Macroeconomic Modeling of the Russian Economy under Uncertainty

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Abstract: Within the framework of this article, macroeconomic modeling of the Russian economy is carried out under conditions of uncertainty. The spread of the new coronavirus infection and the introduction of appropriate protective restrictive measures, as expected, led to a recession in the world economy and the economy of Russia. If earlier the determining factor of Russia's economic growth was the conjuncture of the world fuel and energy market, now, in the current restrictive conditions, the problem of changing the development paradigm has become especially acute. This fact and other conditions that form a single system of interconnected factors are reflected in the developed structural econometric model of the Russian Federation. By combining possible options for changing the exogenous factors of the model under consideration based on the scenarios proposed by the Ministry of Economic Development of the Russian Federation (MED of the Russian Federation), a medium-term scenario forecast of the main socio-economic factors until 2023 was made.

Keywords: structural econometric model; macroeconomic model of Russia; socio-economic forecast.

INTRODUCTION

Many scientific works of Russian researchers are devoted to the issue of econometric modeling of the Russian economy. Among them, one should especially highlight the scientific work of the team of authors, i.e. M. Turuntseva, A. Yudin, S. Drobyshevsky, P. Kadochnikov, S. Ponomorenko, P. Trunin. In their work 'Some approaches to forecasting economic indicators' (Turuntseva et al., 2005), the authors considered an econometric model of scenario forecasts of the main macroeconomic indicators of the Russian Federation. The results of calculations of predicted values based on two scenarios are presented. It is also necessary to highlight the work of S.A. Ayvazyan and B.E. Brodsky (2006), who outlined in their article the approach of macro-econometric modeling of the Russian economy.

However, it should be noted that the predictive models described in the framework of these scientific works describe the state of the Russian economy in the conditions that took place in the early 2000s. Since that time, there has been a certain qualitative structural shift. Along with the factors that existed at that time, other factors came into force, determining the current socio-economic agenda.

This fact confirms the practical necessity and validity of research and development based on this study of an updated econometric model that most fully and reliably describes modern economic processes and has a fairly accurate predictive ability in the medium-term time horizon.

METHODS

The development of the econometric model was carried out by applying the method of correlation - regression analysis in several successive stages.

At the first stage, a list of socio-economic indicators was formed, united in general groups (Table 1). To take into account, the inertial nature of economic development, lagged values are also considered for some indicators.

Table 1: Main macroeconomic factors of the Russian Federation

Index group	Index	Unit	Symbol	Data source
National accounts	Gross Domestic Product (GDP) in prices of 2016	Ruble	GDP	Federal State Statistics Service of the Russian

	Gross domestic product in prices of 2016, recalculated at the current nominal USD / RUB exchange rate	USD	GDPE	Federation
Commodities	The cost of a barrel of Urals oil	USD	Urals	International investment platform Investing.com
	The cost of a barrel of Urals oil with a lag in one period		Urals1	
Consumer prices	Consumer price index	% to the same period of the previous year (SPPY)	CPI	Federal State Statistics Service of the Russian Federation
	Consumer price index with a lag in one period		CPI1	
Money turnover	Money supply (M2 unit)	Ruble	M2	Central Bank of the Russian Federation
	The ratio of the aggregate M2 with a lag in one period to the volume of GDP in prices of 2016, recalculated at the current nominal exchange rate of the US dollar to the ruble (specification of the economy monetization coefficient)	%	M21GDP_E	
Investment activity	Fixed investment at constant prices	Ruble	Inv	Federal State Statistics Service of the Russian Federation
	Fixed capital investments at basic prices with a lag in one period		Inv1	
Exchange rate and its derivatives	Average nominal USD / RUB exchange rate	Ruble	E	Central Bank of the Russian Federation
	Average nominal USD / RUB exchange rate with a lag in one period		E1	
	Index of the real effective exchange rate of the ruble against foreign currencies	SPPY	R	
	Index of the real effective exchange rate of the ruble against foreign currencies with a lag in one period		R1	
	Index of the real effective exchange rate of the ruble against foreign currencies with a lag in two periods		R2	
	Average nominal EUR / USD exchange rate	USD	Dlr_Eur	International investment platform Investing.com
Public finance	International reserves of the Russian Federation	USD	Res	Central Bank of the Russian Federation
	International reserves of the Russian Federation with a lag of four periods		Res4	
	Consolidated budget revenues of the Russian Federation	Ruble	Tax	Ministry of Finance of the Russian Federation
	Revenues of the consolidated budget of the Russian Federation with a lag of four		Tax4	

	periods			
	Share of RF consolidated budget revenues in GDP in prices of 2016	%	TaxGDP	
Foreign trade (customs statistics)	Export volume	USD	Ex	Federal Customs Service of the Russian Federation
	Export volume with a lag in one period		Ex1	
	Import volume		Im	
Domestic trade	Retail turnover at constant prices	Ruble	Trade	Federal State Statistics Service of the Russian Federation
	Retail turnover at constant prices with a two-period lag		Trade2	
Labor market	Unemployment rate	% of the economically active population	U	Federal State Statistics Service of the Russian Federation
	Unemployment rate lagged in one period		U1	
	Unemployment rate lagged in two periods		U2	
Standards of living	Real disposable income of the population	SPPY %	Inc	Federal State Statistics Service of the Russian Federation
	Real disposable income of the population with a lag in one period		Inc1	
Industrial production	Industrial production index	SPPY %	Ind	Federal State Statistics Service of the Russian Federation
	Industrial production index with a lag in one period		Ind1	
Epidemiological situation	COVID - factor	'1' - has an effect; '0' - does not affect	COVID	Ministry of Economic Development of the Russian Federation

For the selected indicators, statistical samples were formed from 2013 to 2020 on a quarterly basis. The selected indicators are presented in dynamics (in% to the same period of the previous year), with the exception of COVID, a factor reflecting the impact of the coronavirus pandemic on the economy and representing a dichotomous variable.

At the next stage, a correlation analysis of the selected factors was carried out. The result is shown in Figure 1. Dark red background means a close direct relationship, dark blue - a close feedback, white background - no statistically significant relationship.

