups not related to mining and quarrying (Table 3). And, although it is practically impossible to replace imported equipment and raw materials with domestic ones in full, the dependence of the Russian economy on imports somewhat decreased. Consequently, enterprises experienced a positive effect of the Russian ruble depreciation that contributed to an increase in the competitiveness of Russian commodities, which outweighed the negative impact of the devaluation.

For example, in the Volga and Siberian Federal Districts where the relationship between the Russian ruble exchange rate dynamics and output changed after 2014: the weakening of the Russian ruble exchange rate in 2015–2019 had a positive effect on the output of regions associated with mechanical engineering (Samara, Nizhny Novgorod, Ulyanovsk and Saratov regions, Republic of Udmurtia), woodworking and pulp production (Irkutsk region), due to prevalance of import substitutions effects.

Also, after 2014, the Far Eastern Federal District experienced a significant change in the relationship between the exchange rate and output, but here the impact of the exchange rate on output changed from negative to positive (from -0.11 up to 0.11% in response to 1% strengthening of the Russian ruble real exchange rate). The change in the pass-through effect in the Far East can be primarily explained by the completion of one of the stages of the Sakhalin offshore oil and gas production projects in 2014. This ensured a significant increase in oil production, stimulated a rise in the physical volume of the Sakhalin Region GRP and that of the Federal District as a whole (3.1 and 0.5%, respectively) against the background of the Russian economy general recession in 2015. However, the further development of the region's oil and gas potential and the maintenance of sustainable growth depended on the development of new offshore fields and the implementation of projects for the production of liquefied gas and petroleum products, i.e. those areas with the highest dependence of the Russian industry on the import of high-tech equipment. In addition to the rise in the imports cost due to the Russian ruble depreciation, the situation was aggravated by the imposition of US sectoral sanctions against the Russian oil and gas industry in 2014. The sanctions prevented a number of Russia's foreign partners from participating in joint offshore projects and the sale of the specialised equipment. Usually, exchange rate depreciation promotes development of export-oriented mining industry, but this is not a sufficient condition for increasing production. Also, the Far Eastern Federal District's geographical location contributes to a greater predisposition of its industry and population to imports. For example, significant volumes of imports (mainly from China, Japan and South Korea) to Russia pass through the Primorye Territory. The Russian ruble strengthening and increase in demand for imports simulates the region's rise in

the volume of transportation and storage – the industry where about a fifth of the gross value added of the Primorye Territory is generated. The aggregate change in the regional relationship between the exchange rate and economic activity in the Far East led to a modification of the exchange rate pass-through effect on output for the federal district after 2014.

Figure 6. Groups of regions by positive/negative impact of the exchange rate on output in 2010–2014

Source: author's calculations.

In total, this study contains calculations of estimates of the exchange rate effect on output accumulated over 12 months for 79 regions of Russia (Figures 6 and 7):

- for 2010–2014 (8 statistically significant results were obtained for regions) strengthening of the ruble exchange rate:

- has a positive effect on output in 38 regions;

- has a negative effect on output in 23 regions;

- in 18 regions has an insignificant effect on output (from -0,015 to 0,015% in response to a 1% change in the exchange rate);

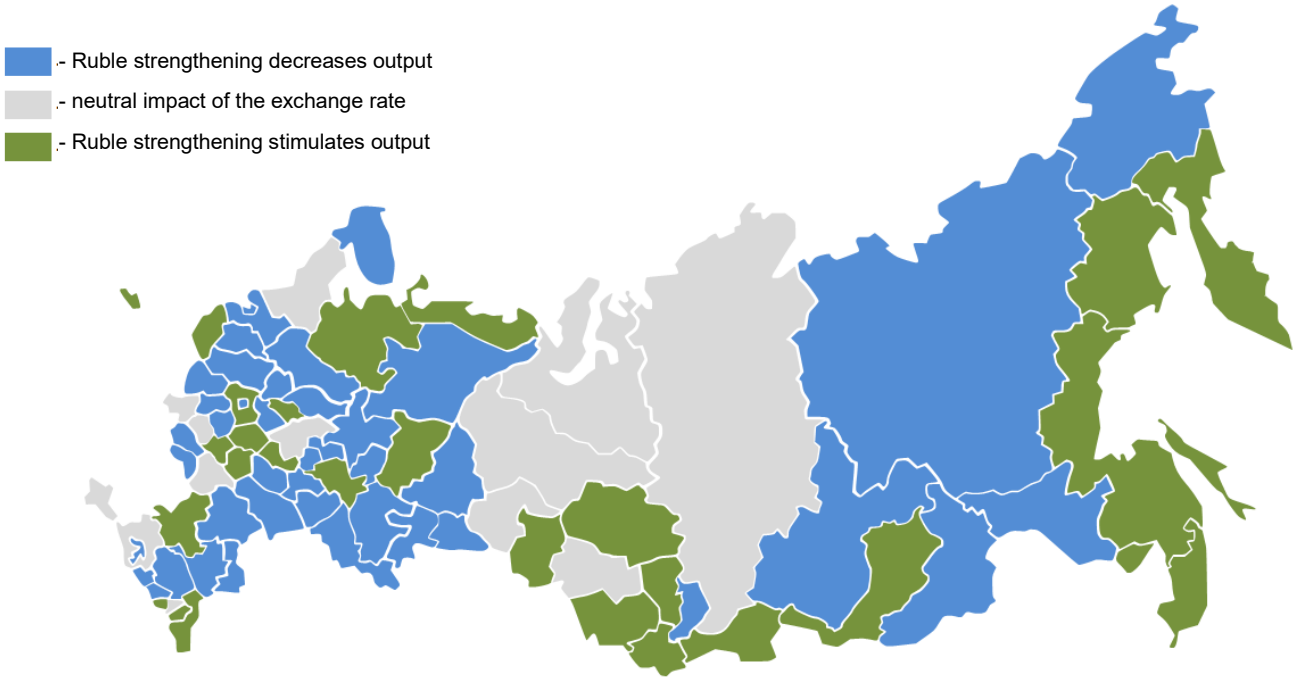
- for 2015–2019 (23 statistically significant results were obtained for regions) strengthening of the ruble exchange rate:

- has a positive effect on output in 28 regions;

- has a negative effect on output in 42 regions;

- has an insignificant effect on output in 9 regions.

Figure 7. Groups of regions by positive/negative impact of the exchange rate on output in 2015–2019



Source: author's calculations.

The results obtained confirm the heterogeneous character of the impact of the Russian ruble exchange rate dynamics on output in the first (2010–2014) and second (2015–2019) periods. At the same time, the second period saw an increase in the number of regions (by 19) where the strengthening of the exchange rate had a negative impact on output, and the decrease in the number of regions where the strengthening of the exchange rate had a positive impact on economic activity or was neutral (near zero). The example of federal districts explains this fact by the increased importance of price competitiveness of Russian commodities in the domestic and foreign markets, the end of economic recovery, the intensification of import substitution, and a slight decrease in the dependence of the domestic industry on imports. Measures of state policy aimed at supporting import substitution and stimulating non-commodity exports also had their effect.

