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A Macroeconomic Model of the Russian Economy

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Abstract. The constructed macroeconomic model of Russian economy is presented. The model takes into account the key features of behavioral mechanism, economic policy mechanism, and key structural features of the economy for medium and short periods. We model the budget rule mechanism, consider interaction between the Central Bank and the budget in the context of monetary and budget reserves accumulation, including the process of gold-currency reserves' accumulation as well as the sterilizing mechanism for state funds formation. Include two different monetary policy rules in the model: domestic credit rule and exchange rate rule. The exchange rate sub-model describes a Balassa—Samuelson effect and terms of trade effect. Our model demonstrates high prognostic power: its model prognostic quality is higher than of the Ministry of Economic Development of the Russian Federation for the majority of macroeconomic indicators.

Keywords: macroeconomic modeling, error correction model, budget rule, transmission mechanism of monetary policy.

JEL Classification: E170, C530, C510.

1. INTRODUCTION

Methodology of applied macroeconomic modeling is usually divided into structural and non-structural (econometric) approaches[1]. The basis of structural approach is theoretical view of the

[1] Detailed analysis of macroeconomic modeling may be found in (Diebold, 1997).

economic system, as a rule — macroeconomic; in the second case attention is concentrated on the analysis of facts and solutions of parameters' identification problem. The academic community dominates another notion: the parameters, which cannot get theoretical ground (from the point of microeconomics), reflect only some special regime, the economic system is involved in under the measures of special politics or the outside shocks. Econometric models do not allow finding the active economic mechanisms. At the same time as the observations show, the parameters of microeconomics' grounded models are often less stable (including changes in policies) than the models with the parameters of econometric models. The structural models demonstrate low prognostic quality. At the same time structural modeling requires additional assumptions, which validity also needs additional testing, especially for the countries with the transitional to the market economy.

The aim of our analysis is the construction of macroeconomic model of the Russian economy, aimed at short and medium term prognosis and scenario analysis of the consequences of structural shocks and change in policy's regimes.

Many researchers were in concern with modeling the Russian economy. One of the most interesting economic models of the Russian economy is model in (Benedictow, Fjærtoft, Løfsnæs, 2010) (hereinafter BFL-model). We use this model as a starting point for our research. Approach under BFL-model is flexible and constructive; it allows to build-up the model further and to adjust it for our system and aims of modeling. The attempts to reconstruct BFL-model for the longer interval, though did not give good results, since the model failed to produce satisfying results because of ignoring some specialties of the Russian economy.

Our model as compared to BFL-model includes a description of budget rule mechanism. It accounts for two monetary rules — to control gold-currency reserves and the bank-credit channel[2]. We describe interaction between budgetary system in the context of control gold-currency reserves and the budget funds. Describing the dynamics of the exchange rate we consider Balassa—Samuelson and well-being effects. The tendency of increased oil-extraction expenses was also concerned. Still more, we rejected long-term connection between consumption and revenue. At the same time introduction of varying behavior parameter "propensity to consume" revealed the extra-limit of assumptions about the Russian economy. The clear design of optimization task of a producer allowed us to correctly describe demand on labor.

Including the basic behavior parameters and politics' mechanisms, and creating the short and

[2] After the model was constructed, the article was being preparing for the publication we had found the article by Schulgin (Schulgin, 2014). The author used the very similar idea of exploiting two monetary policies' rules. The basic difference of assumption is monetarist approach (analysis) in the description of monetary transmission.

long-term dynamics into the model, as well as the account for the basic structure specifications of the Russian economy allows us to make the scenario analysis of the consequences of changing the regimes of politics and make its high quality prognostics. Comparison of the prognosis outcomes with the official prognosis of the Ministry of Economic Development is in favor of our model.

2. MACROECONOMIC MODELS OF THE RUSSIAN ECONOMY

In recent years attempts were made to design aggregated dynamic models of the general economic equilibrium for the Russian economy (Polbin, 2013). In most cases the models were the mere calibration of modeling schemes, used for the economic systems' description of the developed countries. The model had the description of economic mechanisms, but their forms and the assumptions system need discussion and verification. It is known that in comparison to the developed countries, where the shocks are predominantly temporary and lead to the system's fluctuations around the trend, the structural shocks dominate in the developing countries — these are the growth shocks — influencing the mere trends itself (Aguiar, Gopinath, 2007). The research with DSGE-modeling schemes was taken in the article (Schulgin, 2015). The author comes to the conclusion that introduction of two rules instead of one will give a more accurately the facts and data. The author (Ivashchenko, 2013) gives the comprehensive description of the bank system and model endogenous default. These descriptions and models disprove the after 2008-crisis critics of DSGE-models for its inability not only to predict the crises (like that of 2008), but also to explain them.

Interesting results were obtained by the scientific school, created by RAS academician V.L Makarov[3]. They built a desegregated computable model of general economic equilibrium RISEC, the computable model with neuron nets etc. (Makarov et al., 2013; Makarov, 1999). These models describe the outcomes of economic politics' measured, and construct the regimes of government control. The computable model of general economic equilibrium were also realized in the Center for economic and financial research and development (CEFIR) (Alekseev et al., 2006), it was used for analyzing the integration processes, where Russia had participated (WTO integration, integration in EEC frame) as well as for the analysis за the outcomes of tax reforms, and tariff changes. Most of the model of this type are based on the assumption that prices are absolutely flexible and do not include the mechanisms of adjustment to equilibrium, being in this way being static[4].

One of the first econometric models of the Russian economy was (Basdevant, 2000). He used

[3] The CGE-models are used in the Center for situation analysis and prognostics at CEMI RAS.

[4] The prognostic power of CGE-models is not considered high. However, there are no articles analyzing the prognostic power of CGE-model. (Kehoe, 2003) is one of the few.

Cobb—Douglas production function, which parameters were calibrated by GDP revenues' structure and besides it used Calman filtering algorithm to correct the low quality data on capital. The constructed model allows making an important observation: the author came to the conclusion that fiscal consolidation in before-crisis (before 1998) period was far from optimal economic policy. The budget policies should be better oriented to support the structural changes in the supply side. Our analysis showed that a bigger class of functions with constant elasticity of substitution does not support Cobb—Douglas from for the production function in the Russian economy.

In (Makarov et al., 2001) one can find the econometric model of the Russian economy. It consists of six equations and is used for making short-term macroeconomic prognosis and scenario computations. Stresses were made on research of correlation between the economic dynamics and the world oil prices, between the schedules of foreign debt payments and the size of government social expenditures. Model was presented as a system of simultaneous equations and identified on the quarterly data. The graphic (analysis of pared correlation fields, "bi-plots") and static (verification of linear correlations between the functions, Box—Cox transformation) procedures were used to develop the equations of the model. The choice of predefined variables for every endogenous variable is carried on the basis of Granger causality test in combination of determination coefficients' analysis and *t*-statistics values in the corresponding regression equations. The problem of outside shocks' neutralization came out to the front side; this had changed the key mechanisms of monetary and budget policies and created the additional limitations on their operation. Mechanism of employment of production capacities had changed, the oil-extraction of economics became dominating as well as economic dependence on the oil prices. The changes were used in modeling the modern tendencies.

The authors (Aivazian, Brodsky, 2006) test their own methods of designing the econometric model of the Russian economy of macroeconomic type. Their work can be classified as hybrid, but there were no special indications of that fact. The two-steps procedure of designing econometric correlations was described. At the first step a theoretical model was created, describing the basic economic sectors, at the second step an econometric model, containing co-integration correlations and balance conditions, was also created. At present the proposed approach is the basis of macroeconomic prognosis publicized by the Center of situation analysis and prognostics at CEMI RAS[5]. This authors' approach is of much interest, though the transition procedure from the theoretical to estimating models is described without details[6], but this outcome is an obstacle to exploiting the methodology by

[5] See site http://data.cemi.rssi.ru/GRAF/center/forecasts.htm.

[6] It is not clear whether there were linearization of equations from the optimization conditions, or the estimated equations was the linear combination of variables from the corresponding theoretical equations.

the other researchers.

In 2009 a collective of the authors (Merlevede, Schoors, Aarle, 2009) created a compact macro-economic model of the Russian economy of 14 levels. The logics of a model are close to the logics in (Basdevant, 2000). It consists of five blocks (IS, LM, labor market, fiscal block and monetary rule)[7]. The target of the article is to study the influence of oil prices, currency exchange rate, and fiscal politics on the Russian economy. The authors note structural shift in a consumption function, and it explains the change in grade of government trusting, connecting it to Vladimir Putin entering the power. Model simulation confirms critical dependence of the Russian economy on oil price. The authors find, that influence of the government fiscal politics is positive and it reduces the economy's sensitivity to the shocks of oil prices.