Using the obtained results of the correlation analysis, as well as based on the a priori assumption about the cause-and-effect relationships of the factors under study, a structural interaction scheme was obtained (Figure 2), which formed the basis of the econometric model of the Russian economy.
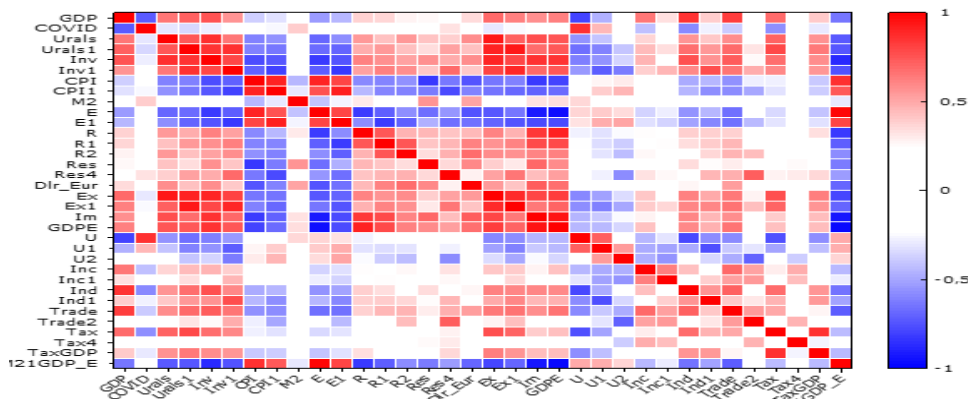

Fig.1: Correlation matrix plot of selected macroeconomic factors

The model is a system of simultaneous regression equations. The model is a system of an open cycle, consisting of external (exogenous) factors and internal (endogenous), which form a chain of interrelated factors.

The following were selected as exogenous factors (in the figure, they are circled in ovals):

- The price of Urals oil;
- Money supply M2;
- A factor of influence on the economy of the coronavirus pandemic (COVID);
- The nominal exchange rate of the US dollar against the euro.

The system of equations was evaluated jointly in the Gretl econometric package using the two-step least squares method. The obtained equations are characterized by high statistical significance (significance level not less than 5%).
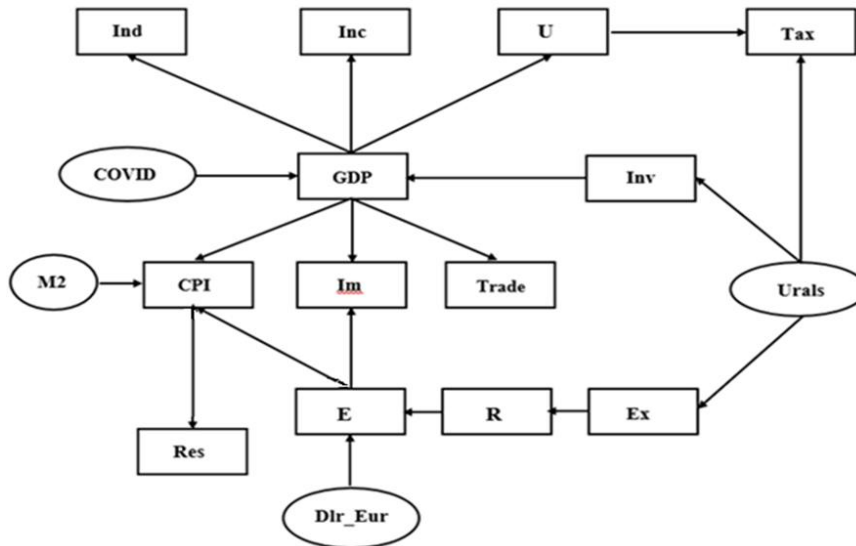

Fig.2: The causal scheme of the interaction of factors in the macroeconomic model of Russia

In conclusion, combining options for changing the exogenous parameters of the model, a scenario forecast of socio - economic factors up to 2023 was made. The scenarios of economic development of the Ministry of Economic Development of the Russian Federation (2020) were taken as a basis.

The forecast is made in two scenarios: baseline and conservative. Both scenarios are based on the fact that sanitary and epidemiological restrictions are removed gradually and unevenly across regions, depending on the epidemiological situation and the capacity of the healthcare system. Despite the existing risks, it is assumed that the impact of the pandemic on the economy will gradually weaken. In terms of the econometric model, this means that the exogenous variable COVID - factor takes the value '0', starting from the first quarter of 2021.

Differentiation of forecast parameters in the framework of the selected scenarios consists in different dynamics of world oil prices, the exchange rate of the US dollar against the euro, and the money supply. The baseline scenario, in contrast to the conservative one, assumes a more favorable background for the initial parameters of the economy (Table 2).

Table 2: Scenarios for the development of exogenous factors of the macroeconomic model of Russia until 2023

Index	Scenarios	2019	2020	2021	2022	2023
		fact	estimation	forecast		
Average annual prices for Urals oil, USD / bbl	Base	63.8	40.4	45.3	46.6	47.5
	Conservative			43.3	44.1	45
Average annual euro exchange rate, USD	Base	1.12	1.15	1.18	1.20	1.21
	Conservative			1.18	1.19	1.20
Money Supply (M2 Unit),% YoY Growth	Base[2]	9.7	8.6	10	9	9
	Conservative[3]			8	8	8

Below is a description of the main equations of the model, as well as the forecast of the simulated indicators for 2021 and 2023.under the conditions of the two considered scenarios.

RESULTS

Fixed capital investment

Within the framework of the correlation analysis, a direct close relationship was established between the dynamics of oil prices and real investments in fixed assets (the correlation coefficient was about 0.86). Favorable external economic conditions in the form of high prices for energy resources and, in particular, oil prices in the medium term have always been one of the main factors of economic growth, regardless of the nature of the growth itself.

Since Russian exports are largely raw materials, the rise in resource prices directly leads to an increase in income from foreign trade. Russian companies in the oil and gas industry accumulate significant profits. Tax revenues to the state budget are increasing due to the high tax burden on the industry and increasingly growing as world prices for energy resources rise. All this together leads to an expansion of opportunities for increasing investment activity both on the part of the private (or partially private) and on the part of the public sector.

The model specification presented below (Figure 3) reflects the medium-term impact of changes in the price of Urals oil on the dynamics of real investments in fixed assets. The normalized R^2 of the presented model is about 0.82.

Figure 4 shows the forecast for the growth rates of real investments in fixed assets for 2021, 2022 and 2023. According to the conservative scenario, the obtained estimate of the average annual investment growth rates at the end of 2021 is about 101.5%, in 2022, and 2023 will be about 101.1%. According to a more optimistic scenario (baseline), the average annual growth rates in 2021 will be 102.2%, in 2022 and 2023 - 101.4 and 101.2%, respectively.

```
Модель  : 2МНК, использованы наблюдения 2013:1-2020:3 (T = 31)
Зависимая переменная: Inv
Инструменты: const COVID M2 Dlr_Eur Urals Inv1 U1 U2
   Inc1 Ind1 Trade2 Ex1 R1 R2 Urals1 Tax4 CPI1 Res4


                Коэффициент   Ст. ошибка   t-статистика   P-значение
        ----------------------------------------------------------------
   const        49,6893       9,19573        5,404        9,21e-06  ***
   Urals        0,105522      0,0177709      5,938        2,16e-06  ***
   Inv1         0,402353      0,101617       3,959        0,0005    ***

Среднее зав. перемен     99,81935    Ст. откл. зав. перемен   5,287874
Сумма кв. остатков       141,0817    Ст. ошибка модели        2,244690
R-квадрат                0,831815    Испр. R-квадрат          0,819802
F(2, 28)                 69,24167    P-значение (F)           1,45e-11
Лог. правдоподобие       -67,47505   Крит. Акаике             140,9501
Крит. Шварца             145,2521    Крит. Хеннана-Куинна     142,3524
Параметр rho             -0,160356   Стат. Дарбина-Вотсона    2,282945
```