The absence of a statistically significant relationship between the exchange rate and economic activity for a large number of Russian regions can be explained by the following reasons:

- a high share in the region's economy of the public sector and/or the service sector oriented at the domestic consumer (as a rule, these areas are less dependent on exchange rate fluctuations);

- the implementation in some regions of large, relative to the regional economy size,

investment projects that caused significant changes in output dynamics in the short term;

- high dependence of the region on both exports and imports (mutual non-simultaneous overlap of effects);

- a significant impact of factors not related to the exchange rate (harvest, restrictions on import/export of certain types of products, etc.) on output dynamics.

Regional examples

The highest statistically significant positive effect of the strengthening of the Russian ruble exchange rate on output was found for the Chechen Republic for the period from 2010–2014, where in the early 2010s the restoration of socio-economic infrastructure was going on and high rates of construction were sustained, which jointly caused significant volumes of imports (the Republic's import was more than 50 times higher than export volumes in nominal values). This explains the positive dependence of the output on strengthening of the exchange rate.

The change in the exchange rate pass-through effect on output since 2015 can be explained for many regions by the example of the Volgograd Region where the positive effect of the exchange rate strengthening became negative. A number of investment projects were completed here in 2015–2016 to modernise the sites of inactive factories and create new production lines. After the depreciation of the Russian ruble exchange rate, many enterprises switched to manufacturing of import-substituting products from domestic raw materials (mainly in the metallurgy and chemistry industries). According to the Volgograd Region Governor's press service, 44 industrial enterprises in the region produced 57 types of import-substituting products in 2016, to increase the 2016 volume of production by 50% compared to the previous year [6]. This import substitution was caused by the opportunity to produce inexpensive equivalents of foreign goods.

At the same time, a number of regions with a high share of manufacturing in the gross regional product demonstrated a positive relationship between the strengthening of the exchange rate and output after 2014, which can be explained by the high dependence of regions on imports. For example, in the Ivanovo Region, where the structure of the real sector's output is dominated by the light industry, focused mainly on the domestic market (the volume of imports in the region is more than three times higher than that of exports in nominal values). It is expected that the rise in the cost of imports due to the depreciation of the Russian ruble may lead to a decrease in the profitability of industries with a high import component in the costs.

It should be noted that the model used in this study does not describe the economy as a

whole and is not a model of economic growth. The objective of this work is to assess the impact of exchange rate dynamics on economic growth in the regional context.

Limitations of the results obtained:

1) the models calculated for individual regions take into account the impact of the exchange rate and interest rate for Russia as a whole, while the economic indicators of a particular region do not have a significant impact on formation of all-Russian indicators, which prevents the establishing of more accurate dependencies of variables in VAR.

A possible solution is to use the calculated regional exchange rates (taking into account a set of goods of the region's foreign trade), regional interest rates, or panel data technique to detect individual effects.

2) prices for certain import and export commodities corresponding to specific industries of the region can have a significant impact on output of a number of regions; when added to the exchange rate, they will bring about more accurate estimates of the pass-through effect.

Possible solution: making a model for each region with an individual set of explanatory variables.

5. Conclusion

This study evaluates the impact of exchange rate dynamics on economic activity in the context of Russian regions using a structural vector autoregression. The results obtained confirm the hypothesis of the presence of a heterogeneous reaction of regional output to changes in the Russian ruble exchange rate. The paper also revealed a change in the exchange rate pass-through effect on output as a result of a significant depreciation of the Russian ruble and structural changes in the economy at the end of 2014. The strengthening of the Russian ruble exchange rate in 2010–2014 stimulated output in regions associated mainly with the manufacturing industry but at the same time negatively affected a number of regions with the predominance of the mining industry in the economy. In 2015–2019, the strengthening of the Russian ruble exchange rate negatively affected the economic activity of regions where products are competitive in the domestic and foreign markets, and the production processes are based mainly on the domestic raw materials and technological base.

In general, the Russian Federation shows a moderate level of influence of exchange rate on output. The obtained results make it possible to agree with the assertion that there is no unambiguous dominance of a positive or negative effect from the depreciation/devaluation of the exchange rate on the Russian economy. This supports the view that active intervention of the monetary authorities in the exchange rate is redundant. However, moderate volatility of the Russian ruble exchange rate (for example, smoothed out within the framework of the fiscal rule) will help economic agents to better adapt to existing circumstances, expand the horizons of business planning, and contribute to the implementation of the inflation targeting policy followed by the Bank of Russia, which in aggregate will create favourable conditions for the sustained and balanced economic growth.

It should be noted that the analysis of this paper takes into account a number of factors that accompanied exchange rate dynamics and caused structural changes in the period under study. The results obtained should be extrapolated to other time periods and situations with some caution.

The quality of the assessment of the existing relationships can be improved by taking into account the specific features of regions and by individually approaching each case. This may require adding other variables and using a different calculation methodology, but shall require accumulation of additional historical data from the floating ruble exchange regime era to render sufficiently robust results.

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Annexes

Annex 1

A brief description of econometric studies on the relationship between the Russian ruble exchange rate and the output dynamics of in Russia

Study	Measurement method, data	Main conclusions
Картаев Ф.С. Эконометрическое моделирование взаимосвязи курса рубля и динамики ВВП // Вестник Московского университета, серия 6. Экономика № 2. 2009 (F.S. Kartaev 'Econometric modelling of the relationship between the ruble exchange rate and GDP dynamics' Bulletin of Moscow University, series 6 Economy. No. 2, 2009)	Regression constructed in stationary differences with dummy variables added. Industry output indexes are used as dependent variables, and REER (Real Effective Exchange Rate) is used as an explanatory variable. Period under study: 1999–2006	No significant relationship between REER and the production of the extractive industry was found. At the same time, it is noted that the weakening of the exchange rate has a stimulating effect on the manufacturing industry and Russia's GDP
Бадасен П.В., Картаев Ф.С., Хазанов А.А. Эконометрическая оценка влияния валютного курса рубля на динамику выпуска // Деньги и кредит, 7/2015, с.41-49 (Badasen, P.V., Kartaev, F.S., Khazanov, A.A., 'Econometric assessment of the impact of the ruble exchange rate on the dynamics of output'. Money and Finance, 7/2015, pp. 41–49)	Structural vector autoregression with exogenous variables. Endogenous variables: REER, real interest rate (calculated value), output index, inflation, M2 aggregate growth. Exogenous variables: Urals crude oil, Chicago Stock Exchange Volatility Index VIX. Period under study: 2005–2014	Positive impact of the REER depreciation on the following industries was found: mining and quarrying, wood processing, pulp and paper production, coke production, chemicals production, mineral products production, metallurgy, electric power production. Negative impact of the REER depreciation on the construction industry was found. No impact on textile, leather production, production of machinery and equipment, production of electrical equipment and vehicles was found
Евдокимова Т.В., Зубарев А.В., Трунин П.В. Влияние реального обменного курса рубля на экономическую активность в России. – М.: Издательство	1. Regression. Industry output indexes are used as dependent variables, and REER (Real Effective Exchange Rate) is used as an explanatory variable, growth of M2 aggregate in real value, average electricity prices released to producers in real value, trend.	2001–2008: No significant statistical effect of the exchange rate on GDP was found. Positive impact of REER depreciation was found on the following industries: Fuel and energy complex, chemical and petrochemical industry. Negative impact of REER