The approach in the article (Merlevede, Schoors, Aarle, 2009) was developed in (Benedictow, Fjærtoft, Løfsnæs, 2010). A group of Norwegian authors constructed a compact macro-economic model of the Russian economy. Model was formed in the logic of IS–LM-approach, it consists 13 of equations, having a formula to correct the remainders, got in the co-integration analysis. Besides parameter GDP, the authors describe labor market on the basis of a system of equations like "wage — unemployment", as well as they model a reaction of monetary politics in a form of Taylor rule. Fiscal block is represented by the income equation and expenses equation of the consolidated budget. The authors describe the price dynamics and GDP deflator dynamics. The dynamics of oil export is modelled separately. The authors showed critical dependence of the Russian economy on oil prices and its sensitivity to their decrease using the counter-facts model simulation. But the authors showed that a considerable part of economic growth cannot be explained by the oil prices booming. The observation confirms that there are the other sources of the Russian economic growth.

We did not find among the mentioned models the researches with the results of out-of-sample prognosis; this did not allow making a conclusion on the prognostic quality of the model and the ways to use it in practice. Besides, those models did not account the specific features of monetary and the budget politics connections in the Russian economy, as well as the mechanism of a budget rule. Sometimes we could find the attempts to identify a monetary rule in terms of interest rate. In the terms of Russian economic politics it has little chances for success, since Central Bank behavior radically differs from that of the behavior of the central banks in the rest of the world.

[7] No production function.

3. METHODS OF MODELLING

In case of perfect price elasticity optimality and balance terms provides the balanced dynamics of the whole economic system. When the prices are not elastic, demand may increase supply, and vice versa, while the dynamics may be unbalanced. In this case the models of general equilibrium require a description of price adjusting mechanism and the system to the balanced state. Economic science at present does not have any single opinion about the form of adjustment mechanism. It looks still more difficult to model the price mechanisms in specific economic systems, deep research is necessary to identify these mechanisms. Special attention is needed to identify them in developing and transforming economies, which economy is too far not only from stationary state, but from the balanced condition. This notion is related not only to the mechanisms of price adjustment. For example, in perfect prognostics where the economic agents are not fully rational, as well as there is no domination of private property — decision to save presents inter-time redistribution of consumption, but the current technology provides transformation of savings into the future consumption. Ig we give up one or several assumptions the model requires introduction of a series of additional assumptions and the new objects. Every new element of a model, in turn, requires additional assumptions. Relative simplicity of econometric macro-models use them as a basis for building-in those mechanisms which description is important for modeling, leaving supplementary and unknown mechanisms outside the analysis. In our case the aim of a model is short- and middle-term prognosis and short- and middle-term scenarios for analyzing the consequences of economic policy change, including politics regimes. So, the model needs a description of the relevant behavior mechanisms, tracking these changes, and identifying the relevant structural (stable) parameters. Mechanisms irrelevant to the aims of modeling are described in econometric terms. Our case the basic irrelevant mechanisms include budget rule, interaction between the budget and monetary politics, labor market and formation of consumer demand[8]. The principle difficulties to restore BFL-models are connected with these economic mechanisms.

Thus, BFL-model assumes that consumption in the long run is connected to the income and single elasticity. This means that consumers aim at their permanent income. We consider, that assumption of having a single parameter describing consumer behavior, is too limiting in the conditions of transitive economy with newly-born market economy.

To reject this assumption and introduction of the varying behavior parameter “tendency to

[8] Note that the need to understand these mechanisms appears at the stage of model verification.

consume" allowed finding this parameter is systematically reviewed by the agents, and depends on a series of factors. Stable connection is traced between consumption and capital income, while salary covers the current consumption.

A clear description of producer optimization task allows describing labor demand and correctly specifying unemployment equation. Economic description of short- and long-term suggestion factors allows identification of the parameters responsible for short- and medium term dynamics — demand for labor parameters. Note that we used a big class of CES-functions while modeling labor demand. Estimation of parameters showed that production function in the Russian economy does not belong to sub-class of Cobb—Douglas production function. Part of the optimality parameters is described by the terms of optimality *per se*, the other part is based on the real data and considered to be the coefficients of co-integrating combination.

From the point of politics the difference of our analysis from BFL-model is evident budget rule modeling where budget expenses are described econometrically. We stress that government activities' (Ministry of Finance) modeling *per se* is important when choosing the upper-most level of government expenses. Thus, at every time period one model iteration produces macro-parameters, incomes and budget expenses at the basic oil price; the second iteration uses the results of the first iteration and recalculates macro-parameters with the scenario oil prices and exogenous variables. We could not get the single equation of satisfactory quality for budget incomes as opposed to BFL-model. The problem is that aggregate incomes contain components differentiating the dynamics character, in particular, oil & gas and non-oil & gas budget incomes. Fiscal block is presented in disaggregated form — as a special equation for every type of budget income[9], that increases accuracy of the whole model.

Model differs in the description of Central Bank interactions with the budget system in the context of the current budget rule. Modeling the money politics accounts for the influence of budget funds' accumulation on the money supply, as well as the effect of investment in the foreign assets (gold & currency reserves). Modeling the dynamics of gold & currency reserves also accounts for currency exchange target.

We consider that one of the principle reasons of a failure to repeat BFL-model is connected with the attempts to identify the Taylor monetary rule in terms of interest rate. We could not find the effect of interest rate on the real sector, as well as the correlation between interest rate and macro-economic situation (Central Bank control). Traditional channels of monetary transmission for the developed countries did not function in the Russian economy and were not used really by the Central Bank. The

[9] 17 equations.

Central Bank used currency exchange rate and bank credits as the principle channels of monetary transmission. We have found regularity — rule of Central Bank control — in terms of using these channels of monetary transmission, and their influence on the real sector.

At last, the real model as compared to BFL-model reflects a number of structural specifications of a system. Thus, a model of currency exchange rate accounts for Balassa— Samuelson effect, as well as the effect of well-being (terms of trade)[10]. The equilibrium level of mining and extraction of hydrocarbons is determined by the supply side for the Russian exogenous outside demand, that means by the disposable assets of mining and processing, which capacity depends on the investment and mining expenses in the sector. These two parameters in the equation and their correlation allows to explain the observed dynamics of oil and gas export — that is export values beginning from 2004 concerning intensive growth of the oil prices.

4. DATA AND THE METHODS OF ESTIMATION

Our model estimates the quarter data of 2000—2011. Some of the equations, as a rule, auxiliary, are estimated for the shorter intervals. This fact is connected with the official statistics for earlier periods or with considerable changes of the statistical accounting rule. In estimating we took into account that after 2008 crisis the growth model had not changed significantly. The reference-points of the economic policy remain the same. Where we could, we found explanations for the economy re-actions to 2008 economic crisis (increasing the number of explanatory variables).

In the other cases the crisis points were removed from the equation using the dummy-variables. To control possible change in the dynamics' character step variables of structural shifts were added into the corresponding equations.

A choice of a quarter as a time period of our model was motivated by the need to get sustainable estimates of the equations' parameters. Monthly data was unfortunately impossible to get for the most important variables of the model, for example for GDP. A shift from quarterly to monthly data was connected with the significant errors.

The information data for our model is the official statistics. The source of data for the GDP components, wages, occupation, GDP deflator and consumer price index (CPI) is the Federal Service of Russian Federal State Statistics Service (RosStat). The source of information data for the budget sector was Federal Treasury and the Ministry of Finance of the Russian Federation. The source of information data for money aggregates and for currency exchange rate was The Central Bank of the

[10] The model of currency exchange rate accounts for the influence of the budget politics.

Russian Federation.

The main connections in the model were traced through the real variables which require the comparative variables. Comparison is got by nominating the parameters in the 2005 prices the basic. The model includes a series of deflators; their dynamics is described as endogenous.

Most data series were taken logarithms that allowed overcoming the problem of heteroscedasticity. Using the quarterly data a researcher would stop in front of a serious problem — the seasons. There are two remedies for that: to overcome season with different methods, the second — modeling. In our case we do not need the annually data. At the same time the quarterly data is not necessary too — season numbers is modeled including the dummy-variables.

Finally, all the model variables were tested for stationarity. As expected working with the macro-economic data, most variables turned to be unstationary with the level of integration not exceeding 1. We used the Augmented Dickey — Fuller (ADF) and Kwiatkowski — Phillips — Schmidt — Shin (KPSS) tests.

