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MODIFICATION OF THE GE-IO MODEL OF THE RUSSIAN ECONOMY WITH DYNAMIC OPTIMIZATION OF MACROECONOMIC POLICY *

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ABSTRACT

The paper describes recent results connected with extension of the general equilibrium input-output model of Russia with aggregated markets (Gilmundinov, 2015). Consideration of economic policy's influence on a variety of macroeconomic and structural policy goals is an aim of this extension. For this purpose we add into GE-IO model sectoral fixed capital investment's sub-models and sub-model of dynamic optimization of economic policy. Sectoral sub-models of fixed capital investments are based on the assessments of sectoral production functions with variable degree of capacity use. Sub-model of dynamic optimization of economic policy is based on extension of basic approaches suggested by H. Theil (1954; 1964), J. Tinbergen (1952) and R. Mundell (1962) with dynamic social losses function and accounting of influence of economic policy on sectoral structure of national economy.
The suggested modification allows to simulate impact of different variants of economic policy on national economy, aggregated markets and main sectors. That is very helpful for estimation of consequences of various internal and external shocks and development of optimal economic policy and gives more advantages in comparison with standard DSGE or CGE models.
The preliminary results of simulations based on suggested model for the Russian economy show considerable dependence of the Russian economy dynamic and structure on economic policy. Optimal economic policy should be hybrid with combining structural policy with sectoral credit policy of Central Bank. According to the basic scenario of simulation with neutral economic policy the Russian GDP in constant prices will decline at 1.8% in 2016 in comparison to 2015 and almost have no changes in 2017 in comparison to 2016. Stimulating economic policy allows to raise growth rates of the Russian economy at 2-3%.