Института Гайдара, 2013. 164 с. (Evdokimova, T.V., Zubarev, A.V., Trunin, P.V. The impact of the real exchange rate of the ruble on economic activity in Russia. Moscow: Gaidar Institute Publishing House, 2013. p.164)	2. Vector autoregression model: Endogenous variables: REER, growth of M2 aggregate in real value, output index. Period under study: 2001–2008, 2008–2011	depreciation was found on the following industries: light industry, motor vehicle industry. For 2008–2011, the authors note the emerging changes in the effect due to the crisis
Букина И.С., Ореховский П.А. Особенности российской модели экономического роста // Финансы: Теория и практика, № 22 (6), 2018, с. 6 -24 (Bukina, I.S., Orekhovsky, P.A., 'Features of the Russian model of economic growth'. Finance: Theory and Practice, No. 22 (6), 2018, pp. 6–24)	Vector autoregression model. Endogenous variables: nominal exchange rate of the Russian ruble, labour productivity, real GDP. The period under study: quarterly data of 1998–2017	There is no statistically significant relationship between the nominal exchange rate and GDP, while exchange rate fluctuations affect labour productivity: the depreciation of the ruble increases labour productivity in the short term, which contributes to the revival of business activity in the medium term (up to two years)
Трунин П., Каменских М., Дробышевский С. (2008) Анализ трансмиссионных механизмов денежно-кредитной политики в российской экономике – М.: ИЭПП (P. Trunin, M. Kamenskikh, S. Drobyshevsky (2008) Analysis of monetary policy transmission mechanisms in the Russian economy. Moscow: Institute of Economic Problems of the Transition Period)	Vector autoregression model with exogenous variable. Endogenous variables: REER, monetary aggregates, basic industries output index, inflation. Exogenous variables: Brent crude oil price, trend. Period under study: 2002–2007	The authors do not find a statistically significant response of the issue to exchange rate shocks in the period under study

Annex 2

Specification 1.

Explanatory variables	**Dependent variables**				
	REER	VRP	CPI	W	RUONIA
REER	1	1	1	1	1
VRP	0	1	1	1	0
CPI	0	1	1	1	0
W	0	1	1	1	0
RUONIA	1	1	1	1	1
Brent	1	1	0	0	0

1/0 – assumption/restriction of the influence of the explanatory variable on the dependent one.

Specification 2.

Explanatory variables	**Dependent variables**				
	NEER	VRP	CPI	W	RUONIA
NEER	1	1	1	1	1
VRP	0	1	1	1	0
CPI	0	1	1	1	0
W	0	1	1	1	0
RUONIA	1	1	1	1	1
Brent	1	1	0	0	0

Specification 3.

Explanatory variables	**Dependent variables**				
	REER	VRP	CPI	W	RUONIA
REER	1	1	1	1	1
VRP	0	1	1	1	0
CPI	0	1	1	1	0
W	0	1	1	1	0
RUONIA	1	1	1	1	1
Brent	1	1	0	0	0
D_BR*	1	1	0	0	0

**D_BR is a dummy variable that divides the study period into time periods before and after February 2017.*

Annex 3

Number of lags and dummy variables introduced to eliminate atypical shocks (outliers) in models (specifications 1 and 2)

	Period Jan 2010 – Oct 2014		Period Mar 2015 – Dec 2019	
Region of Russia	number of variable lags in the model	number of dummy variables	number of variable lags in the model	number of dummy variables
Russian Federation	**1**	**1**	**2**	**0**
Central Federal District	**1**	**2**	**2**	**0**
Belgorod Region	1	3	1	1
Bryansk Region	1	2	3	0
Vladimir Region	2	5	4	2
Voronezh Region	3	4	3	2
Ivanovo Region	3	2	3	2
Kaluga Region	1	2	3	2
Kostroma Region	1	3	3	1
Kursk Region	1	2	3	1
Lipetsk Region	1	1	4	2
Moscow Region	1	3	4	0
Orel Region	1	3	3	0
Ryazan Region	1	4	3	2
Smolensk Region	1	1	3	0
Tambov Region	1	3	3	1
Tver Region	1	2	3	2
Tula Region	1	4	4	2
Yaroslavl Region	1	3	3	0
Moscow	1	2	2	2
North-Western Federal District	**1**	**2**	**2**	**1**
Republic of Karelia	2	0	3	0
Republic of Komi	1	1	3	0

Arkhangelsk Region	4	4	4	0
Vologda Region	1	3	3	0
Kaliningrad Region	1	2	2	0
Leningrad Region	1	4	2	1
Murmansk Region	2	2	3	1
Novgorod Region	1	2	3	1
Pskov Region	1	3	2	1
St Petersburg	1	1	2	3
Southern Federal District	**1**	**4**	**3**	**1**
Republic of Adygeya	1	2	3	0
Republic of Kalmykia	1	0	3	0
Republic of Crimea	-	-	-	-
Krasnodar Region	1	5	2	1
Astrakhan Region	1	5	4	1
Volgograd Region	1	3	2	3
Rostov Region	1	1	4	4
Sevastopol	-	-	-	-
North Caucasian Federal District	**1**	**5**	**1**	**2**
Republic of Dagestan	1	3	3	4
Republic of Ingushetia	-	-	-	-
Kabardino-Balkarian Republic	1	3	3	1
Karachay-Cherkess Republic	1	2	3	0
Republic of North Ossetia – Alania	1	3	3	1
Chechen Republic	1	6	3	0
Stavropol Region	1	3	2	1
Volga Federal District	**1**	**3**	**3**	**2**
Republic of Bashkortostan	1	2	1	1
Republic of Mari El	1	1	2	5
Republic of Mordovia	1	4	3	1
Republic of Tatarstan (Tatarstan)	3	5	3	0
Republic of Udmurtia	1	0	3	1
Chuvash Republic (Chuvashia)	1	2	3	0
Perm Region	1	2	2	1
Kirov Region	1	3	3	1