The basis for model equations' estimating is the mechanism of co-integration analysis and the model remainders corrections. In most cases we could use the two-step Engle — Granger procedure. The essence of this procedure is to identify co-integrating combination at the first step, and decomposed explaining variable for long-term and short-term changes at the second.

The main difficulty in parameters identification in the equation system is connected to the problem of synchronicity. Thus, sequential estimating of the model equations by the ordinary method of the least-square method leads to bias and invalid estimates of the parameters. The advantage of co-integration analysis are the models equations in the form of remainder corrections; they structure the system according to the recursive scheme, which would estimate by every element. When we cannot avoid synchronicity, we used generalized method of the moments, where the instruments were the lag meanings. According to generalized moments' method (GSM) and moments' method of the parameters' estimation does not differ much from the estimates, received by least-square method. This may be explained by super-justability of co-integrating combination.

Trends are formed in the interval of model estimation, which are absorbed by the model equations (and very well, as a rule). Extrapolation of these trends beyond the period in question often does not give realistic prognosis. For example, the intensive growth in 2000-s turned to the stable growth in 2010-s during the high and stable oil prices. The comprehended prognosis and its consistency with the economic logics are the main criteria when we verify the model and choose the final equations' specification.

5. GENERAL DIAGRAM OF THE MODEL AND FORECAST QUALITY

The implemented model is a set of equations, a detailed description of which is contained in sect. 6. The core of the model is the behavioral mechanism of the aggregate consumer, whose decisions at each point in time regarding the distribution of income between consumption and savings are determined by the propensity to consume — a variable that depends on fundamental factors and the policy pursued. The production plan that ensures the implementation of the decisions chosen by the consumer is implicitly described by the equation for the accumulation of fixed capital. Formation of the production plan also occurs depending on external demand — total exports. Depending on the chosen production plan, the demand for labor from the industrial sector is selected, the technology of which is described by the CES function. Price mechanisms are modeled econometrically and include variables that reflect imbalances in their respective markets. Most of the equations of the model are written out in a dynamic form, connecting the increment of the explained variable with the increment of the variables of the model, and in addition, with the deviation from the long-term levels, given by the co-integration relation. The general scheme of the model is shown in the figure.

Among the exogenous variables of the model are deflators of US GDP and the European Union for (key countries), the price of oil, and indicators of foreign trade turnover of the countries-trading partners of Russia. At each step of the forecast, current and previous values of exogenous variables, as well as previous values of endogenous variables are fed to the input of the model. In the first step of the forecast, real economic data is used as the previous values. The model is solved by numerical methods (Gauss – Seidel, Broyden).

Below is an estimate of the predictive quality of the model. To do this the accuracy of the model is compared to the accuracy of official forecast of the RF Ministry of Economic Development. The use of forecasts by the Ministry of Economic Development of the Russian Federation is due to the good availability of the history of forecasts. Usually, when evaluating the quality of the forecast, the model is estimated at the training interval, then the forecast is made for the remainder of the interval (or one step ahead) and the forecast error is calculated depending on the data series and analysis objectives: RMS, average, absolute mean, etc. In our case, however, the evaluation period for the equations is short. At the same time, it accounts for a significant number of changes related to statistical accounting and legislation, as well as serious structural changes. Training a model at even shorter intervals requires frequent changes in the specification of many equations. In addition, the set of minor equations is estimated at different, and non-rarely short, intervals. Comparison quality predic-

tions thus performed for the 2012 and 2013 (Table 1, 2)[11]. For 2013 (Table 2) due to space savings, the comparison is made only for GDP and the deflator.

Recall that the model was estimated in the interval from the first quarter of 2000 to the fourth quarter of 2011. The forecast prepared on the basis of the model takes into account information up to the fourth quarter of 2011 inclusive. The nearest date of the forecast of the Ministry of Economic Development of the Russian Federation for 2012 is the beginning of the first quarter of 2012. The forecast of the Ministry of Economic Development of the Russian Federation is thus based on a wider information set in comparison with the model forecast. We emphasize that the forecast for 2013 is also based on information available until the fourth quarter of 2011. The concurrent forecast of the RF Ministry of Economic Development for 2013 was released in the first quarter of 2013 and is based, therefore, on much larger information set than even in the case of the forecast of the Ministry of Economic Development of the Russian Federation for 2012. As it is known, official statistics are subject to regular review, both current and past. When calculating the forecast error, thus, the data available at the beginning of 2014 is taken as actual data, since it is this version of the data that was used in evaluating the present model[12].

From the data presented in Table 1, it is clear that the model gives the best forecast for such indicators as nominal GDP, GDP deflator, CPI, exports and imports. The accuracy of the forecasts of the model and the Ministry of Economic Development of the Russian Federation for the unemployment rate are comparable (the accuracy of the forecast of the Ministry of Economic Development of the Russian Federation is slightly higher). The accuracy of the model wage forecast is lower than prognosis of the RF Ministry of Economic Development, but they are still comparable. The model forecast for the nominal exchange rate of the dollar and the real effective exchange rate of the ruble turned out to be much more precise. However, the Ministry of Economic Development predicts investments more accurately.

[11] Low accuracy of RF MED of the nominal GDP is compensated by the inaccuracy of deflator prognosis — so, that the accuracy of real GDP prognosis is very high. Thus, despite the mistake of our prognosis is 0% for GDP deflator (accurate targeting), mistake of nominal GDP is very close to the real figures, while the prognosis of real GDP is less accurate as compared to RF MED one.

[12] Database available upon request.

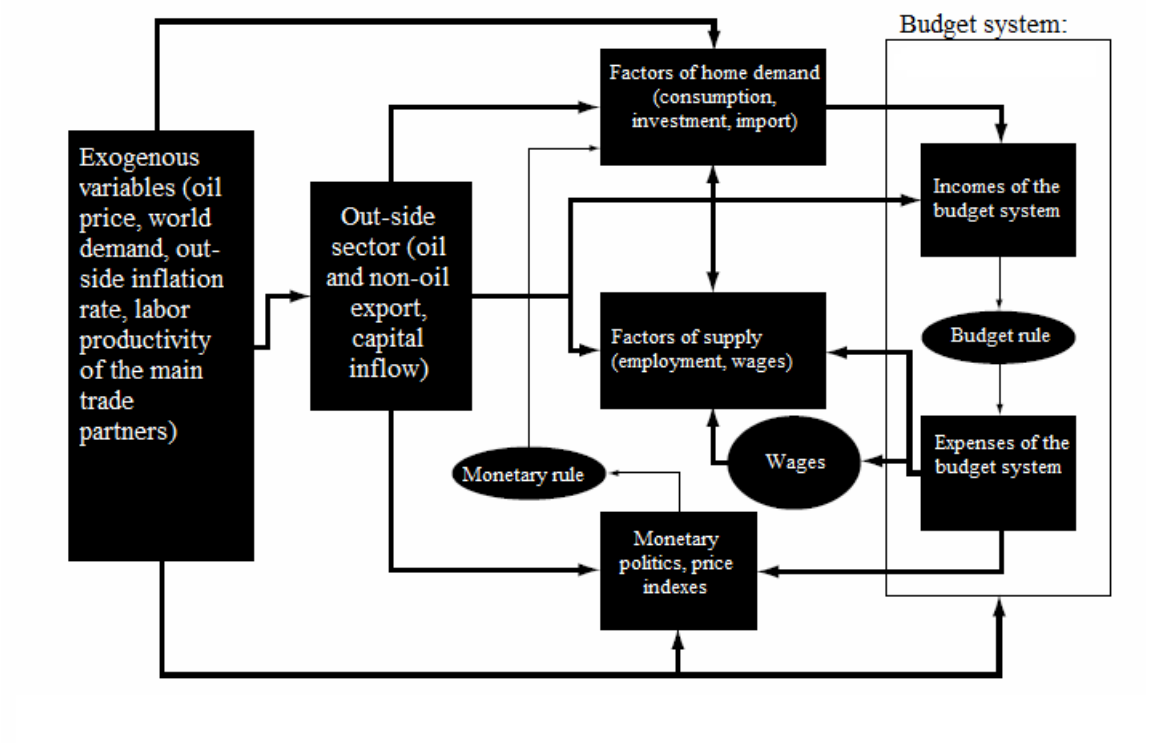

Figure. General model scheme

Table 1. Comparison of forecasts of the Ministry of Economic Development (MED) of the Russian Federation and the model for 2012, %

Indicator	Forecast error MED RF	Forecast error models
Nominal GDP	3,21	1,58
GDP deflator	–0,55	0
Consumer price index (CPI)	–1,69	0,56
Export	5,41	4,22
Import	10,07	3,81
Unemployment rate	0,378	0,379
Nominal wages	1,30	1,39
Dollar exchange rate, rub.	6,15	1,53
Real effective exchange rate of the ruble index	0,951	0,922

Consumption		4,66
Investments	1,56	2,00
Government spending		3,27

Table 2. Comparison of forecasts of the Ministry of Economic Development (MED) of the Russian Federation and the model for 2013, %

Indicator	Error forecast of the RF MED	Model prediction error
Nominal GDP	–3,52	0,36
Real GDP	2,37	0,79
Deflator	–2,97	1,21

The proposed approach, therefore, is effective in describing the short and medium term dynamics. Modeling key behavioral mechanisms and policy mechanisms based on it allows you to implement a model that has high predictive quality and allows you to predict and analyze the short- and medium-term[13] consequences of policy impacts, as well as the effects of external shocks.