Fig.3: Regression model of the dynamics of the real volume of investments in fixed assets in Russia

Модель: 2 МНК, использованы наблюдения Model: 2 international corporations, observations used
Зависимая переменная: Dependent variable:
Инструменты: Tools:
Коэффициент Coefficient Ст. ошибка Standard mistake t-статистика t-statistics P- значение P- value
Среднее зав. Перемен Average variable
Сумма кв. остатков Amount of sq. leftovers
R-квадрат R-square
Лог. Правдоподобие Logical plausibility
Крит. Шварца Schwarz criterion
Параметр rho Rho parameter
Ст. откл. зав. Перемен Standard deviation of variables
Ст. ошибка модели Model standard error
Испр. R- квадрат Corrected R-square
P- значение (F) P-value (F)
Крит. Акаике Akaike criterion
Крит. Хеннана-Куинна Hennan-Quinn test
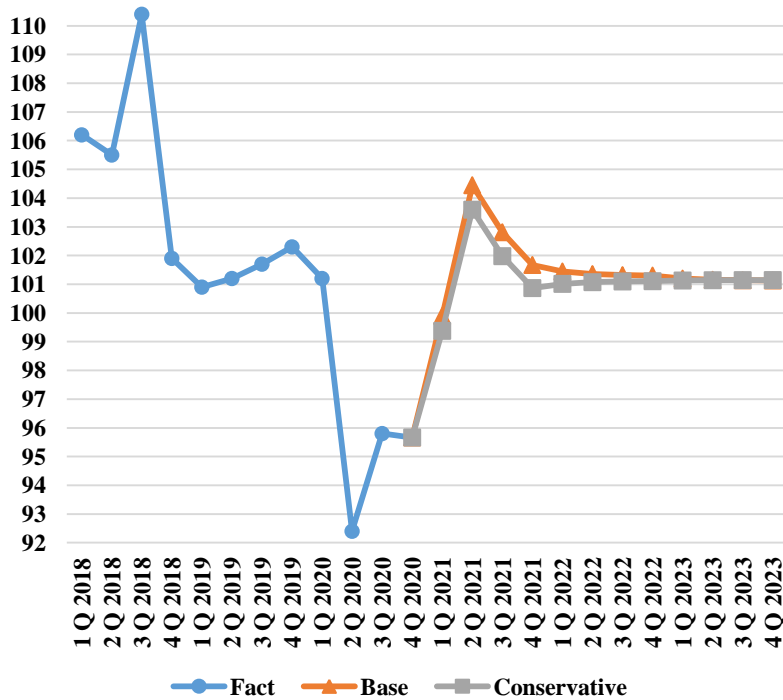Стат. Дарбина-Вотсона Stat. Darbin-Watson

Fig.4: Scenario forecast of the dynamics of real investments in fixed assets, in% to SPPY

Gross domestic product

Modeling of the medium-term dynamics of GDP was carried out based on the prerequisites for the impact on economic activity in Russia of the dynamics of real investments in fixed assets and the impact of restrictions imposed on the Russian economy in connection with the spread of the new coronavirus infection. The normalized R^2 of the presented model of real GDP dynamics (Figure 5) is about 0.85.

Figure 6 shows the forecast for real GDP growth rates for the period 2021-2023. According to the conservative scenario, the average annual GDP growth rate in real terms at the end of 2021 will be about 101.2%, in 2022 - 2023 - 101.1% According to the baseline scenario, the average annual GDP growth rate in 2021 will be 101.4%, in 2022 - 2023 - 101.2%. Slightly higher GDP growth rates in the second scenario are explained by higher investment growth rates.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: GDP
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

Coefficient Standard mistake t-statistics P- value
----
const   75,4431   3,37416   22,36   2,14e-019 ***
COVID   −5,06001   0,695495   −7,275   6,40e-08   ***
Inv   0,254255   0,0336275   7,561   3,09e-08   ***

Average variable   100,4962   Standard deviation of variables 2,264459
Amount of sq. leftovers 23,12605 Model standard error   0,908807
R-square   0,849677   Corrected R-square   0,838940

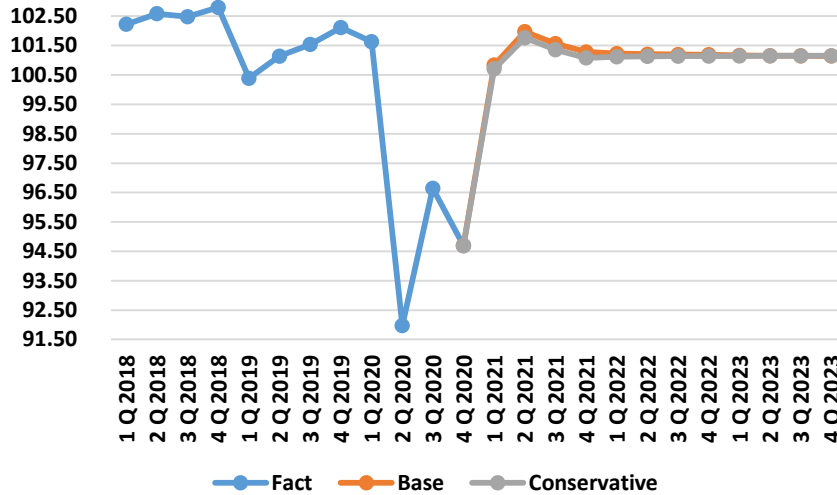**Fig.5: Regression model of the dynamics of real GDP in Russia**

Fig.6: Scenario forecast of real GDP dynamics in Russia, % to SPPY

Real income of the population

Modeling the medium-term dynamics of real disposable incomes of the population was based on the assumption that in the medium-term there is a relationship between the growth rates of real incomes of the population and GDP as the main indicator of economic activity. The normalized R^2 for the equation is about 0.57.