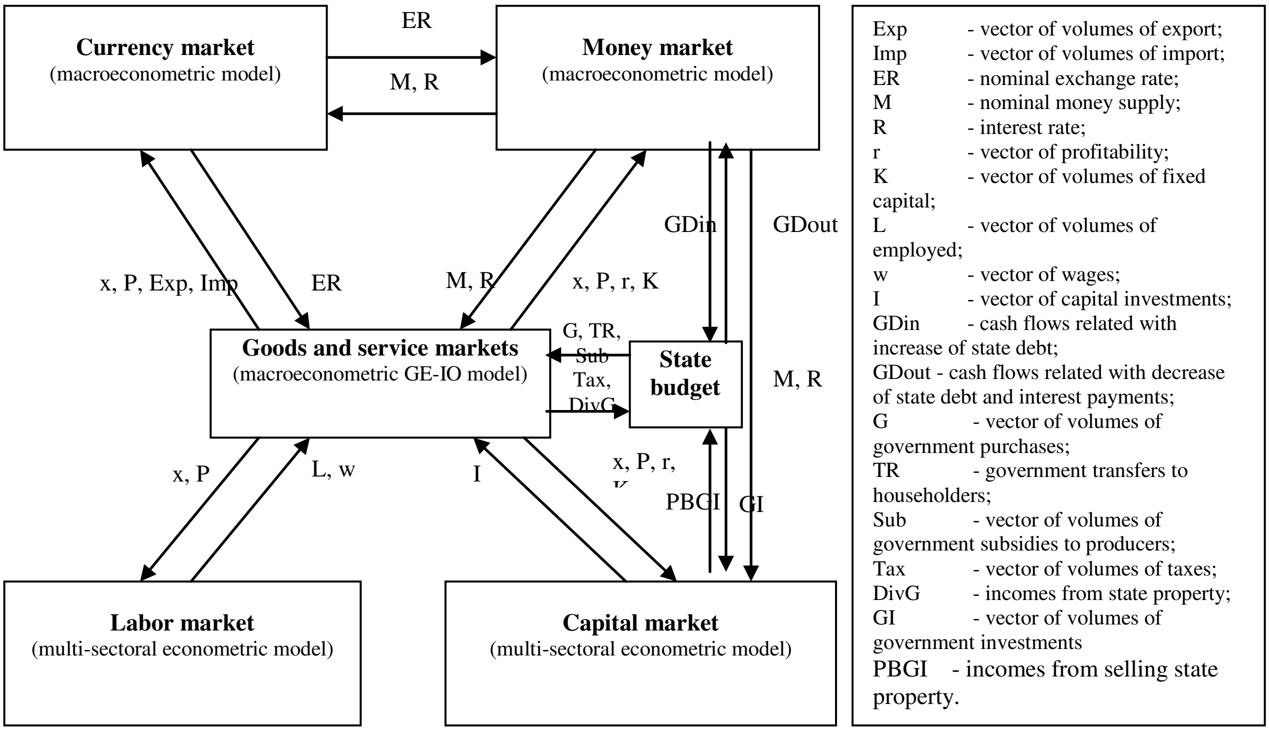
1. INTODUCTION

A problem of optimization of state economic policy in simulation of economic development on macro-level is under consideration in this study. Applied multisectoral models are mainly focused on economic dynamic and consequences of various economic shocks. But most of them do not suggest optimization of economic policy. Meantime nowadays the Russian economy faces with different considerable restrictions for economic growth. Decreasing of the Russian GDP growth rates, long-term insufficient fixed capital formation for whole period after economy liberalization, technological backwardness were highly strengthened by sectoral sanctions concerned with Ukrainian conflict and decreasing of prices on world oil market. It raises a problem of elaboration of appropriate economic policy which would be able to stimulate progressive structural changes in the Russian economy and form a base for sustainable growth of socio economic development. Taking macroeconometric general equilibrium input-output model of the Russian economy with aggregated money and currency markets as a base model we offer its extension with building of sub-model of optimization of economic policy and some results of simulation for 2016-2020 in this paper.

2. BASIC MACROECONOMETRIC GE-IO MODEL OF THE RUSSIAN ECONOMY WITH AGGREGATED MONEY AND CURRENCY MARKETS

A basic version of the macroeconometric general equilibrium input-output model of the Russian economy with aggregated money and currency markets is described in (Gilmundinov, 2015). The extension of the model is based on the combination of the macroeconometric input-output approach suggested by C. Almon (1989), the computable general equilibrium approach suggested by L. Johansen (Johansen, 1974) and the neo-classic and neo-Keynesian macroeconomic models used to describe aggregated markets (see, for example, (Gali, 2008)).

The theoretical structure of the extension of the macroeconometric general equilibrium input-output model of the Russian economy with aggregated money and currency markets is shown in Scheme 1. The model includes IO equations for product markets with input-output coefficients to simulate inter-sectoral relations, as well as econometrically estimated equations for aggregate monetary and currency markets and sectoral output elasticities to simulate an intersectoral competition and links between aggregate markets.



Scheme 1. A Concept of macroeconometric GE-IO model with aggregated money and currency markets and shocks of monetary and fiscal policy

In the current version, the core of the model is a macroeconometric GE-IO model with 28 (see equation (1) below). The GE-IO model simulates total outputs for each sector of economy based on the projection of total demand (see equation (2) below) and production capacities (see equation (3) below). Total demand and capacity constraints are based on inward and backward links with macroeconometric models, which describe aggregate markets (the current version has models only for money and currency markets). Links between the GE-IO model and the macroeconometric models of the aggregate markets are based on the endogenization of some key variables of the aggregate markets which influence sectoral variables (interest rate, exchange rate, inflation rates). In the current version of the model we assume only three variables of aggregate markets are linked with total demand (real exchange rate, real wage, and real interest rate).

$$x_{i,t} = \sum_{j=1}^{n} a_{i,j} \cdot x_{j,t} + y_{i,t} \qquad i = 1,\dots,n \qquad (1)$$

$$Ln(x_{i,t} / x_{i,t-4}) = e_{x_i,ExR\$R} \cdot Ln(ExR\$R_{t-\tau_{x_i}^{ExR\$R}} / ExR\$R_{t-\tau_{x_i}^{ExR\$R}-4}) + \\ + e_{x_i,WR} \cdot Ln(WR_{t-\tau_{x_i}^{WR}} / WR_{t-\tau_{x_i}^{WR}-4}) + e_{x_i,IRR} \cdot Ln(1+IRR_{t-\tau_{x_i}^{IRR}}) + e_i^0 \qquad i = 1,\dots,n \qquad (2)$$

$$x_{i,t} \le Cap_{i,t} \qquad i = 1,\dots,n \qquad (3)$$

where

n – number of sectors (n = 28 in the current version);

$x_{i,t}$ – total demand for the product of sector i in quarter t in constant prices;