An important advantage of the model is its adaptability. The result of our approach makes it easy to reconfigure individual blocks of the model — turn on or off the budget rule mode, inflation targeting mode, etc.

6. SPECIFICATION OF OUR MODEL

This section provides a detailed description of the model and discusses the choice of specification of equations[14].

6.1. Domestic demand. **Consumption.** The factors of domestic demand conditionally include aggregated consumption and total investment in fixed assets. As noted earlier, the assumption of the existence of two parameters, short-term and long-term income elasticities of consumption, which determine consumer behavior, we tend to consider as overly restrictive in the conditions of an emerging market system. In this paper, the variation of the propensity to consume parameter is al-

[13] Usually, a medium-term interval is an interval of 3–5 years. In the present work, since the model is a quarterly one, a short-term interval is an interval of less than one year, while the short- and medium-term intervals are from 1 year (inclusive) to 5 years.

[14] The results of estimating equations see — https://drive.google.com/open?id=0B-vtp_YiI5fYTmNSc3dtbGZnV1k.

lowed. The expansion of the class of consumption functions allows us to identify the specific features of a system, such as the Russian economy, that remain invisible in the framework of the previous approach.

In each separate period t, consumption is related to income by the ratio

$$c_t^r = y_t^r - b_t^r, \tag{1}$$

where c_t^r is consumption, y_t^r is income, b_t^r is savings. Rewrite equation (1) as

$$c_t^r = a_t y_t^r, \tag{2}$$

where $a_t = 1 - b_t^r / y_t^r$ is the behavioral parameter of the aggregated consumer. Assuming that the parameter is not constant, we represent it as a function $a_t = f(x, c_{t-1}^r, y_{t-1}^r, \ldots)$ from fundamental factors, factors of economic policy and structural parameters corresponding to these factors. Logarithm and going to the differences, we get

$$\Delta \log\left(c_t^r\right) = \Delta \log\left(a_t\right) + \Delta \log\left(y_t^r\right). \tag{3}$$

Rewriting GDP at current prices (nominal comprehensive income) in the form $y_t = w_t e_t + (y_t - w_t e_t)$, we have $\log(y_t) = \log(y_t - w_t e_t) + \log(1 + w_t e_t / (y_t - w_t e_t))$, where w_t – nominal wages in the economy, e_t – the number of people employed in the economy. It is convenient to represent the second term in the form of a Taylor series, neglecting terms of higher than the third order. As a result, the following equation is identified for consumption[15]:

$$\begin{aligned}\Delta \log\left(\frac{c_t}{p_t^c}\right) = \underset{(5,82)}{0,3363}\,\Delta \log\left(\frac{y_t}{p_t^c} - \frac{w_t}{p_t^c} e_t\right) + \underset{(5,82)}{0,3363}\,\Delta\left(\left(\frac{w_t}{p_t^c} e_{t-1}\right) / \left(\frac{y_t}{p_t^c} - \frac{w_t}{p_t^c} e_t\right) - \right.\\ \left. - \frac{1}{2}\left(\frac{w_t}{p_t^c} e_{t-1} / \left(\frac{y_t}{p_t^c} - \frac{w_t}{p_t^c} e_t\right)\right)^2 + \ldots\right) - \underset{(-1,87)}{0,0541} - \end{aligned} \tag{4}$$

$$\underbrace{\underset{(-2,21)}{-0,7169}\Delta \log\left(p_t^c\right) + \underset{(2,82)}{0,1205}\Delta \log\left(\frac{m2_{t-3}}{y_{t-3}}\right) - \underset{(-3,62)}{0,1958}\left(\log\left(\frac{c_{t-1}}{p_{t-1}^c}\right) - \log\left(\frac{y_{t-1}}{p_{t-1}^c} - \frac{w_{t-1}}{p_{t-1}^c} e_{t-1}\right)\right)}_{\Delta \log\left(a_t\right)},$$

where $m2_t$ – M2 monetary aggregate; p_t^c – inflation. Thus, the deviation from the long-run equilibrium, i.e.

$$\log\left(\frac{c_t}{p_t^c}\right) - \log\left(\frac{y_t}{p_t^c} - \frac{w_t}{p_t^c} e_t\right),$$

[15] In formula (4) and further, under the coefficients of the equations in parentheses is *t*-statistics.

is only one of three factors that change the model of consumer behavior. In addition, agents are reviewing their consumption model depending on inflation p_t^c and monetary policy $m2_t / y_t$. Inflation includes a mechanism for adjusting consumption as a result of an imbalance in the consumer market. Monetary policy, facilitating the availability of credit, stimulates consumer demand and also changes the pattern of consumption. The interest rate channel was not found by us (for more details on the transmission channels of monetary policy (see p. 6.10).

Note that the consumption model can change only as a result of growth in capital income, the salary income of the model remains unchanged. This is due to the fact that most consumers do not have the ability to make serious savings and are forced to spend the bulk of their income on current consumption. In addition, agents whose income is represented mainly by wages, as a rule, have limited access to the financial market and are deprived of the opportunity to smooth consumption by corresponding financial instruments. The continuing high degree of uncertainty in the economy does not allow these agents to form sustainable expectations of future consumption. As a result, the permanent component of the salary income is unstable and does not affect the model of consumer behavior.

6.2. Factors of the supply. As already noted, the main purpose of building a model is to analyze the short / medium-term dynamics and the short and medium-term forecasts. The main mechanism related to the short / medium term dynamics is related to the labor market, which is emphasized in the model. Capital market dynamics are modeled econometrically in terms of investment.

6.3. Labor market. Let the cumulative proposal describe production functions with constant elasticity of substitution (CES) of the form [16]

$$y_t^r = \gamma\left(\delta k_t^{-\rho} + (1-\delta) e_t^{-\rho}\right)^{-1/\rho}, \tag{5}$$

where k_t – capital stock γ, δ, ρ – options. When $\rho = 0$ the function takes the form of the Cobb – Douglas function and is characterized by the unit elasticity of substitution between labor and capital.

Consider the optimal choice of labor and capital (r_t, w_t^r – real prices of factors of production):

$$\begin{cases} \min\limits_{k_t, l_t} \left(r_t k_t + w_t^r e_t\right); \\ s.t.: \overline{y}_t^r = \gamma\left(\delta k_t^{-\rho} + (1-\delta) e_t^{-\rho}\right)^{-1/\rho}. \end{cases} \tag{6}$$

It is easy to show that the conditions of the first order in this case are:

[16] No technological progress.

$$w_t - \beta\gamma(1-\delta)\, y_t^{1+\rho} e_t^{-(1+\rho)} = 0, \qquad r_t - \beta\gamma\delta y_t^{1+\rho} k_t^{-(1+\rho)} = 0,$$
$$\gamma\left(\delta k_t^{-\rho} + (1-\delta) e_t^{-\rho}\right)^{-1/\rho} - \overline{y}_t^{\,r} = 0, \tag{7}$$

where β is the Lagrange multiplier in the optimization problem. Logarithm optimal condition for labor, we obtain

$$\log(e_t) = -\sigma \log\left(w_t^{\,r}\right) + \log\left(y_t^{\,r}\right) + \alpha, \tag{8}$$

where $\sigma = 1/(1+\rho)$ – elasticity of substitution between labor and capital, $\alpha = \log\left(\beta\gamma(1-\delta)\right)$. The identification of parameters is carried out on the basis of a cointegration analysis — the variables turn out to be cointegrated. The assumption of the unit elasticity of the production function is not confirmed by labor, which means that for the Russian economy the production function does not belong to the Cobb – Douglas class of functions.