According to the basic version of the forecast, which assumes somewhat more favorable economic activity, the average growth rate of real money incomes of the population turns out to be 0.1 - 0.2 percentage points higher in annual terms than in the conservative forecast. At the same time, both scenarios assume a continuation of the fall in income: in 2021 by 1.5 - 1.7%; in 2022 and 2023 by 0.5 - 0.6%.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Inc
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
  Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

Coefficient Standard mistake t-statistics P- value

	Coefficient	Standard mistake	t-statistics	P- value	
const	−14,3738	19,7385	−0,7282	0,4725	
GDP	0,679115	0,201710	3,367	0,0022	***
Inc1	0,453752	0,121928	3,721	0,0009	***

Average variable   98,91613   Standard deviation of variables 3,457079
Amount of sq. leftovers 143,7442   Model standard error   2,265772
R-square   0,599712   Corrected R-square   0,571120

Fig.7: Regression model of the dynamics of real incomes of the population of Russia
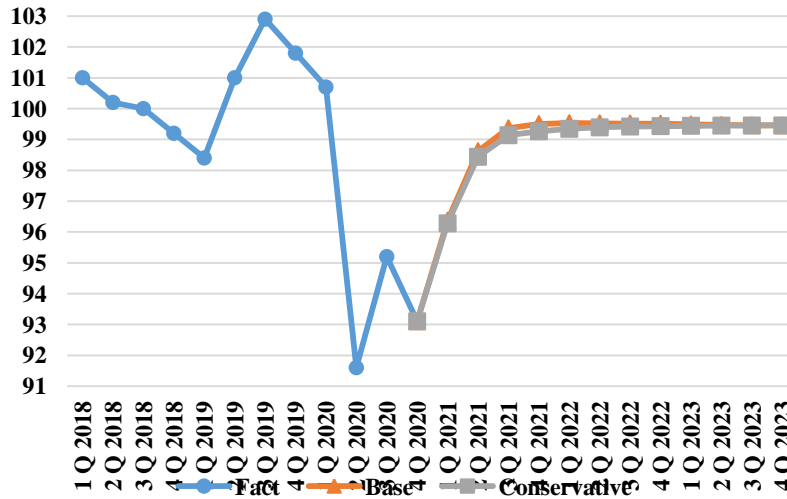
Fig.8: Scenario forecast of the dynamics of real incomes of the population of Russia, in% to SPPY

Industrial production index

Modeling the medium-term dynamics of the industrial production index (IPI) was based on the fact of a close and direct correlation between the growth rates of industrial production and the growth rates of the economy as a whole. The corresponding correlation coefficient was 0.85. Accordingly, the indicator of the growth rate of real GDP for the same period was added to the equation for the industrial production index (Figure 9). The normalized R^2 for the above equation is 0.78.

From the presented (Figure 10) scenario forecasts of the industrial production index, it follows that under the baseline scenario in 2021 the decline in industrial production is expected to continue, albeit a slow one - 99.1% (in 2020 the growth rate was 96.8%), in 2022 the rate will be 101.7%, in 2023 - 101.6%. Within the framework of the conservative option: in 2021 - 99%, in 2022 - 101.6%, in 2023 - 101.6%.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Ind
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

```
        Coefficient Standard mistake t-statistics P- value
    ----------------------------------------------------------------
    const    −26,4065   12,9671      −2,036     0,0513    *
    GDP       0,994772   0,128466     7,743     1,96e-08  ***
    Ind1      0,269651   0,103840     2,597     0,0148    **
```

Average variable   100,8000   Standard deviation of variables 2,877383
Amount of sq. leftovers 55,42339   Model standard error   1,406914
R-square   0,777713   Corrected R-square   0,761836

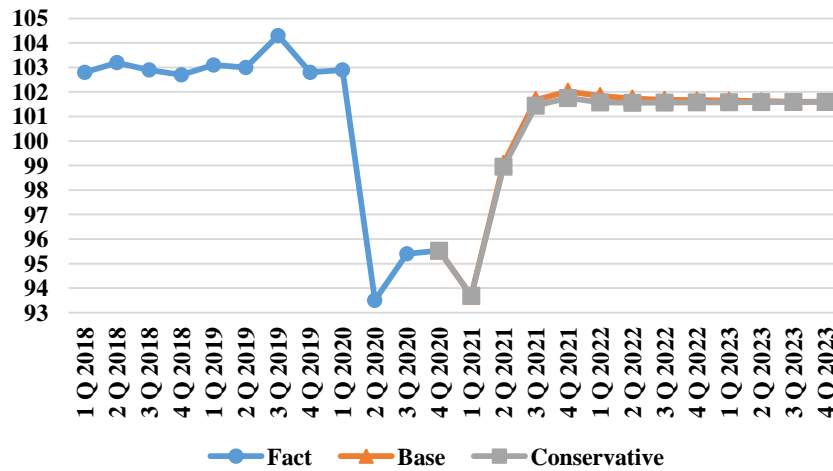**Fig.9: Regression model of the Russian industrial production index**

Fig.10: Scenario forecast of industrial production index in Russia, % to SPPY

Retail turnover

The volume of gross domestic product was chosen as the main factor explaining changes in the variable of trade activity. The resulting estimate of the normalized R^2 for the above equation is about 0.87.

Thus, according to the baseline scenario, the growth rates of retail turnover in 2021, 2022, and 2023 are 97.1, 100.2, and 100.7%, respectively. According to the conservative scenario, growth rates are lower in 2021 - 2022 by 0.4 p.p., in 2023 - by 0.1 p.p.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Trade
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

Coefficient Standard mistake t-statistics P- value

	Coefficient	Standard mistake	t-statistics	P- value	
const	−147,062	18,5379	−7,933	1,22e-08	***
GDP	1,95362	0,176473	11,07	9,74e-012	***
Trade2	0,499315	0,0787739	6,339	7,40e-07	***

Average variable   99,30968   Standard deviation of variables 5,498930
Amount of sq. leftovers 122,8610   Model standard error   2,094730
R-square   0,865593   Corrected R-square   0,855993

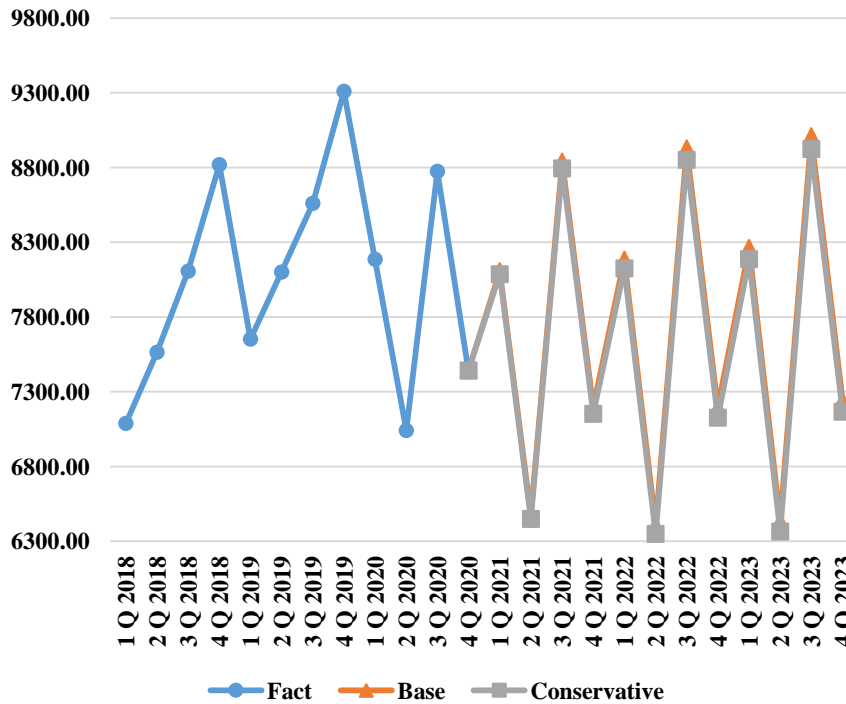**Fig.11: Regression model of the dynamics of the real volume of retail trade in Russia**