$y_{i,t}$ – final demand for product of sector i in quarter t in constant prices;

$a_{i,j}$ – coefficients of direct expenditures of sector j for products of sector i, $i, j = 1,\dots, n$;

$\tau_{x_i}^{ExR\$R}, \tau_{x_i}^{WR}, \tau_{x_i}^{IRR}$ – time lags in influence of changing in real exchange rate, real wage, and real interest rate on total demand for product of sector i estimated by constructing regression equations;

$ExR\$R_{t-\tau_{x_i}^{ExR\$R}}$ – real exchange rate of the Russian ruble to US dollar in quarter $t-\tau_{x_i}^{ExR\$R}$;

$WR_{t-\tau_{x_i}^{WR}}$ – real wage in quarter $t-\tau_{x_i}^{WR}$;

$IRR_{t-\tau_{x_i}^{IRR}}$ – average annual real interest rate (deflated with deflator of GDP) for credits for non-financial sector in quarter $t-\tau_{x_i}^{IRR}$;

$e_{x_i,ExR\$R}$, $e_{x_i,WR}$, $e_{x_i,IRR}$ – elasticity coefficients of total demand for product of sector i to real exchange rate, real wage, and real interest rate, accordingly, estimated by constructing regression equations (see Table 1);

e_i^0 – a constant term of the regression equation for total demand for product of sector i;

$Cap_{i,t}$ – production capacities for total output of sector i in quarter t estimated by constructing of production function.

As it follows from the equations above the current version of the model is mainly the demand-side. More updates for production capacity constraints and other supply-side equations will be presented in the next papers. Notwithstanding this the equilibrium variables of aggregate markets in equations (2) make the model GE type by harmonizing the equilibriums of the different aggregate markets.

To construct a model for the aggregate money market we use the well-known Baumol-Tobin model to simulate money demand and a new-Keynesian concept of inflation based on adaptive learning. For the inflation model we assume that inflation expectation include non-monetary factors. Based on quarterly statistics for 2003-2010 we have estimated the following two regressions:

$$\text{Ln}((1+IRN_t)/(1+IRN_{t-4})) = -0.02+0.16*\text{Ln}(P_{t-4}/P_{t-8}) - \\ -0.08*\text{Ln}((M_t/P_t) / (M_{t-4}/P_{t-4})) + 0.16*\text{Ln}(X_{t-5}/X_{t-9}) \quad (R^2 = 80.2\%) \qquad (4)$$

$$\text{Ln}(P_t/P_{t-4}) = 0.146*\text{Ln}(M_t/M_{t-4}) + 0.979*\text{Ln}(P_{t-1}/P_{t-5}) - \\ -0.321*\text{Ln}(P_{t-2}/P_{t-6}) \quad (R^2 = 67.1\%) \qquad (5)$$

where

IRN_t – the average annual interest rate for 1year or less credits for non-financial sector in quarter t;

P_t – GO deflator index in quarter t;

M_t – money supply (M2) in quarter t;

X_t – real GO in quarter t.

The model for the money market allows us to endogenize the interest rate and the inflation rate, and as a result endogenize the links between the aggregate money market and the product market. The money supply is the only exogenous variable in this case.

A model of currency market is based on estimation of currency inflows and outflows in the Russian Balance of payments and allows to simulate dynamic of exchange rate of the Russian ruble to USD. Based on quarterly statistics for 2003-2010 we have estimated following regression:

$$\mathrm{Ln}(ExR\$N_t/ExR\$N_{t-4}) = -0.04+1.20*\mathrm{Ln}(1+dPrivateReserves_t/CurrenceInflows_t) - 0.49*\mathrm{Ln}(1+dCurrenceInflows_t/CurrenceInflows_t) \quad (R^2 = 79.5\%) \qquad (6)$$

where

$ExR\$N_t$ – the average exchange rate of the Russian ruble to USD in quarter t;

$dPrivateReserves_t/CurrenceInflows_t$ – ratio of change in net foreign currency reserves of private sector to total foreign currency inflows in the Russian economy in quarter t;

$dCurrenceInflows_t/CurrenceInflows_t$ – ratio of net foreign currency inflows in the Russian economy to total foreign currency inflows in the Russian economy in quarter t.