Complementing the optimality condition with an econometric entry of labor supply factors and rewriting the equation in terms of unemployment u_t, the dynamics of which depends on both demand factors and supply factors, we obtain the specification of the model equation

$$\Delta \log(u_t) = \underset{(3,17)}{0,3535}\left(\log(e_{t-1}) - \log\left(\frac{y_{t-1}}{p_{t-1}^y}\right) + \underset{}{0,6392}\log\left(e_{t-1}\frac{w_{t-1}}{p_{t-1}^y}\right) + \underset{}{0,7960}\right) +$$
$$+\underset{(4,17)}{0,3818}\Delta\log\left(\frac{y_t}{p_t^y}\right) - \underset{(-5,13)}{0,5195}\Delta\log(u_{t-2}), \tag{9}$$

where p_t^y – GDP deflator.

In order to close the labor market, it is necessary to supplement the system with an equation for salary dynamics (i.e., the Philips curve). Here we follow the approach proposed in (Bardsen et al., 2005). The approach is based on a theoretical construction, which assumes that the Phillips curve is formed under the influence of both the factors of demand for labor and the factors of labor supply. The theoretical construct, along with structural unemployment, allows for unemployment resulting from a non-instantaneous adjustment of the labor market to a new equilibrium. In terms of the specification of the Phillips curve, wage growth rates depend on the ratio of wage level and unemployment rate. This means that in a steady state wage depends on unemployment. In the traditional formulation of the Phillips curve, the steady state wage corresponds to the only meaning of unemployment. The unemployment rate is usually called the unemployment rate, not accelerating inflation (non-accelerating inflation rate of unemployment, NAIRU). It is the instability of NAIRU and other parameters of a similar specification of the Philips curve that has generated a number of studies

designed to explain this phenomenon. The specification of the Philips curve implemented in this model has the form

$$\Delta \log\left(\frac{w_t}{p_t^y}\right) = \underset{(-2,93)}{-0,2004} \log\left(\frac{w_{t-1}}{p_{t-1}^y}\right) + \underset{(2,08)}{0,1196} \log\left(\frac{\gamma e_{t-1}}{p_{t-1}^y}\right) - \underset{(1,81)}{0,0833} \log\left(u_{t-1}\right) + \\ + \underset{(2,27)}{0,0918}\, \Delta \log\left(\frac{\gamma e_t}{p_t^y}\right) + \underset{(3,42)}{0,2633}\, \Delta \log\left(\frac{y_t}{p_{t-1}^y e_t}\right) + \underset{(3,26)}{0,7031}, \quad (10)$$

where γe_t – government spending. The stability of the parameters of the Phillips curve is achieved just by the specification, in which wages depend on unemployment in a stationary mode. In addition, the stability of the parameters is achieved by expanding a set of factors, which allows more accurate identification of structural parameters that are stable to changing policy regimes and structural shocks. So, the specification controls the structural shifts by the entry of a variable reflecting the dynamics of labor productivity, and the influence from the policy side is controlled by the variable of public spending.

6.4. Capital market, investment. Aggregated investments in real terms in a stationary mode stabilize at a certain level, sufficient to compensate for the disposal of capital, as well as the investment of new employees with capital, and represent a fixed share of the total income of the economy y_t / p_t^y. In addition, in the stationary mode, the investments depend on the factors of the offer — the inflow of foreign capital. fk_t. Investments react to the monetary policy of the Central Bank:

$$\Delta \log\left(\frac{i_t}{p_t^y}\right) = \underset{(-2,53)}{-0,2373} \log\left(\frac{i_{t-1}}{p_{t-1}^y}\right) + \underset{(2,81)}{0,4705} \log\left(\frac{y_{t-1}}{p_{t-1}^y}\right) + \underset{(2,12)}{0,0007}\, fk_{t-2} + \\ + \underset{(4,55)}{1,0312}\, \Delta \log\left(\frac{m2_{t-1}}{y_{t-1}}\right) - \underset{(-3,70)}{3,15}, \quad (11)$$

where i_t – fixed investment.

6.5. External demand. Export. The abundance of raw materials in relation to the needs of the national economy determined the specialization of the Russian economy in international trade. The oil and gas sector, both directly and indirectly (through the budget, real and nominal ruble exchange rates, etc.) affects all macroeconomic indicators. Oil and gas exports are the main channel for the penetration of external shocks into the system. Therefore, it is advisable to consider separately the components of oil and gas exports. In addition, the undivided export indicator is poorly econometric description, because it includes components that differ in the nature of the dynamics. Thus, oil and gas

exports are not sensitive to the real exchange rate, while for non-oil and gas exports price competitiveness is one of the key factors.

6.6. Oil export. Under the conditions of exogenous foreign demand for hydrocarbons for the Russian economy, the equilibrium volume of their exports is largely determined by the supply side — disposable production and processing facilities, the size of which depends on investments in the oil and gas industry. On the supply side, another factor influences production costs. In response to the boom in oil prices in 2003, the industry responded with a permanent increase in export volumes, because it had unloaded capacities. In the second half of the 2000s, despite the continuing rise in prices, there was no further increase in exports — the impact of investments in fixed assets was insufficient against the background of rapid growth in production costs. The corresponding structural shift is controlled by the specification of the equation. We emphasize that the dependence of oil and gas exports on exchange rate dynamics was not found by us, which is consistent with economic logic:

$$\Delta \log\left(\frac{export_t^{oil}}{p_t^{oil}}\right) = \underset{(-5,85)}{-0,7538}\left(\log\left(\frac{export_{t-1}^{oil}}{p_{t-1}^{oil}}\right) + 0,2219\log\left(\frac{cost_{t-1}^{oil}}{p_{t-1}^{y}}\right) - 0,0990\log\left(p_{t-1}^{oil}\right) - 0,2554\log\left(\frac{i_{t-1}^{oil}}{p_{t-1}^{y}}\right)\right) + \underset{(2,35)}{0,3637}\,\Delta\log\left(p_{t-4}^{oil}\right) + \underset{(2,39)}{0,7450}\Delta\log\left(\frac{i_{t-3}^{oil}}{p_{t-3}^{y}}\right) \underset{(-1,48)}{-0,0507}, \quad (12)$$

where $export_t^{oil}$ – value of oil and gas exports, p_t^{oil} – oil price, i_t^{oil} – investment in fixed assets of the oil and gas industry, $cost_t^{oil}$ – oil production costs.

6.7. Non-oil export. Key factors determining the dynamics of non-oil and gas exports (those $export_t^{nonoil} / p_t^y$) the Russian economy, are the real exchange rate of the ruble rer_t and labor productivity $y_t / \left(p_{t-1}^y e_t\right)$. The real strengthening of the ruble has a depressing effect on the non-oil and gas exports of the Russian economy. The possibilities of increasing the share of non-commodity products in the structure of exports without increasing labor productivity are limited. The volume of non-oil and gas exports also depends on external demand, which is monitored by the indicator of the physical volume of imports $imp_{t-1}^{EU} / p_{t-1}^{EU}$ to the countries of the Eurozone, Russia's main trading partner:

$$\Delta \log\left(\frac{export_t^{nonoil}}{p_t^{y}}\right) = \underset{(-4,11)}{-0,9395}\log\left(\frac{export_{t-1}^{nonoil}}{p_{t-1}^{y}}\right) + \underset{(2,95)}{0,9382}\log\left(\frac{imp_{t-1}^{EU}}{p_{t-1}^{EU}}\right) - \underset{(-2,83)}{0,5900}\log\left(rer_{t-1}\right) + \underset{(1,77)}{0,3793}\,\Delta\log\left(\frac{y_t}{p_{t-1}^{y}e_t}\right) + \underset{(3,78)}{9,2438}. \quad (13)$$

6.8. Import. Long-term imports are determined by the growth of real income, which depends on the real exchange rate of the ruble, and the relative price of domestic and foreign goods. It is

impossible to finance imports on a permanent basis by external borrowing, therefore the long-term level is determined by non-oil exports. In addition, the dependence on the non-oil and gas component of exports is due to the withdrawal of a significant share of the oil and gas revenues of the economy by the current fiscal policy regime. In the short run, the change in total disposable income affects the dynamics of imports. Then

$$\Delta \log\left(\frac{imp_t^{RUS}}{p_t^y}\right) = \underset{(-5,13)}{-0,5209}\log\left(\frac{imp_{t-1}^{RUS}}{p_{t-1}^y}\right) + \underset{(2,38)}{0,0032}\, rgdp_{t-1} + \underset{(5,17)}{0,3378}\log\left(rer_{t-1}\right) + \\ + \underset{(2,28)}{0,2148}\Delta\log\left(export_{t-1}^{nonoil}\right) + \underset{(1,78)}{0,3897}\Delta\log\left(\frac{\left(y_t - gr_t\right)}{p_t^y}\right) + \underset{(3,83)}{2,0342}, \tag{14}$$

where $\left(imp_t^{RUS} / p_t^y\right)$ – long-term import volumes; gr_t – budget revenues; rer_t – real ruble exchange rate; $rgdp_t$ – real income; $export_t^{nonoil}$ – non-oil and gas exports.