Fig.12: Scenario forecast of the real volume of retail trade in Russia, in billion rubles

Unemployment rate

In recent years, as the economy has developed, more jobs have been created and, accordingly, more job opportunities. The shock that caused a sharp increase in the unemployment rate was the introduction, starting from the II quarter of 2020, of a self-isolation regime and, accordingly, a freeze in economic activity. As a result, official statistics recorded a quarterly increase in the share of the unemployed in the economically active population at an average of 1.4 - 1.9 percentage points to the level of 6.3% in the third quarter of 2020. Therefore, the indicator of real GDP growth was chosen as the main factor determining the medium-term dynamics of the share of the unemployed among the economically active population.

The normalized R^2 for the specified equation specification is 0.84. From the presented results of the scenario forecast (Figure 14) for 2021, 2022, and 2023 it follows that under a more optimistic (baseline) scenario, the share of unemployed in the total economically active population at the end of the year will be 5.8; 5.5; 5.4% respectively. Whereas in the conservative version, the unemployment rate forecast for the period under review is 0.1 percentage points higher than in the first scenario.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: U
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

	Coefficient	Standard mistake	t-statistics	P- value	
const	424,053	52,9769	8,004	1,33e-08	***
GDP	−3,45657	0,460007	−7,514	4,40e-08	***
U1	0,716786	0,130915	5,475	8,52e-06	***
U2	−0,484297	0,147754	−3,278	0,0029	***

Average variable   100,2796   Standard deviation of variables 11,44068
Amount of sq. leftovers 622,0593   Model standard error   4,799920
R-square   0,844542   Corrected R-square   0,827268

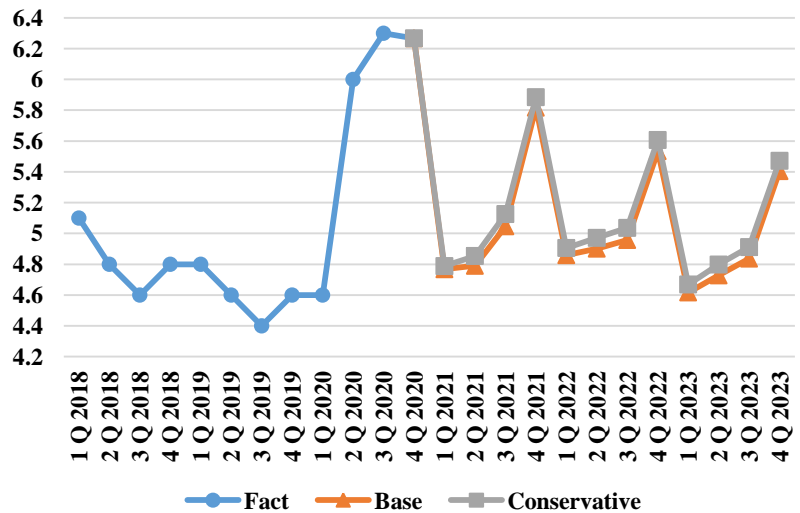**Fig.13: Regression model of the dynamics of the unemployment rate in Russia**

Fig.14: Scenario forecast of the unemployment rate in Russia, in% of the economically active population

Consolidated budget revenues

The oil and gas sector still plays a dominant role in the formation of the state budget. Despite the gradual decrease in the relative weight of oil and gas revenues, their share in the total revenues is about 20% in the consolidated budget of the Russian Federation and about 28% in the federal one. In this regard, it is obvious that one of the significant factors in the formation of the budget revenues is the cost of oil.

Another important factor in the dynamics of budget revenues is economic activity as a whole. The growth of real GDP leads to an expansion of the tax base and, accordingly, to an increase in the revenues of the budgetary system at all levels. However, as empirical analysis has shown, the correlation between the dynamics of the budget revenues and the growth rate of real GDP is moderate, amounting to 0.67. The closest was the relationship between budget revenues and the unemployment rate (-0.76). Therefore, within the framework of the model, the indicator of the dynamics of the unemployment rate in the country was chosen as a factor of economic activity. The normalized R^2 in the above model is about 0.76.

Figure 16 presents the forecast of the quarterly total cash receipts to the consolidated budget. Thus, in the framework of both scenarios, budget revenues are expected to grow relative to the level of 2020, when this value was about 36.6 trillion rub. Under a somewhat optimistic (baseline) scenario, $ 42.5 trillion is expected in 2021 rub. cash receipts to the budget, in 2022 - 45.2 trillion rubles, in 2023 - 49.5 trillion rub. Whereas in the framework of the conservative option in 2021, the forecast is lower by 0.3 trillion rubles, in 2022 - by 0.5 trillion rubles, in 2023 - by 0.4 trillion rub.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Tax
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1

```
            Coefficient Standard mistake t-statistics P- value
         ----------------------------------------------------------------
 const     155,601    18,0131      8,638    2,97e-09  ***
 U        −0,357827   0,104122    −3,437    0,0019    ***
 Urals1    0,153701   0,0393656    3,904    0,0006    ***
 Tax4     −0,253735   0,111710    −2,271    0,0313    **
```

Average variable   106,6235   Standard deviation of variables 9,196251
Amount of sq. leftovers 602,2774   Model standard error   4,722983
R-square   0,762641   Corrected R-square   0,736268

Fig.15: Regression model of the dynamics of the volume of incomes of the consolidated budget of Russia
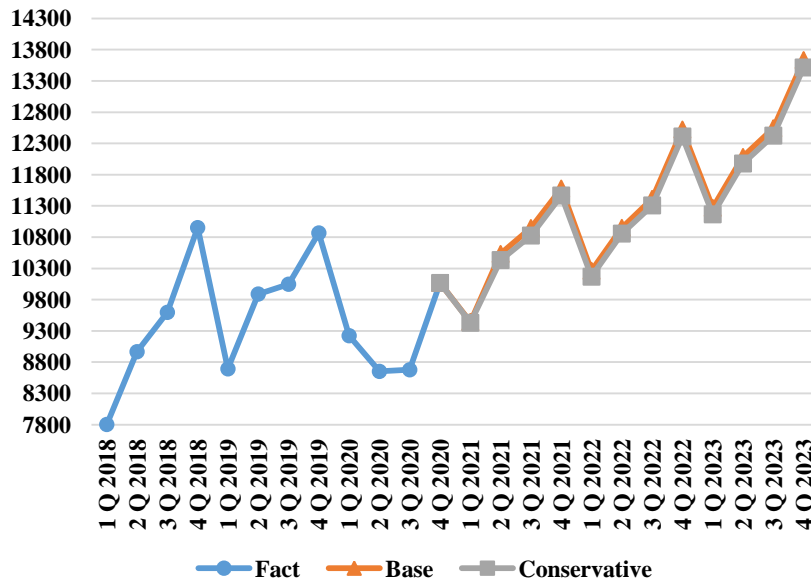
Fig.16: Scenario forecast of the volume of revenues of the consolidated budget of Russia, in billion rubles.