Nizhny Novgorod Region	1	6	2	1
Orenburg Region	1	2	2	4
Penza Region	1	2	2	4
Samara Region	1	3	2	0
Saratov Region	1	2	3	2
Ulyanovsk Region	1	4	3	2
Urals Federal District	**3**	**2**	**3**	**1**
Kurgan Region	1	2	2	0
Sverdlovsk Region	1	4	4	2
Tyumen Region	3	1	2	1
Chelyabinsk Region	1	2	3	1
Siberian Federal District	**1**	**1**	**3**	**0**
Republic of Altai	1	1	3	0
Republic of Buryatia	1	2	3	0
Republic of Tuva	1	3	4	2
Republic of Khakassia	1	4	2	2
Altai Region	1	2	3	1
Baikal Region	1	3	2	1
Krasnoyarsk Region	4	2	4	1
Irkutsk Region	1	3	2	0
Kemerovo Region	1	2	4	1
Novosibirsk Region	1	3	2	2
Omsk Region	1	3	3	3
Tomsk Region	1	2	2	0
Far Eastern Federal District	**2**	**3**	**4**	**3**
Republic of Sakha (Yakutia)	2	3	2	2
Kamchatka Region	2	2	2	1
Primorye Territory	1	2	3	1
Khabarovsk Territory	3	4	4	2
Amur Region	1	2	3	0
Magadan Region	3	4	3	2
Sakhalin Region	1	3	3	3
Jewish Autonomous Region	1	3	3	0
Chukotka Autonomous Area	2	2	2	2

Annex 4

**12-month accumulated impulse response of the output
to 1 standard deviation strengthening of the Russian ruble real effective exchange rate (%)
obtained for different orders of shock identification:**

Specification 1 (real effective exchange rate)

	January 2010 – October 2014				March 2015 – December 2019			
	Scheme of shock identification				*Scheme of shock identification*			
	1st scheme	2nd scheme	3rd scheme	4th scheme	1st scheme	2nd scheme	3rd scheme	4th scheme
Russian Federation	0.04	0.04	0.03	0.03	-0.12**	-0.12**	-0.12**	-0.06*
Central Federal District	0.03	0.03	0.05	0.17	-0.33**	-0.33**	-0.34**	-0.17*
North-Western Federal District	0.06	0.06	0.07	0.03	-0.03	-0.03	-0.03	-0.05
Southern Federal District	0.02	0.02	0.02	0.04*	-0.01	-0.01	-0.02	-0.02
North Caucasian Federal District	0.30*	0.30*	0.29*	0.27*	0.00	0.00	0.02	0.02
Volga Federal District	0.37*	0.37*	0.34*	0.17	-0.19	-0.19	-0.22	-0.21
Urals Federal District	-0.02	-0.02	-0.03	-0.02	-0.14	-0.14	-0.15	-0.11
Siberian Federal District	0.28*	0.28*	0.25	0.25*	-0.16	-0.16	-0.16	-0.08
Far Eastern Federal District	-0.21*	-0.21*	-0.24	-0.21	0.31*	0.31*	0.31*	0.30*

* and ** denote statistical significance at 10- and 5% levels, respectively.

Specification 2 (nominal effective exchange rate)

	January 2010 – October 2014				March 2015 – December 2019			
	Scheme of shock identification				*Scheme of shock identification*			
	1st scheme	2nd scheme	3rd scheme	4th scheme	1st scheme	2nd scheme	3rd scheme	4th scheme
Russian Federation	0.06	0.06	0.06	0.05	-0.11**	-0.11**	-0.11**	-0.06*
Central Federal District	0.07	0.07	0.08	0.16	-0.28**	-0.28**	-0.28**	-0.15*
North-Western Federal District	0.10	0.10	0.11	0.05	0.00	0.00	0.00	-0.04
Southern Federal District	0.03	0.03	0.03	0.05*	-0.02	-0.02	-0.02	-0.02
North Caucasian Federal District	0.24	0.24	0.23	0.26*	0.00	0.00	0.00	0.00
Volga Federal District	0.33*	0.33*	0.31	0.14	-0.17	-0.17	-0.20	-0.20
Urals Federal District	-0.02	-0.02	-0.02	-0.03	-0.11	-0.11	-0.12	-0.10
Siberian Federal District	0.31**	0.31**	0.30*	0.26*	-0.15	-0.15	-0.16	-0.09
Far Eastern Federal District	-0.28*	-0.28*	-0.29*	-0.24	0.29*	0.29*	0.29*	0.29*

* and ** denote statistical significance at 10- and 5% levels, respectively.

Specification 3 (real effective exchange rate and dummy variable 'Fiscal Rule period')

	March 2015 – December 2019			
	Scheme of shock identification			
	1st scheme	2nd scheme	3rd scheme	4th scheme
Russian Federation	-0.11*	-0.11*	-0.12*	-0.08
Central Federal District	-0.31**	-0.31**	-0.32**	-0.17*
North-Western Federal District	0.01	0.01	0.01	-0.05
Southern Federal District	-0.02	-0.02	-0.03	-0.03
North Caucasian Federal District	0.00	0.00	0.00	0.00
Volga Federal District	-0.22	-0.22	-0.24	-0.23
Urals Federal District	-0.12	-0.12	-0.13	-0.10
Siberian Federal District	-0.22	-0.22	-0.23	-0.13
Far Eastern Federal District	0.30*	0.30*	0.31*	0.27

* and ** denote statistical significance at 10- and 5% levels, respectively.

Annex 5

12-month accumulated impulse response of the output to 1% strengthening of the Russian ruble real effective exchange rate (%) obtained for various specifications

	January 2010 – October 2014		**March 2015 – December 2019**		
	Specification		*Specification*		
	1	***2***	***1***	***2***	***3***
Russian Federation	0.04	0.06	-0.12**	-0.11**	-0.11*
Central Federal District	0.03	0.07	-0.33**	-0.28**	-0.31**
North-Western Federal District	0.06	0.10	-0.03	0.00	0.01
Southern Federal District	0.02	0.03	-0.01	-0.02	-0.02
North Caucasian Federal District	0.30*	0.24	0.00	0.00	0.00
Volga Federal District	0.37*	0.33*	-0.19	-0.17	-0.22
Urals Federal District	-0.02	-0.02	-0.14	-0.11	-0.12
Siberian Federal District	0.28*	0.31**	-0.16	-0.15	-0.22
Far Eastern Federal District	-0.21*	-0.28*	0.31*	0.29*	0.30*

* and ** denote statistical significance at 10- and 5% levels, respectively.