6.9. Real and nominal exchange rate of the ruble. The structure of the model involves the description of both nominal and real exchange rates. The nominal dollar rate and the euro rate are modeled separately, and then the dynamics of the real effective exchange rate of the ruble calculated by the Central Bank of Russia is described[17].

According to the existing theoretical approaches, real strengthening (depreciation) of a currency can be a manifestation of the Balassa—Samuelson effect, which occurs when labor productivity in the sector of traded goods is ahead of labor productivity in the sector of non-tradable goods. The real strengthening of the national currency may also be a manifestation of the welfare effect arising from the improvement in the terms of trade. Both of these effects are discussed in detail for the Russian economy in an article (Gurvich, Sokolov, Ulyukayev, 2008). In addition, the real exchange rate is influenced by the actions of economic policy. Thus, the accumulation of foreign exchange reserves leads (under certain conditions) to a real weakening of the currency, in the conditions of openness of the capital account of the balance of payments, however, the effect of such a policy can be short-term:

$$\Delta rer_t = \underset{(5,78)}{0,7409} - \underset{(-5,66)}{0,2098}\left(rer_{t-1} - 0,2552\, p_{t-1}^{oil} - 0,2760 dprod_{t-1}\right) - \underset{(-5,93)}{0,2865}\Delta er_t^{rub/doll} - \\ - \underset{(-8,32)}{0,4210}\Delta er_t^{rub/euro} - \underset{(-1,63)}{0,0453}\,\Delta mr_{t-1}, \tag{15}$$

where rer_t – real effective exchange rate; $dprod_t$ – labor productivity differential; $er_t^{rub/doll}$ – dollar

[17] Note that currency rate modeling turns out to be one of the most difficult tasks in constructing a model. The fact is that a significant proportion of the variation of the indicator falls on the inner part of the model's time slot — a quarter. Any method of averaging leads to a loss of information, making the indicator changes unavailable for econometric analysis. It is precisely the consistency of the results of forecasting and scenario analysis that we consider as the main criterion for the choice of the specification of the equation.

rate $er_t^{rub/euro}$ – euro rate, mr_t – gold reserves; p_t^{oil} – oil price.

The real effective exchange rate has a long-term relationship[18] with the differential in labor productivity and the price of oil, reflecting changes in the terms of trade. The influence on the dynamics of the real exchange rate is also revealed on the part of the policy of accumulating gold and foreign exchange reserves. Thus, we also manage to detect the Ballas—Samuelson effect and the effect of the terms of trade (welfare):

$$\Delta er_t^{rub/doll} = \underset{(2,16)}{0,0192} - \underset{(-6,02)}{0,8905}\, fk_t + \underset{(1,24)}{0,0585}\,\Delta mr_{t-1} - \underset{(-1,9)}{0,5398}\, nexp_t - \underset{(-2,14)}{0,0776}\,\Delta\left(\frac{y_{t-1}}{p_{t-1}^{y}}\right) - \underset{(-7,60)}{0,8380}\Delta rer_t, \quad (16)$$

where $nexp_t$ – net exports, Δmr_{t-1} – increase in gold reserves.

When modeling the nominal exchange rate of the dollar[19] , a short-term effect on the dynamics (increase in the indicator) on the part of the balance of payments is found. The growth of aggregate demand $\Delta\left(y_{t-1} / p_{t-1}^{y}\right)$ puts pressure on the exchange rate ratio in the direction of strengthening the national currency. The inclusion of the indicator rer_t controls the real factors of exchange rate dynamics.

6.10. Monetary block. In developed market systems, the monetary policy transmission is carried out mainly through two channels. The main is the interest rate channel. A change in the nominal rate in the context of price inflexibility leads to a change in the real interest rate. Increasing the real rate makes current consumption more expensive than future and forces agents to postpone costs for later periods, reducing total consumption. The growth of the interest rate reduces the welfare assessment and, as a result, consumption, which is the second important channel of monetary transmission. Often there is an indirect effect. Since the assets act as collateral for loans, a deterioration in the balance sheet of a borrower resulting from a revaluation of assets leads to a restriction of lending or an increase in the loan premium, which reduces consumption and investment.

In our study, the use of the BFL-model, where the Taylor rule is modeled in terms of the interest rate and the transmission of this instrument to consumption and investment is found, did not give satisfactory results. For the full operation of the first channel, a developed credit market is required, as well as the widespread use of credit cards and other retail financial products. In Russia, the capacity of this segment of the financial system and its effectiveness is still insufficient. Consumers do not have long credit histories, which complicates the assessment of credit risk and the differentiation of good

[18] The growth rate means a real ruble appreciation
[19] The amount of rubles for one dollar.

and bad borrowers. A high level of systemic risk leads to overstatement and credit rationing. The link between the policy instrument and the amount of loans issued becomes unsustainable or disappears altogether and is not identified. The second transmission channel assumes that firms rely more on the stock market in financing investments, and households directly use financial market instruments, while having a significant share of financial assets in the structure of wealth. In Russia, the main share of consumption is carried out by agents who do not have financial assets, while in the financing of investments, bank lending prevails. Therefore, the decisions of agents are not sensitive to changes in interest rates. The Russian financial system was formed based on the banking sector and bank lending. A banking-type system is more stable than a market-based financial system, but at the same time it less effectively conducts monetary impulses through traditional channels of monetary transmission. It should be noted that the low efficiency of the interest rate channel and the welfare channel is associated with the intensive use of the Central Bank of Russia of another monetary transmission channel — the exchange rate channel — the effect of which we discovered earlier.

The fourth main channel of monetary transmission is associated with bank lending: the Central Bank of the Russian Federation, reducing the amount of available reserves in the banking system, forcing banks to change the conditions for granting loans to the real sector. For Russia, this channel of bank lending, along with the channel of the exchange rate, is one of the main ones, and it is precisely these two channels that are modeled in the present work.

The monetarist approach given in (Meltzer, 1995) is used to identify channels. When describing the transmission of monetary impulses, the approach considers not one, but several markets at once: the money market, the markets of financial and real assets. A more general theoretical approach allows us to describe a number of additional effects arising from the actions of the Central Bank: the reaction of current and expected asset prices, changes in the conditions for the provision of intermediary financial services, the temporal structure of interest rates, the volume of lending, the exchange rate etc. You can choose the parameters of a theoretical model in which monetary impulses associated with changes in the money supply (monetary base) will have real effects with an unchanged interest rate. Thus, the key factor for the monetarist approach (analysis) is the dynamics of the monetary base. Note that, unlike developed systems, where exchange rate changes occur as a result of changes in interest rates, in accordance with the law of interest parity, in the Russian economy, the exchange rate channel is also associated with the dynamics of the monetary base[20]. Sometimes the described scheme is distinguished into a separate monetarist channel of monetary

[20] This note was made by M.Yu. Golovnin.

transmission.

Let us describe how does the monetarist approach to our model look like. Ay first we identify the monetar rule of the Russian Federation Central Bank in terms of using the currency and bank credits channels. According to the Central Bank's monetary program (analytical groups of Central Bank's balance sheets), the growth of money base mb_t corresponts to the growth of net international assets mr_t and the growth of net inside assets. Change in the international assets, excluding the currency part of the government funds[21] (Stabilization Fund and The Reserve Fund, as well the Fund of Natrional Well-being, that have substituted the first one), that reflects the monetary rule of using the vurrency channel, controling the exchange dynamics:

$$\Delta mr_t + \frac{bd_t}{er_t^{rub/doll}} = \underset{(6,45)}{168,9777}\ \Delta nexp_t - \underset{(-9,70)}{2925,759}\ \Delta er_t^{rub/doll} + \underset{(22,85)}{292,2085}\ \Delta fk_t^p + \underset{(1,57)}{902,7205}, \quad (17)$$

where bd_t is budget deficit (proficite); $\Delta er_t^{rub/doll}$ is dollar/rouble exchange rate. The control index of a nodel are pribate capital inflow Δfk_t^p and net export index $\Delta nexp_t$, which is very small.