Export

About half of the value of Russian exports is made up of products of the fuel and energy complex, the prices of which are either directly determined by the price of oil, or strongly correlate with it. Thus, the main factor that determines the dynamics of exports in the medium term is oil prices. The normalized R^2 for the presented model (Figure 17) is about 0.96.

Figure 18 shows the forecast for the export volume in 2021 - 2023. Thus, under both scenarios, the export value is expected to increase relative to the level of 2020, when this value was about the US $ 329.8 billion. Under the baseline scenario, in 2021 the expected volume of exports will amount to USD 350.2 billion, in 2022 - USD 364.5 billion, in 2023 - USD 376.2 billion. Whereas under the conservative option due to lower oil prices in 2021, the forecast is lower than the base case by USD 10.4 billion, in 2022 - by USD 15.2 billion, in 2023 - by USD 16 billion.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Ex
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

```
          Coefficient Standard mistake t-statistics P- value
       ----------------------------------------------------------------
const     13,8279    4,08273       3,387    0,0021    ***
Urals     0,433895   0,0397738    10,91     1,36e-011 ***
Ex1       0,436680   0,0581676     7,507    3,54e-08  ***
```

Average variable   97,11646   Standard deviation of variables 20,95612
Amount of sq. leftovers 591,5158   Model standard error   4,596256
R-square   0,955102   Corrected R-square   0,951895
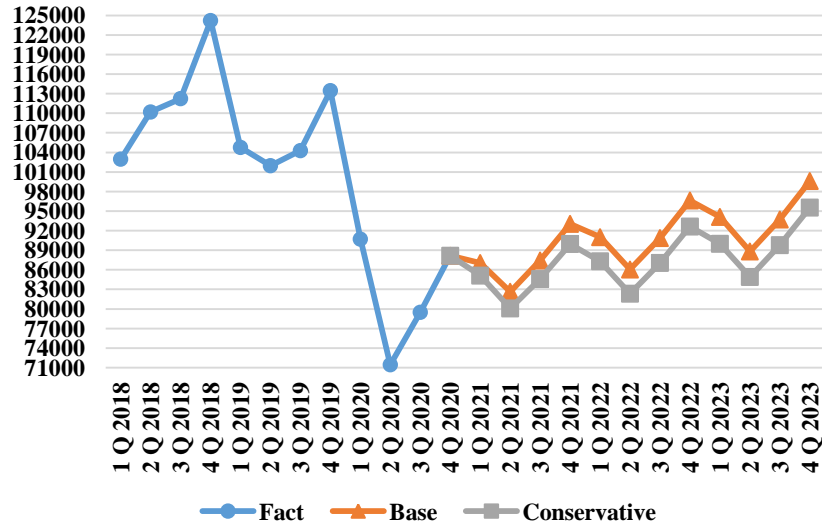
Fig.17: Regression model of Russian export dynamics

Fig.18: Scenario forecast of export volume, USD million

Real effective ruble exchange rate

The real effective exchange rate is the sum of the indices of the country's real exchange rate, weighted by the shares of the trading partner countries in the foreign trade turnover. In this work, the growth rate of Russian exports was chosen as the main factor characterizing the medium-term dynamics of the real effective exchange rate. Below is the specification of the regression equation that gives the best estimates (Figure 19). The adjusted R^2 for the equation presented is about 0.74.

Figure 20 shows the forecast of the growth rate of the real effective exchange rate of the ruble in% to SPPY (cumulative total) for 2021–2023 according to the established scenarios. According to the baseline scenario, at the end of 2021, the ruble will strengthen by 6.6%, in 2022 it will weaken by about 0.8% and in 2023 - it will strengthen by about 0.2%. In the case of a conservative scenario, the real effective exchange rate by the end of 2021 will strengthen by 5.1%, in 2022 it will weaken by about 0.6% and in 2023 - it will strengthen by about 0.4%.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: R
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
  Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

	Coefficient	Standard mistake	t-statistics	P- value	
const	31,5426	10,7358	2,938	0,0068	***
Ex	0,532628	0,128071	4,159	0,0003	***
Ex1	−0,406287	0,131931	−3,080	0,0048	***
R1	0,908023	0,159814	5,682	5,62e-06	***
R2	−0,352067	0,157325	−2,238	0,0340	**

Average variable   98,27742   Standard deviation of variables 12,31824
Amount of sq. leftovers 1197,317   Model standard error   6,786063
R-square   0,737039   Corrected R-square   0,696583

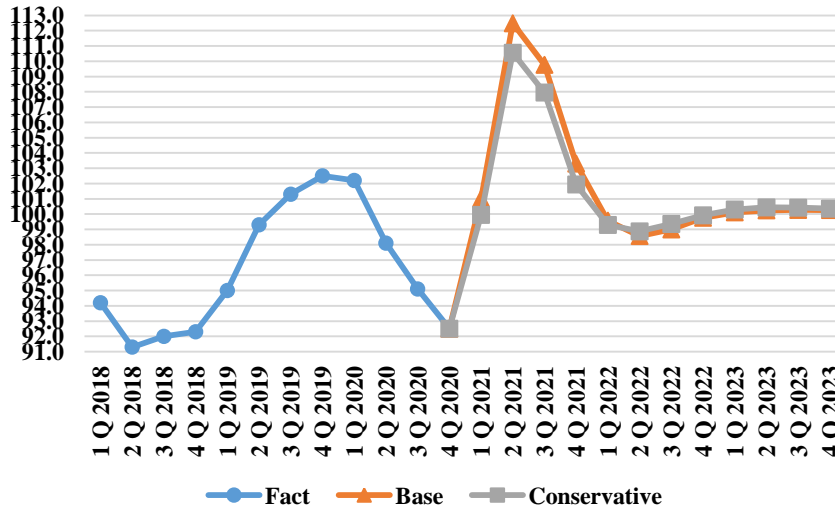**Fig.19: Regression model of the dynamics of the real effective exchange rate of the ruble**

Fig.20: Scenario forecast of the dynamics of the real effective ruble exchange rate, in% to SPPY (cumulative total)

Nominal exchange rate of the ruble against the US dollar

As a rule, given the dynamics of the real effective rate, the nominal exchange rate is calculated using internal and external price indices. Within the framework of this work, an attempt has been made to estimate the nominal exchange rate of the ruble against the dollar for a given index of the real effective exchange rate of the ruble. For this purpose, the model has added the nominal exchange rate of the US dollar to the euro, which to some extent takes into account the relative appreciation or depreciation of the dollar against the euro and, therefore, to the basket of currencies, based on which the real effective exchange rate of the ruble is calculated. Thus, according to the obtained estimates of the presented equation (Figure 21), the normalized R^2 is 0.86.