Annex 6

Accumulated impulse response of the output to strengthening of the Russian ruble exchange rate

1. Values of the output impulse response function to 1% shock of the real effective exchange rate (REER)

Region of Russia	January 2010 – October 2014			March 2015 – December 2019		
	Region's GRP weight in Russian GRP (2010–2014), %	Accumulated impulse response of the output at a 1% strengthening of the Russian ruble exchange rate within 12 months	Statistical significance **p<0.05 *p<0.10	Region's GRP weight in Russian GRP (2015–2018), %	Accumulated impulse response of the output at a 1% strengthening of the Russian ruble exchange rate within 12 months	Statistical significance **p<0.05 *p<0.10
Russian Federation	**100,0**	**0,02**		**100,0**	**-0,05**	**
Central Federal District	**35,4**	**0,02**		**34,6**	**-0,10**	**
Belgorod Region	1,1	0,06		1,0	-0,15	**
Bryansk Region	0,4	0,00		0,4	0,00	
Vladimir Region	0,6	-0,01		0,6	-0,02	
Voronezh Region	1,1	0,04		1,2	0,00	
Ivanovo Region	0,3	0,11		0,3	0,20	*
Kaluga Region	0,5	-0,40		0,5	-0,80	**
Kostroma Region	0,3	0,01		0,2	-0,02	*
Kursk Region	0,5	-0,11		0,5	-0,11	
Lipetsk Region	0,6	0,30	*	0,7	0,08	
Moscow Region	4,7	-0,01		5,0	0,02	
Orel Region	0,3	-0,11		0,3	0,00	
Ryazan Region	0,5	0,33	*	0,5	0,20	*
Smolensk Region	0,4	0,00		0,4	-0,11	
Tambov Region	0,4	0,20		0,4	0,08	
Tver Region	0,6	0,11		0,5	-0,10	*
Tula Region	0,6	0,53		0,7	-0,30	*
Yaroslavl Region	0,7	-0,05		0,7	-0,10	
Moscow	21,8	-0,07		20,8	-0,16	**
North-Western Federal District	**10,3**	**0,03**		**10,9**	**-0,01**	
Republic of Karelia	0,3	-0,20		0,3	0,00	
Republic of Komi	0,9	-0,26		0,8	-0,17	**
Arkhangelsk Region	0,9	-0,05		1,0	0,15	
Vologda Region	0,7	-0,16		0,7	-0,20	*

Kaliningrad Region	0,5	0,11		0,5	0,05	
Leningrad Region	1,3	-0,20		1,3	-0,04	
Murmansk Region	0,6	0,00		0,6	-0,04	
Novgorod Region	0,3	-0,05		0,3	-0,20	*
Pskov Region	0,2	-0,05		0,2	0,05	
St Petersburg	4,6	0,04		5,1	-0,02	
Southern Federal District	6,3	0,01		7,1	0,00	
Republic of Adygeya	0,1	-0,11		0,1	-0,04	
Republic of Kalmykia	0,1	0,50		0,1	-0,60	
Republic of Crimea	-	-		0,5	-	
Krasnodar Region	2,9	0,00		2,9	-0,01	*
Astrakhan Region	0,4	0,05		0,6	-0,04	
Volgograd Region	1,1	0,20	*	1,1	-0,08	*
Rostov Region	1,7	0,26		1,8	0,05	**
Sevastopol	-	-		0,1	-	
North Caucasian Federal District	**2,5**	**0,16**	*****	**2,5**	**0,00**	
Republic of Dagestan	0,8	0,40		0,8	0,15	
Republic of Ingushetia	0,1	-		0,1	-	
Kabardino-Balkarian Republic	0,2	-0,11		0,2	-0,23	
Karachay-Cherkess Republic	0,1	0,69		0,1	-0,08	
Republic of North Ossetia – Alania	0,2	-0,32		0,2	0,04	
Chechen Republic	0,2	2,40	*	0,2	0,15	
Stavropol Region	0,9	0,36	*	0,9	-0,23	
Volga Federal District	**15,5**	**0,15**	*****	**15,0**	**-0,07**	
Republic of Bashkortostan	2,1	-0,02		2,0	-0,03	
Republic of Mari El	0,2	-0,16		0,2	-0,04	
Republic of Mordovia	0,3	0,00		0,3	0,30	*
Republic of Tatarstan (Tatarstan)	2,8	0,13		2,9	0,10	*
Republic of Udmurtia	0,7	0,05		0,8	-0,40	*
Chuvash Republic (Chuvashia)	0,4	0,15		0,4	-0,08	
Perm Region	1,7	-0,05		1,6	0,11	*
Kirov Region	0,4	-0,06		0,4	-0,16	*
Nizhny Novgorod Region	1,7	0,06		1,7	-0,01	
Orenburg Region	1,2	0,01		1,2	-0,08	

Penza Region	0,5	-0,01		0,5	-0,03	
Samara Region	1,9	0,20		1,8	-0,10	
Saratov Region	1,0	0,20		0,9	-0,08	
Ulyanovsk Region	0,5	0,21		0,5	-0,02	
Urals Federal District	13,9	-0,01		14,2	-0,05	
Kurgan Region	0,3	0,00		0,3	-0,08	
Sverdlovsk Region	2,9	0,13		2,8	-0,04	
Tyumen Region	9,1	-0,01		9,3	-0,01	*
Chelyabinsk Region	1,7	0,12		1,8	-0,04	
Siberian Federal District	**10,5**	**0,14**	*	**10,4**	**-0,06**	
Republic of Altai	0,1	-0,02		0,1	0,04	*
Republic of Buryatia	0,3	-0,26		0,3	0,11	
Republic of Tuva	0,1	0,09		0,1	0,20	*
Republic of Khakassia	0,3	0,37		0,3	-0,08	
Altai Region	0,8	0,09		0,7	0,07	
Baikal Region	0,4	0,07		0,4	-0,07	
Krasnoyarsk Region	2,5	-0,01		2,6	0,00	
Irkutsk Region	1,5	0,21		1,6	-0,11	
Kemerovo Region	1,5	0,21		1,4	0,11	
Novosibirsk Region	1,4	0,01		1,5	0,00	
Omsk Region	1,0	-0,01		0,9	0,05	
Tomsk Region	0,7	0,13		0,7	0,07	
Far Eastern Federal District	**5,5**	**-0,11**	*	**5,4**	**0,11**	*
Republic of Sakha (Yakutia)	1,0	-0,01		1,2	-0,02	**
Kamchatka Region	0,2	-0,70	**	0,3	0,19	
Primorye Territory	1,1	0,69		1,1	0,26	
Khabarovsk Territory	0,9	0,09	*	0,9	0,02	
Amur Region	0,5	-0,21		0,4	-0,08	
Magadan Region	0,2	0,05		0,2	0,04	
Sakhalin Region	1,3	-0,58		1,2	0,08	
Jewish Autonomous Region	0,1	0,05		0,1	0,04	
Chukotka Autonomous Area	0,1	-1,80	*	0,1	-0,49	