Deducing money base index from index of international reserves we identify monetary rule of using the bank credits channel. Besides the international reserves it is necessary to account the givernment assets, firstly — Treasurty accounts in the Central Bank. To avoid a new variable introducing and complicating our model, we use proxi-variable bd_t. It is introduced into the model on the econometric base (and not of the balance), despite the fact that the budget deficite (more precise — proficit) is reconciled with the fund dynamics, but this coordination is still observed. The thing is that there is not only inflow into the Treasure accounts, but also the outflow of money from th efunds, as well as currency revaluation of the currency part of funds:

$$\begin{aligned}\Delta mb_t - \Delta\left(mr_t \Delta er_t^{rub/doll}\right) = \underset{(6,04)}{0,6235}\Delta bd_t - \underset{(-6,73)}{288,444}\Delta er_t^{rub/doll} - \underset{(-7,32)}{0,8747}\Delta\frac{y_t}{p_t^y} - \underset{(-2,07)}{0,5371}\Delta p_t^y - \\ - \underset{(-1,77)}{0,1622}\left(\Delta mb_t - \Delta\left(mr_t \Delta er_t^{rub/doll}\right)\right) - \underset{(-3,26)}{371,6613}.\end{aligned} \quad (18)$$

This expression looks like Taypor rule, but not in terms of interest rate, but in terms of the amounts of Central Bank credits for the bankin sector. According to our estimates, the currency exchange rate, the purpose of issue and inflation target are of prior importance for the Central Bank.

The money impulses are transfered through the multiplier $mult_t$ to the level of money amount $m2_t$. The multiplier, aggregating the characteristics of the country's fiscal system, is described by the

[21] The effect is controlled by budget balance index bd_t.

trend component, as well as short-term fluctuations are described by the real putput:

$$mult_t = \underset{(4,63)}{0,0198}t + \underset{(3,18)}{0,0017}\frac{y_t}{p_t^y} + \underset{(2,40)}{0,4516}, \tag{19}$$

$$m2_t = mult_t\, mb_t. \tag{20}$$

Aggregator M2 on the real sector is identified in p.6.1 and 6.9.

To finish up the description of the transmission mechanisn of the monetary politics it is necessary to understand the influence of the monetary impulses on the price mechanisms of our model.

Let us analyze GDP deflator p_t^y and the consumer price index p_t^c. GDP deflator is defined by the money mass $m2_t$, real incomes y_t / p_t^y and the pay-roll amounts $w_t e_t$ in the stationary regeme. High output presses down the prices, but the high wages acts in the opposite direction. Real incomes in the short run act positively on the prices. Index of the consumption prices has a long-term connection to the GDP deflator, but it is corrected by the dynamics of environment (euro-zone) inflation $p_t^{c_{EU}} er_t^{rub/eur}$ and specially — to the euro exchange rate $\Delta er_t^{rub/doll}$, because the most part of this index is correlated to import goods prices, sensitive to the exchange rates:

$$\begin{aligned}\Delta p_t^y = \underset{(-5,18)}{-0,6354}\left(p_{t-1}^y - 0,0152 m2_{t-4} + 0,0600\frac{y_{t-1}}{p_{t-1}^y} - 0,0031 p_{t-1}^{oil} - 0,0002 w_{t-1}e_{t-1}\right) - \\ \underset{(-2,59)}{-0,2939}\Delta p_{t-1}^y + \underset{(3,08)}{0,0007}\Delta p_t^{oil} + \underset{(2,89)}{0,0359}\Delta\frac{y_{t-1}}{p_{t-1}^y} + \underset{(3,61)}{0,0004}\Delta w_t e_t + \\ \underset{(2,77)}{+2,6105}\Delta p_t^{y_{EU}} + \underset{(4,63)}{0,0128}(t-1) + \underset{(1,80)}{0,0819},\end{aligned} \tag{21}$$

$$\begin{aligned}\Delta p_t^c = \underset{(-4,08)}{-0,1940}\left(p_{t-1}^c - 0,4051 p_{t-1}^y - 0,0207 w_{t-1}e_{t-1} - 0,0061 p_{t-1}^{c_{EU}} er_t^{\frac{rub}{eur}}\right) + \\ \underset{(1,72)}{+0,0014}\,\Delta er_{t-1}^{rub/doll} + \underset{(4,07)}{0,0003}\,\Delta p_t^{oil} + \underset{(1,58)}{0,0031}\,\Delta m2_{t-2} + \underset{(4,91)}{0,3605}\,\Delta p_{t-1}^c - \underset{(-5,86)}{0,0160}\,\Delta\frac{y_t}{p_t^y} + \underset{(4,26)}{0,0563}.\end{aligned} \tag{22}$$

6.11. The budget block and budget rule. The income part of the budget block in our model is presented by 17 equations, which describe all the consolidated budget balance sheet income items: VAT, profit charges, import duties, export duties (three componenets of oil revenues ect.), tax on the extracted (output) mineral resources (three components), exsise-duties, social tax, tax on the incomes of individiuals. As a rule every item of incomes is the product of income rate t_i and the aggregated income tax base nb_t (so, VAT is a tax on GDP), as well as coefficient of levy, assesed by econometric mechnisms. It allows to make prognosis not only the normative (planned) amount of tax incomes, but

their real amounts:

$$GR_t = \sum_{i=1}^{17} t_i nb_t, \tag{23}$$

where GR_t are the government revenues.

Modeling of a process of formaing the budget expences according to the budget rule is the important specific feature of our model. As compared to BFL-model the expences in our model are not described by the econometric equation, but the mechanism of the budget rtule is immitated on the basis of the folowing procudure. Thus, at every tackt one model iteration computes macro-indexes and the corresponding budget incomes at the basic oil price, calculated as a standing (many years) average. The basic amount of income is used to calculate the level of expences — as comes from the current budget rule. The expences, scenario oil price and th rest exogenous model variables are the input parameters for the second model iterartion, which gives us the final macro-prognosis for this time tackt:

$$\begin{cases} GE = GR\left(Model\left(p_{base}^{oil}, exogen_{base}\right)\right) + 1\% \times GDP\left(Model\left(p_{base}^{oil}, exogen_{base}\right)\right), \\ MF = Model\left(GE, p_{scen}^{oil}, exogen_{scen}\right), \end{cases} \tag{24}$$

where GE are the gevernment expences; GR — gevernment incomes; MF — macro-economic prognosis; $Model(\bullet)$ — prognosis model in question. Index *base* shows some calculations around the vasic oil price; index *scen* — is attached to the scenario oil price and to the other exogen model variables. Note, that this approach to budget expences modeling accounts for the influence of governement economic expences, that provides better accuracy of prognosis and thus gives a better description of structural connections.

7. CONCLUSION

Quarterly macro-economic model of the Russian economy including the basic economic mechnisms shaping the shrot-middle term dynamics, is presented in the article. These mechanisms are: budget ruel, correlation betweeen the monetary and budget politics in the context of gold-currency reserves and the budget funds, two-channel regulation of money basis by the Central Bank, consumers' behavior and labor demand. Including the basic behavior and politics' mechanisms, as well as reflecting the principle structure specifics of the Russian economy gives the opportunity to make scenario analysis of the effects of politics' changes and construct high quality prognoses.

The author (Basdevant, 2000) comes to a conclusion that fiscal consoliddation in the

before-crisis period (before 1998) is not the optimal politics' variant. We think, the budget politics should have been targeted at structural transformations on the supply side. Russia had favoured the conservvative budget politics, which basic target was to support macro-economic stability, that was supposed to provide for the private investment, mainly from abroad. It is still interesting to analize the alternative scenario of government expences dynamics on the basis of our model. This subject is the aim of our future research. The calculation of the optimal budget rule may be of special interest, accounting the aims of reaching the economic stability and the economic growth. This will clarify one of the most disputable problems of the present macro-economic politics in Russia.

Model varification is carried in the interval of 2006—2011. It is necessary to stress that at varification we use the data received at the previous iteration (as the initial conditions), but not the actual data. That means the result is a dynamic prognosis. Fihures A1—A15 show the calculated dynamics of the basic model parameters. The doted line in the charts show the model results, the solid lines show the real data (facts).