Figure 22 shows the forecast for the nominal exchange rate of the ruble against the US dollar in 2021 - 2023. Under both scenarios, further depreciation of the ruble is expected. Under the baseline scenario, in 2021 the expected average annual ruble / dollar exchange rate will be 69.8, in 2022 - 75, in 2023 - 80.7. the USA. Whereas in the framework of the conservative option, due to lower growth in the real effective exchange rate and a slightly lower rate of strengthening of the euro against the dollar, the average annual ruble against the dollar in 2021 is expected to be 71.2, in 2022 - 77.2, in 2023 - 82.9.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: E
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

```
        Coefficient Standard mistake t-statistics P- value
    ----------------------------------------------------------------
const      370,945     21,3430        17,38      1,56e-0,16 ***
R         −1,17963    0,152431       −7,739      1,98e-08  ***
Dlr_Eur   −1,43986    0,236222       −6,095      1,42e-06  ***
```

Average variable   113,0724   Standard deviation of variables 23,76936
Amount of sq. leftovers 2338,223   Model standard error   9,138268
R-square   0,862051   Corrected R-square   0,852197

Fig.21: Regression model of the dynamics of the nominal exchange rate of the ruble against the US dollar
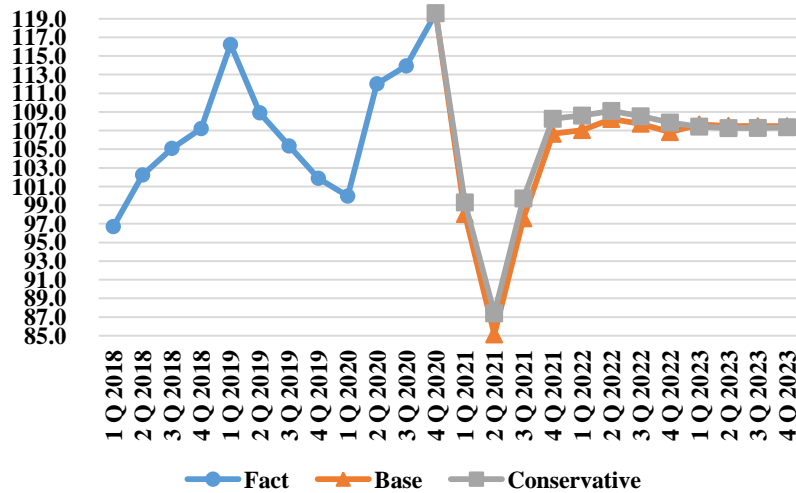
Fig.22: Scenario forecast of the dynamics of the nominal exchange rate of the ruble against the US dollar, in% to SPPY

Import

The main factor that determines the dynamics of imports is GDP. At the same time, imports depend on the exchange rate: all other things being equal, a stronger national currency should lead to an increase in demand for imported goods. In the regression equation presented below (Figure 23), the main explanatory variable is the growth rate of real GDP, converted at the ruble / dollar rate for the corresponding period. The normalized R^2 for the presented model is about 0.89.

According to the baseline scenario (Figure 24), the volume of imports by the end of 2021 will be about $ 244.5 billion (an increase of $ 22.5 billion against the level of 2020) and by 2023 will fall to $ 241.6 billion. 2021 in the case of the conservative scenario is about $ 239.6 billion, and by 2023 it will decrease to $ 235.1 billion.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Im
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

```
        Coefficient Standard mistake t-statistics P- value
  ---------------------------------------------------------------
  const     11,0188    5,80381       1,899    0,0676    *
  GDPE       0,939135  0,0617758    15,20    2,38e-015  ***
```

Average variable   97,72637   Standard deviation of variables 17,60828
Amount of sq. leftovers 1037,038   Model standard error   5,979961
R-square   0,888509   Corrected R-square   0,884664

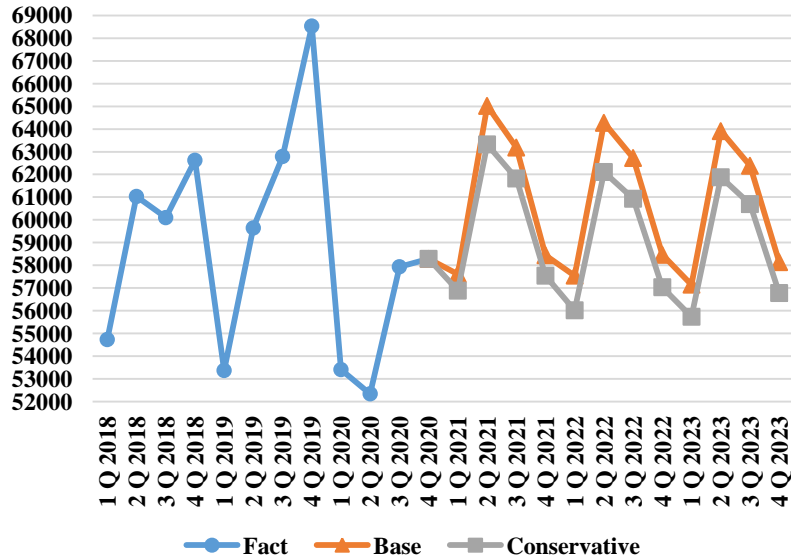**Fig.23: Regression model of the dynamics of Russian imports**

Fig.24: Scenario forecast of import volume, USD million

Consumer price index

The construction of the consumer price index model was based on the traditional approach to determining the demand for money, according to which an increase in the money supply and the velocity of money circulation leads to an increase in prices. With the expansion of real output, all other things being equal, prices fall. Also, one should not overlook the influence on the dynamics of consumer prices of the change in the exchange rate, which varies the cost of imports and the import component in national products. In this regard, a special indicator was added to the estimated equation (Figure 25) that characterizes the rate of monetization of the economy, expressed as the excess of the growth rate of the money supply over the growth rate of real GDP in dollar terms. According to the obtained estimates of the presented equation, the normalized R^2 turns out to be higher than 0.88.