To make the exchange rate for the endogenous regression for import of goods and services (7) and normative model for exports of goods and services (8) are constructed:

$$\mathrm{Ln}(1+Im_t/P_t*X_t) = 0.125 + 0.025*\mathrm{Ln}(ExRR_t/ExRR_{t-4}) \ (PV = 99.7\%) \qquad (7)$$

$$Ex_t = ExNonO\&G_t + OilPrice_t*ExpOilVol_t/dOil_t \qquad (8)$$

where

$ExRR_t$ – real exchange rate of the Russian ruble to the USD.

Im_t – imports of goods and services in rubles in quarter t;

Ex_t – exports of goods and services in rubles in quarter t;

$ExNonO\&G_t$ – non oil&gas exports of goods and services in rubles in quarter t;

$OilPrice_t$ – average actual export price of the Russian oil in USD per barrel in quarter t;

$ExpOilVol_t$ – oil exports in barrels in quarter t;

$dOil_t$ – average share of oil export in total oil&gas export in quarter t.

Flows of capital and financial instruments accounts of the Balance of payments and non oil&gas exports of goods and services are exogenous. For the purpose of macroeconomic forecasting these flows are defined exogenously according to considered scenarios of economic development and macroeconomic policy, historical data and expert estimations.

All regressions above show good statistical significance for main hypotheses.

3. EXTENSION OF THE GE-IO MODEL OF THE RUSSIAN ECONOMY: DYNAMIC OPTIMIZATION OF ECONOMIC POLICY

The including of sub-model of optimization of economic policy makes requires to make some variables of the macroeconometric GEIO model described below endogenous. A list of such variables could be varied. Using R. Mundell's approach (Mundell, 1962) to optimize economic policy and H. Theil's approach (Theil, 1954, 1964) to build social losses function we suggest the following general social losses function with dynamic optimization (9):

$$SL_t = \sum_{\tau=t-t_0}^{\theta} \delta_\tau \cdot \sum_{n=1}^{N} \mu_{\tau,n} \cdot \left(T^*_{t_0+\tau,n} - T_{t_0+\tau,n}\right)^2 \rightarrow \min! \qquad (9)$$

where

t – year of economic policy elaboration/correction [t_0; $t_0+\theta$];

t_0 – first year of planning period;

θ – length of planning period, in years;

SL_t – total social losses from year t to the end of planning period;

τ – index number of year of planning period (beginning from 0 for t_0);

δ_τ – weight of social losses of year with number τ in total social losses for whole planning period;

n – index number of target of economic policy;

N – total number of target of economic policy;

$\mu_{\tau, n}$ – weight of target of economic policy with index number n in total social losses for year with index number τ;

$T^*_{t0+\tau, n}$ – planned value of target indicator related to target of economic policy with index number n in year with index number τ;

$T_{t0+\tau, n}$ – value of target indicator related to target of economic policy with index number n in year with index number τ estimated in a model by optimizing with economic policy's instruments.

In this study we focus only on three instruments of economic policy in terms of J. Tinbergen's approach (Tinbergen, 1952). According to this we consider three following parameters of the macroeconometric GE-IO model: Money supply (M_t), Changes in international reserves ($StateReserves_t$) and Volume of federal budget subsidies to investors ($InvestSubsidy_t$). We suggest that federal budget subsidies to investors are used only for stimulating investments based on domestic fixed capital formation produced by domestic companies.

Instead only one official target of Central Bank policy (Central Bank of the Russian Federation, 2016) we consider 5 targets in our study: growth rates of capital expenditures (in constant prices) with n = 1, growth rates of GDP (in constant prices) with n = 2, growth rates of total output of manufacturing (in constant prices) with n = 3, inflation rates as deflator of GDP with n = 4, balance of consolidate state budget with n = 5.

The main goal of simulation is to check what kind of economic policy will be optimal – oriented on monetary control or on currency control, and how strong is effect from sectoral credit policy (subsidies to investors) for achievement of targets? – to answer this questions we build scenarios for simulation of the Russian economy in 2016-2020 in our model extended with economic policy optimization and make calculations.