2. Values of the output impulse response function at 1% shock of the nominal effective exchange rate (NEER)

Region of Russia	Jan 2010 – Oct 2014			Mar 2015 – Dec 2019		
	Region's GRP weight in Russian GRP (2010–2014), %	Accumulated impulse response of the output at a 1% strengthening of the Russian ruble exchange rate within 12 months	Statistical significance **p<0.05 *p<0.10	Region's GRP weight in Russian GRP (2015–2018), %	Accumulated impulse response of the output at a 1% strengthening of the Russian ruble exchange rate within 12 months	Statistical significance **p<0.05 *p<0.10
Russian Federation	100,0	0,03		100,0	-0,04	**
Central Federal District	35,4	0,04		34,6	-0,09	**
Belgorod Region	1,1	0,06		1,0	-0,14	**
Bryansk Region	0,4	0,00		0,4	0,00	
Vladimir Region	0,6	-0,02		0,6	-0,01	
Voronezh Region	1,1	0,02		1,2	0,00	
Ivanovo Region	0,3	0,22		0,3	0,20	*
Kaluga Region	0,5	-0,28		0,5	-0,80	*
Kostroma Region	0,3	0,02		0,2	-0,02	*
Kursk Region	0,5	-0,17		0,5	-0,07	
Lipetsk Region	0,6	0,28	*	0,7	0,07	
Moscow Region	4,7	-0,01		5,0	0,03	
Orel Region	0,3	-0,06		0,3	0,00	
Ryazan Region	0,5	0,32	*	0,5	0,20	*
Smolensk Region	0,4	0,03		0,4	-0,08	
Tambov Region	0,4	0,18		0,4	0,07	
Tver Region	0,6	0,11		0,5	-0,10	*
Tula Region	0,6	0,45		0,7	-0,30	*
Yaroslavl Region	0,7	-0,06		0,7	-0,11	
Moscow	21,8	-0,04		20,8	-0,15	**
North-Western Federal District	10,3	0,06		10,9	0,00	
Republic of Karelia	0,3	-0,17		0,3	0,00	
Republic of Komi	0,9	-0,17		0,8	-0,16	**
Arkhangelsk Region	0,9	-0,11		1,0	0,11	
Vologda Region	0,7	-0,28		0,7	-0,20	*
Kaliningrad Region	0,5	0,06		0,5	0,06	

Leningrad Region	1,3	-0,11		1,3	-0,04	
Murmansk Region	0,6	0,06		0,6	-0,04	
Novgorod Region	0,3	-0,06		0,3	-0,20	*
Pskov Region	0,2	-0,06		0,2	0,04	
St Petersburg	4,6	0,10		5,1	0,01	
Southern Federal District	6,3	0,02		7,1	-0,01	
Republic of Adygeya	0,1	-0,11		0,1	0,00	
Republic of Kalmykia	0,1	0,89		0,1	-0,67	
Republic of Crimea	-	-		0,5	-	
Krasnodar Region	2,9	0,00		2,9	-0,01	*
Astrakhan Region	0,4	0,06		0,6	0,04	
Volgograd Region	1,1	0,23	*	1,1	-0,08	*
Rostov Region	1,7	0,28		1,8	0,05	**
Sevastopol	-	-		0,1	-	
North Caucasian Federal District	2,5	0,13		2,5	0,00	
Republic of Dagestan	0,8	0,22		0,8	0,14	
Republic of Ingushetia	0,1	-		0,1	-	
Kabardino-Balkarian Republic	0,2	-0,06		0,2	-0,18	
Karachay-Cherkess Republic	0,1	0,89		0,1	-0,04	
Republic of North Ossetia – Alania	0,2	-0,28		0,2	0,07	
Chechen Republic	0,2	2,70	*	0,2	0,14	
Stavropol Region	0,9	0,34		0,9	-0,18	
Volga Federal District	15,5	0,15	*	15,0	-0,06	
Republic of Bashkortostan	2,1	-0,02		2,0	-0,03	
Republic of Mari El	0,2	-0,39		0,2	-0,04	
Republic of Mordovia	0,3	0,11		0,3	0,30	*
Republic of Tatarstan (Tatarstan)	2,8	0,19		2,9	0,10	*
Republic of Udmurtia	0,7	0,06		0,8	-0,30	*
Chuvash Republic (Chuvashia)	0,4	0,17		0,4	-0,07	
Perm Region	1,7	-0,06		1,6	0,13	**
Kirov Region	0,4	-0,03		0,4	-0,16	*
Nizhny Novgorod Region	1,7	0,03		1,7	0,00	
Orenburg Region	1,2	0,03		1,2	-0,07	
Penza Region	0,5	-0,01		0,5	-0,03	

Samara Region	1,9	0,11		1,8	-0,08	
Saratov Region	1,0	0,22		0,9	-0,07	
Ulyanovsk Region	0,5	0,22		0,5	-0,01	
Urals Federal District	13,9	-0,01		14,2	-0,04	
Kurgan Region	0,3	-0,06		0,3	-0,07	
Sverdlovsk Region	2,9	0,13		2,8	-0,03	
Tyumen Region	9,1	-0,01		9,3	-0,01	*
Chelyabinsk Region	1,7	0,15		1,8	0,00	
Siberian Federal District	10,5	0,16	**	10,4	-0,06	
Republic of Altai	0,1	-0,01		0,1	0,04	**
Republic of Buryatia	0,3	-0,34		0,3	0,11	
Republic of Tuva	0,1	0,09		0,1	0,20	*
Republic of Khakassia	0,3	0,34		0,3	-0,07	
Altai Region	0,8	0,12		0,7	0,06	
Baikal Region	0,4	0,09		0,4	-0,06	
Krasnoyarsk Region	2,5	-0,02		2,6	0,04	
Irkutsk Region	1,5	0,28		1,6	-0,11	
Kemerovo Region	1,5	0,28		1,4	0,08	
Novosibirsk Region	1,4	0,01		1,5	0,00	
Omsk Region	1,0	0,01		0,9	0,05	
Tomsk Region	0,7	0,12		0,7	0,05	
Far Eastern Federal District	5,5	-0,15	*	5,4	0,10	*
Republic of Sakha (Yakutia)	1,0	-0,01		1,2	-0,02	*
Kamchatka Region	0,2	-0,80	*	0,3	0,14	
Primorye Territory	1,1	0,61		1,1	0,21	
Khabarovsk Territory	0,9	0,11	*	0,9	0,01	*
Amur Region	0,5	-0,11		0,4	-0,07	
Magadan Region	0,2	0,28		0,2	0,04	
Sakhalin Region	1,3	-0,73	*	1,2	0,07	
Jewish Autonomous Region	0,1	0,06		0,1	0,04	
Chukotka Autonomous Area	0,1	-2,20	*	0,1	-0,30	

Annex 7

Russia's Top Export Products
broken down by federal districts for the period of 2016–2019, according to Federal Customs Service of Russia*