According to the baseline scenario, the consumer price index (CPI) at the end of 2021 will be about 103.4% (at the CPI 2020 level) and by 2023 will grow to 104.9%. The CPI forecast for 2021 in the case of the conservative scenario is about 103.5% and by 2023 it will grow to 104.8%.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: CPI
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R

```
        Coefficient Standard mistake t-statistics P- value
  ----------------------------------------------------------------
  const    35,2981    8,69729      4,059      0,0004    ***
  M21GDP_E  0,0689131  0,0148789    4,632      7,59e-05  ***
  CPI1      0,587826   0,0934182    6,292      8,36e-07  ***
```

Average variable   106,5129   Standard deviation of variables 4,044008
Amount of sq. leftovers 54,11736   Model standard error   1,390238
R-square   0,889696   Corrected R-square   0,881817

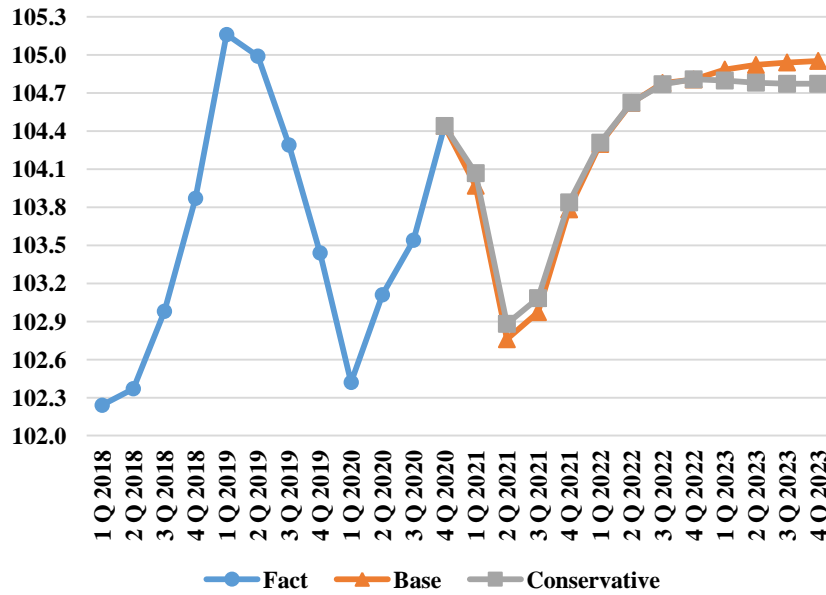**Fig.25: Regression model of the consumer price index (CPI) of Russia**

Fig.26: Scenario forecast of the consumer price index (CPI) of Russia, in% to SPPY

International reserves

The growth in the volume of Russia's international reserves is mainly explained by the inflow of dollar cash as a result of foreign trade operations and the subsequent purchase of foreign cash by the Bank of Russia.

However, as shown by the correlation analysis, these factors are statistically weakly related to the dynamics of reserves. In contrast to the consumer price index, which showed the closest relationship with the dynamics of reserves: the correlation coefficient was 0.83. This dependence can be explained by the policy pursued by the Bank of Russia aimed at achieving the target level of inflation when one of the instruments of such a policy is international reserves.

In this regard, the consumer price index is included in the regression equation (Figure 27) as an explanatory variable. The resulting estimate of the normalized R^2 for the above equation is about 0.75.

Figure 28 shows the forecast of Russia's international reserves for the period 2021–2023 under the scenarios under consideration. According to the baseline scenario, the volume of gold and foreign exchange reserves by the end of 2021 will be about $ 644.9 billion, by the end of 2022 - about $ 674.9 billion and about $ 711.4 billion by the end of 2023. According to the conservative scenario, the following is expected: by the end of 2021 the volume of reserves will be about $ 643.5 billion, by the end of 2022 - about $ 674.2 billion and about $ 714.3 billion by the end of 2023.

Model: 2 international corporations, observations used 2013:1-2020:3 (T = 31)
Dependent variable: Res
Independent variables: const COVID Urals Inv1 Dlr_Eur GDPE U1 U2
 Inc1 Ind1 Trade2 Ex1 Urals1 Tax4 M21GDP_E CPI1 Res4 R1 R2

```
        Coefficient Standard mistake t-statistics P- value
   --------------------------------------------------------------
   const    466,510     50,7183      9,198    5,89e-010  ***
   CPI     −3,12282    0,385462     −8,101    8,05e-09   ***
   Res4    −0,318877   0,132687     −2,403    0,0231     **
```

Average variable   101,8528   Standard deviation of variables 12,48767
Amount of sq. leftovers 1172,103   Model standard error   6,469994
R-square   0,749671   Corrected R-square   0,731791

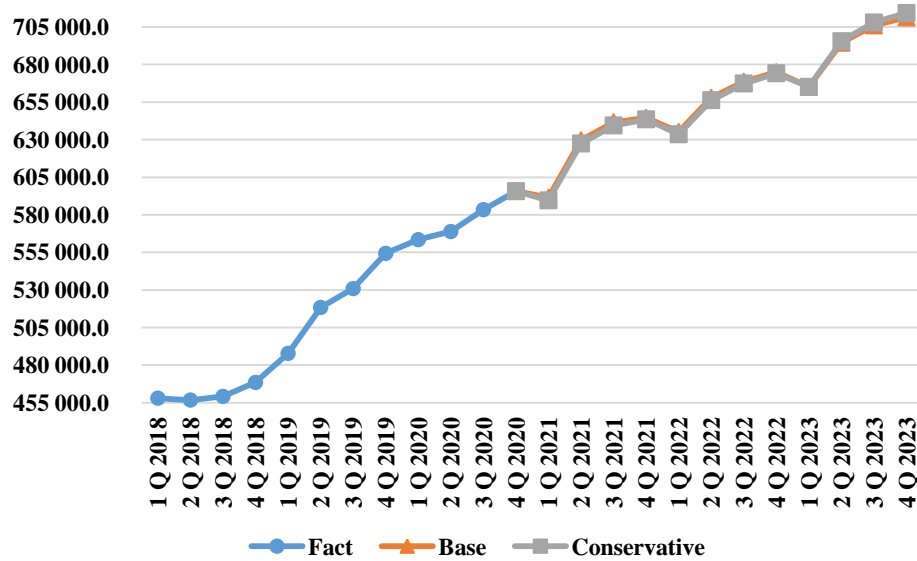**Fig.27: Regression model of the dynamics of Russia's international reserves**

Fig.28: Scenario forecast of the volume of international reserves of Russia, in million US dollars

CONCLUSION

Thus, we can conclude that the obtained forecast estimates, despite the identical input parameters (the scenario conditions of the Ministry of Economic Development of the Russian Federation were used in the work), are more restrained in terms of the number of macro parameters, in contrast to the official forecast of the Ministry of Economic Development of the Russian Federation. In this regard, the obtained forecast can be taken into account as an alternative vision of the future state of the Russian economy.

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