4. SCENARIOS AND RESULTS OF SIMULATION OF THE RUSSIAN ECONOMY DEVELOPMENT IN 2016-2020 WITH OPTIMIZATION OF ECONOMIC POLICY

The macroeconometric GE-IO model of the Russian economy with aggregate money and currency markets presented above allows us to simulate the dynamic and structure of the Russian economy considering changes in economic policy with short list of exogenous parameters, which must be extended by adding a list of planned values of the target indicators. For assumptions of simulation see Table 1. We also assume that government expenditures will be constant in 2016-2017 and after will be increased according to GDP growth rates.

According to the results of our calculations suggested dynamic approach to optimization of economic policy is more flexible than static one. Moreover it allows to reoptimize economic policy year to year with actual data appears for period of planning. The most important indicators of simulation are shown in Table 2. According to the results of calculations shown in Table 2 we can conclude that easing of monetary policy may give good prospects for the Russian economy growth. But it has also negative consequences: higher inflation rates and deficit of state budget. For neutralizing this consequences hybrid monetary policy combining sectoral credit policy with fiscal stimulus can be suggested.

Table 1

Basic scenario's assumptions for dynamic of some key exogenous indicators and planned values of target indicators for the Russian economy in 2016-2020

	2016	2017	2018	2019	2020	2020/ 2015
Average export price of the Russian oil, USD per barrel	50	55	60	65	70	1.7
Net Outflow of Capital, bln USD	60	40	20	-10	-30	-
Capital expenditures, Y to prev. Y	1.01	1.05	1.07	1.08	1.08	1.32
GDP, Y to prev. Y	1.00	1.03	1.02	1.05	1.05	1.16
Total Output of manufacturing, Y to prev. Y	1.02	1.04	1.05	1.06	1.06	1.25
GDP deflator, Y to prev. Y	1.07	1.06	1.04	1.04	1.03	1.21
Deficit of consolidate state budget to GDP	0.0	0.0	0.0	0.0	0.0	
δ_τ	1	0.9	0.81	0.729	0.6561	
$\mu_{\tau,1}$	0.2	0.2	0.2	0.2	0.2	
$\mu_{\tau,2}$	0.2	0.2	0.2	0.2	0.2	
$\mu_{\tau,3}$	0.2	0.2	0.2	0.2	0.2	
$\mu_{\tau,4}$	0.2	0.2	0.2	0.2	0.2	
$\mu_{\tau,5}$	0.2	0.2	0.2	0.2	0.2	

Table 2

Dynamics of some key macroeconomic indicators of the Russian economy in 2016-2020

	2016	2017	2018	2019	2020	2020/ 2015
Capital expenditures, Y to prev. Y	0.987	1.031	1.053	1.057	1.059	1.199
GDP, Y to prev. Y	0.992	1.012	1.022	1.036	1.035	1.100
Total Output of manufacturing, Y to prev. Y	1.018	1.024	1.032	1.036	1.034	1.152
GDP deflator, Y to prev. Y	1.091	1.083	1.076	1.064	1.063	1.438
Deficit of consolidate state budget to GDP	2.1	1.3	1.1	0.4	-0.3	
Money supply, Y to Y	1.167	1.154	1.147	1.142	1.156	2.039
Int reserves, Y to Y	1.026	1.087	1.121	1.136	1.154	1.639
Investments subsidies to GDP	0.003	0.007	0.005	0.011	0.010	

* results of simulation are preliminary and may be updated

Sources: 2015 – Rosstat, Central bank of the Russian Federation; 2016-2020 – results of calculation in macroeconometric GE-IO model of the Russian economy with aggregated money and currency markets and optimization of economic policy.

5. CONCLUSION

Suggested approach of dynamic economic policy optimization based on macroeconometric GE-IO model of the Russian economy with aggregated money and currency markets has shown a good explanatory power to substantiate of economic policy. It fits not only for the model we used in this study and has a good applicability to any multisectoral model which considers links between aggregated markets and state budget. However this extended model requires more clarifications with weights of targets in social losses function and its form, as well as some important economic interrelations such as supply and demand on labor market, capital flows and other should be considered.

According to the results of our calculations it is better for the Russian economy to be under monetary control with sectoral credit policy. It helps to considerably decrease social losses, which arose with misfit of actual and planned values of economic indicators.

Further developments of our approach suggest to reviewing of macroeconometric GE-IO model of the Russian Economy with aggregated money and currency markets to completely incorporate it with sub-model of economic policy optimization in united complex of simulations.

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