	Central Federal District	North-Western Federal District	Southern Federal District	North Caucasian Federal District	Volga Federal District	Urals Federal District	Siberian Federal District	Far Eastern Federal District
FEACN code, short description of the name	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)	Share in Federal District export (%)
0302-0304 Fish	0.0	0.6	0.1	0.1	0.0	0.0	0.0	5.6
1001 Wheat	1.4	1.2	37.5	27.7	0.3	0.1	0.3	0.1
1512 Sunflower-seed oil	0.2	0.3	7.9	1.4	1.4	0.1	0.1	0.0
2208 Ethyl alcohol	0.0	0.2	0.0	0.1	0.0	0.0	0.1	0.0
2510 Calcium phosphates	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0
2601 Iron ore	0.3	1.2	0.0	0.0	0.6	0.1	0.0	0.4
2701 Coal	0.2	0.0	1.5	0.0	0.2	0.0	41.4	6.5
2704 Coke and semi-coke	0.0	0.0	0.0	0.0	0.0	0.1	1.1	0.0
2709 Crude oil	49.5	29.6	0.1	0.0	27.3	66.1	9.8	55.1
2710 Oil products	21.6	42.4	47.0	2.8	42.2	15.9	4.8	5.0
2711 Gas	22.2	0.3	0.3	2.0	1.5	4.7	0.1	20.8
2716 Electrical energy	0.3	0.0	0.1	0.1	0.0	0.0	0.0	0.9
2814 Ammonia	0.1	0.5	0.0	0.6	3.6	0.0	0.0	0.0
2905 Acyclic alcohols	0.1	0.0	0.0	0.1	0.6	0.0	0.0	0.0
3102 Nitrogenous fertilisers	0.4	2.2	0.1	44.8	2.9	0.1	0.8	0.0
3104 Potassic fertilisers	0.0	0.0	0.0	0.0	8.2	0.0	0.1	0.0
3105 Mineral fertilisers containing several fertilising elements	0.3	4.8	1.1	15.6	1.8	0.0	0.0	0.0
4002 Synthetic rubber	0.2	0.0	0.0	0.0	4.5	0.1	0.4	0.0
4403 Unprocessed timber	0.0	0.6	0.0	0.0	0.1	0.0	1.6	2.6
4407 Processed timber	0.1	3.2	0.6	0.7	0.4	0.4	8.3	2.2
4412 Plywood	0.1	1.1	0.0	0.0	0.8	0.3	0.1	0.0
4703-4704 Chemical wood pulp	0.0	0.5	0.0	0.0	0.0	0.0	2.3	0.0

4801 Newspaper	0.0	0.7	0.0	0.0	0.6	0.0	0.0	0.0
5208-5212 Woven fabrics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7201 Cast iron	0.4	0.0	0.0	0.0	1.9	0.2	0.0	0.0
7202 Ferro-alloys	0.1	0.2	0.0	0.0	0.1	1.4	1.3	0.0
7207 Semi-finished iron and steel products	1.6	0.4	2.8	3.5	0.1	2.0	4.4	0.6
7208-7212 Flat-rolled iron and steel products	0.5	3.5	0.1	0.1	0.2	4.6	0.0	0.0
7403 Copper	0.0	1.2	0.0	0.0	0.0	3.5	7.0	0.0
7502 Nickle	0.0	3.1	0.0	0.0	0.0	0.1	2.1	0.0
7601 Aluminium	0.1	0.1	0.5	0.0	0.4	0.1	13.7	0.2
8703 Cars	0.2	0.4	0.0	0.1	0.4	0.0	0.0	0.0
Grand total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

*The Federal Customs Service of Russia keeps records of export transactions at the place of registration of exporting legal entities.

Annex 8

Structure of the gross regional product in accordance with the All-Russian Classifier of Economic Activities (OKVED) 2, average value of indicators in 2016–2018, %

	Russia	Central Federal District	North-Western Federal District	Southern Federal District	North Caucasian Federal District	Volga Federal District	Urals Federal District	Siberian Federal District	Far Eastern Federal District
Agriculture, forestry, and fishing	4.6	3.1	3.1	10.7	15.6	6.6	1.9	4.8	5.9
Mining and quarrying	12.6	0.7	7.2	5.0	0.7	13.9	39.2	18.6	28.0
Manufacturing	17.5	17.6	20.0	15.0	9.3	24.1	13.8	20.8	5.6
Supply of electricity, gas and steam	3.3	3.4	3.2	3.1	3.1	3.4	2.8	4.1	3.8
Wholesale and retail trade	16.5	25.0	13.8	16.0	18.8	12.2	8.7	10.2	10.6
Construction	6.2	4.9	6.2	7.4	11.5	6.5	7.8	5.1	6.7
Transport and storage	7.9	6.9	10.7	10.8	5.8	6.2	6.8	8.4	12.2
Real estate activities	6.3	9.2	7.5	6.1	2.7	4.5	3.3	4.9	3.2
Activities of hotels and catering establishments	1.1	0.9	1.1	2.2	3.2	1.0	0.7	0.8	1.1
Information and communication activities	3.0	4.7	3.2	2.2	2.1	2.3	1.2	2.0	1.6
Professional, scientific, and technical activities	4.4	6.8	4.8	2.7	1.3	3.5	2.6	2.9	1.7
Administrative activities	2.5	2.8	3.1	2.3	1.0	1.9	2.5	2.5	1.9
Public administration and military security, social security	4.7	4.7	4.5	5.5	9.6	4.3	2.8	5.1	7.0
Education	3.0	2.6	3.3	3.4	6.1	3.3	2.1	3.6	3.9
Healthcare	4.0	3.4	5.2	4.9	7.0	4.0	2.7	4.3	4.8
Other	2.4	3.3	3.1	2.7	2.2	2.3	1.1	1.9	2.0

Sources: Rosstat, author's calculations.

Annex 9

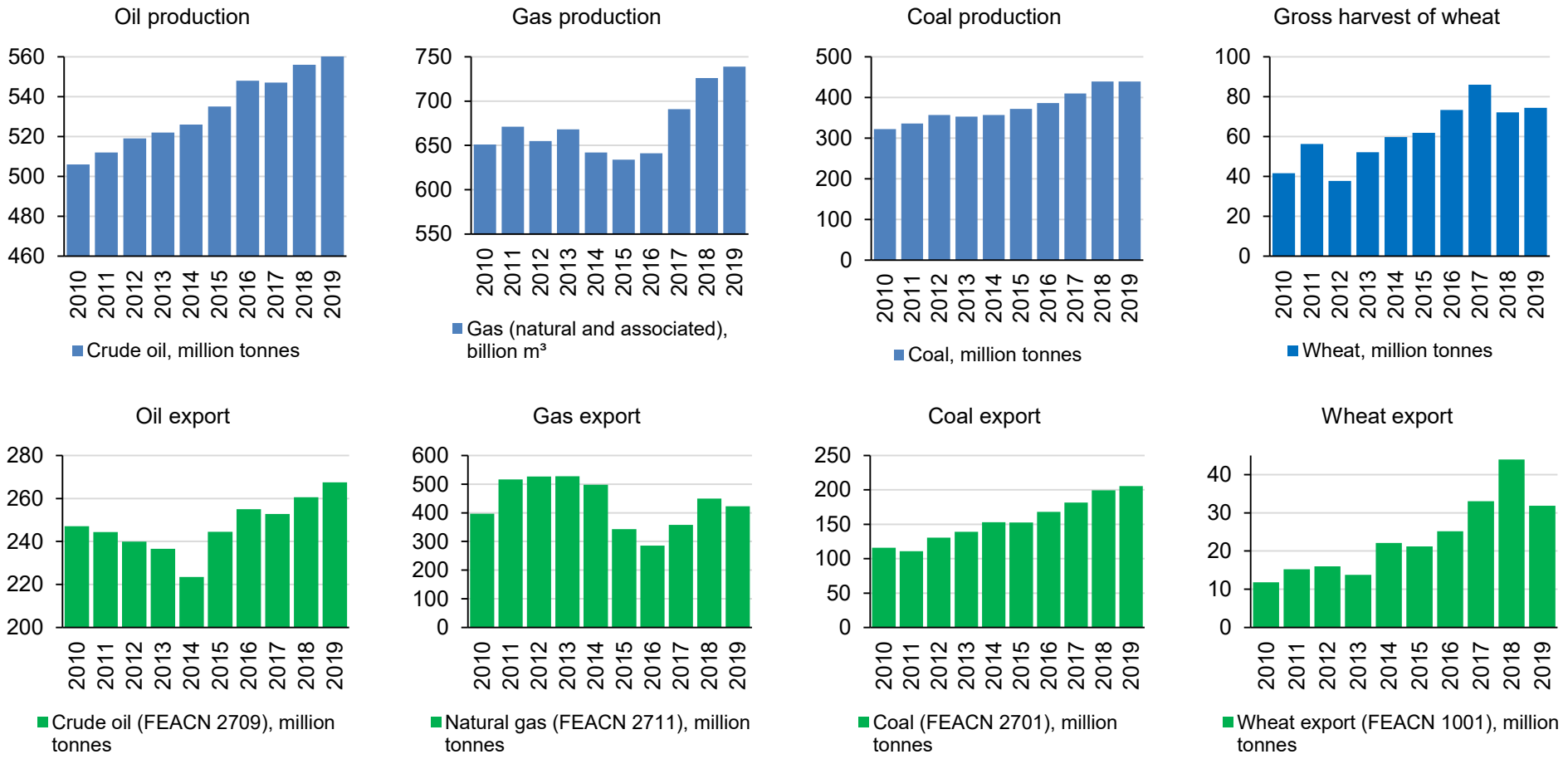
Indexes of physical volume of gross regional product of Russia's federal districts, %

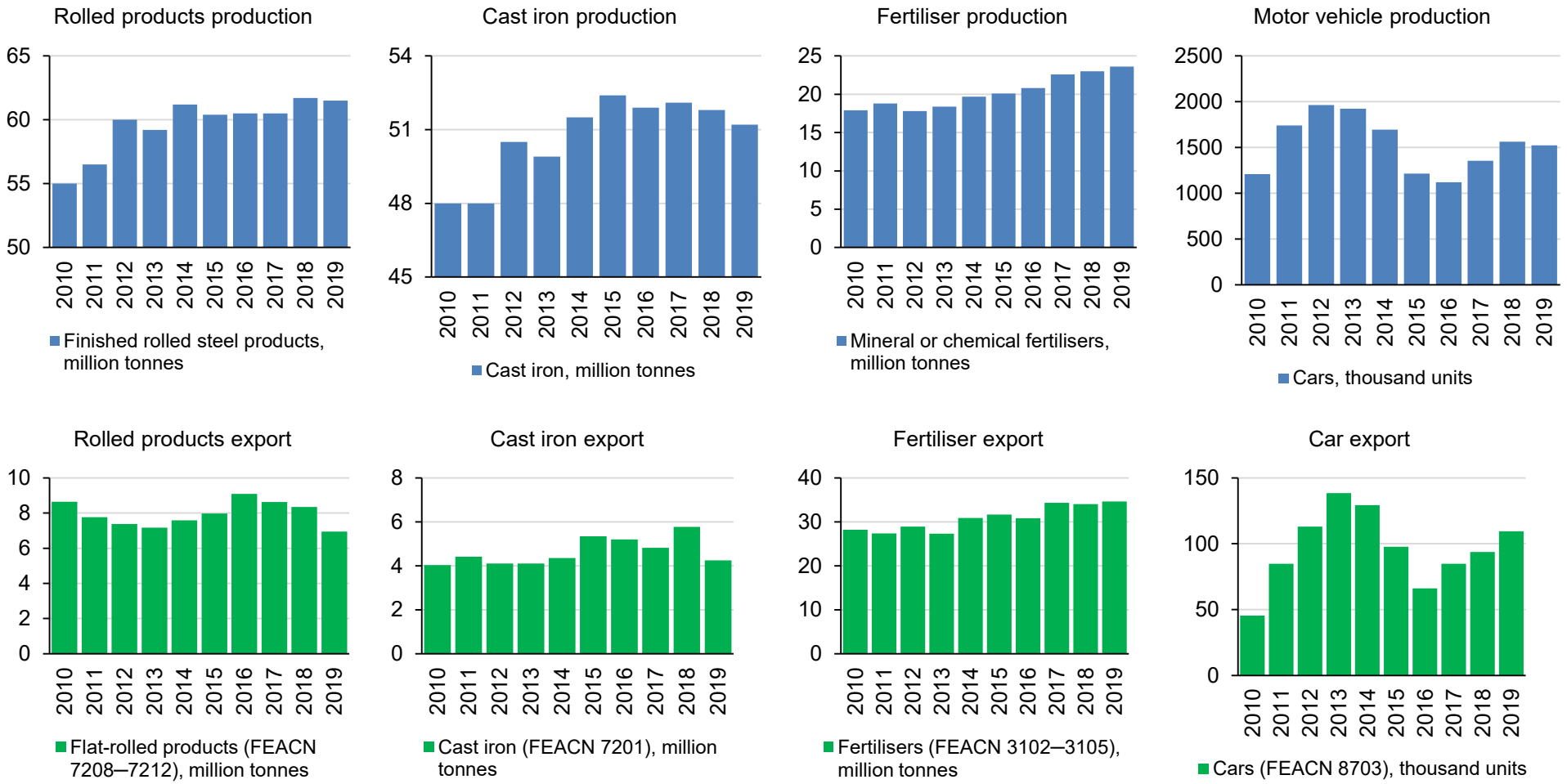
Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total	104.6	105.4	103.1	101.8	101.3	99.4	100.8	101.9	102.8	101.6
Central Federal District	103.0	104.8	103.7	101.6	100.8	99.3	101.3	101.9	102.8	101.8
North-Western Federal District	104.4	106.1	103.8	100.3	100.9	101.5	101.7	100.9	102.4	101.7
Southern Federal District	105.4	106.5	103.7	104.0	102.1	99.5	101.3	103.3	101.7	101.2
North Caucasian Federal District	103.5	106.5	103.4	103.6	104.6	99.8	100.9	101.5	100.8	101.7
Volga Federal District	105.5	106.8	104.1	102.4	102.0	98.7	100.0	101.5	101.8	102.0
Urals Federal District	106.8	104.6	101.5	102.2	99.0	98.8	100.3	103.0	105.2	100.7
Siberian Federal District	104.5	105.0	103.1	102.4	102.1	98.8	100.5	102.4	102.4	101.2
Far Eastern Federal District	106.3	105.4	98.9	99.1	101.1	100.5	99.9	100.1	103.4	103.0

Source: Rosstat.

Annex 10

Production and export of certain physical commodities in Russia in 2010–2019





Source: Rosstat.