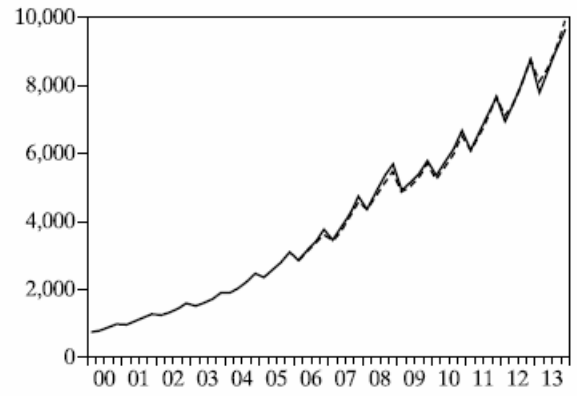

Figure A1. Consumption, bln rub.

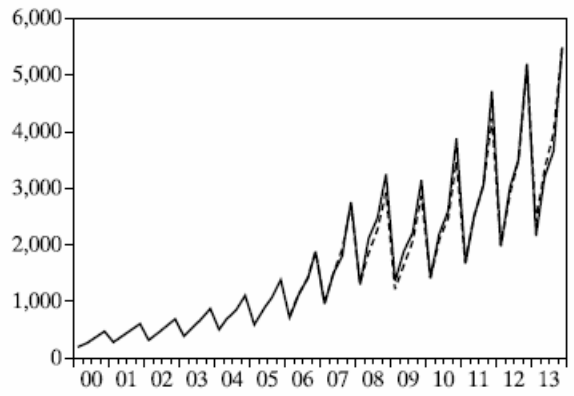

Figure. A2. Accumulated assets, bln rub.

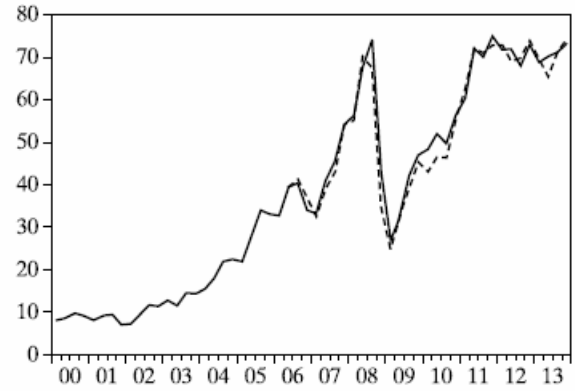

Figure A3. Oil export, bln rub.

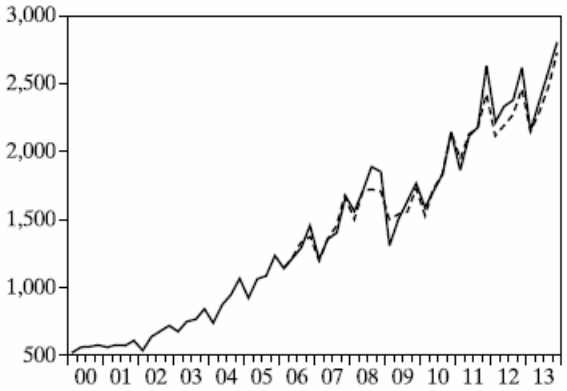

Figure. A4. Non-oil export, bln rub.

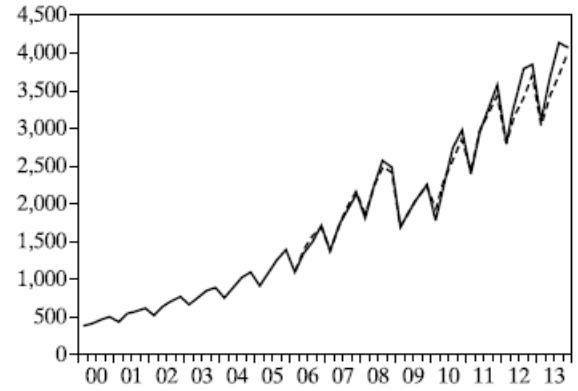

Figure A5. Import, bln rub.

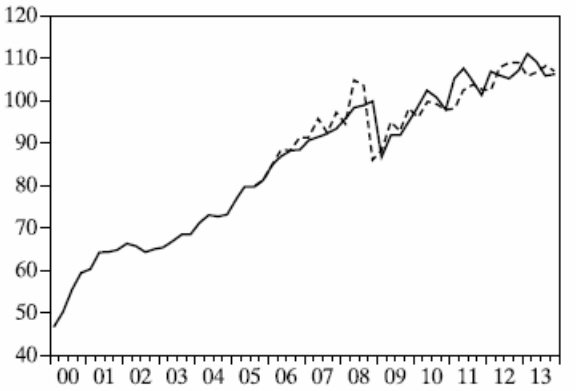

Figure A6. Real effective rouble rate, %

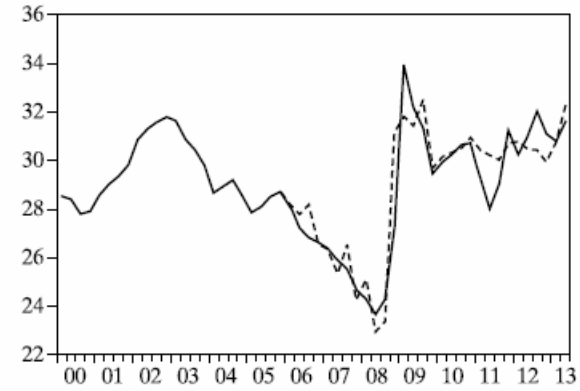

Figure A7. Dollar exchange rate

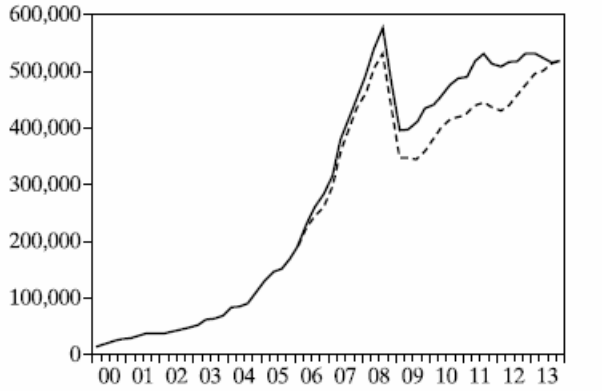

Figure A8. Gold-currency reserves, bln rub.

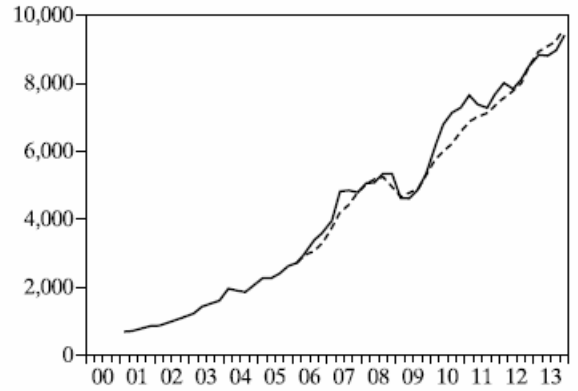

Figure A9. Money basis, bln rub.

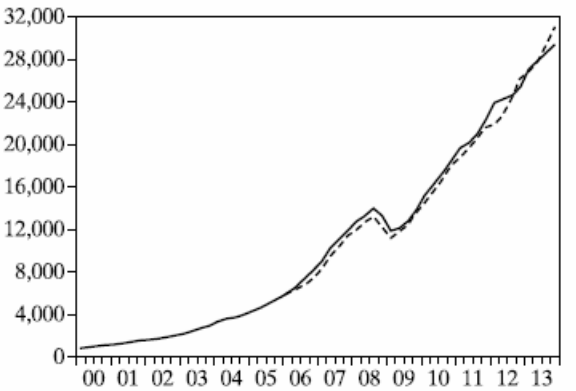

Figure A10. M2, bln rub.

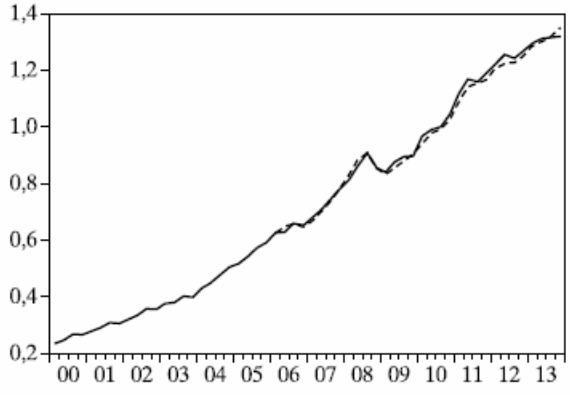

Figure A11. GDP deflator, 2010 = basic year

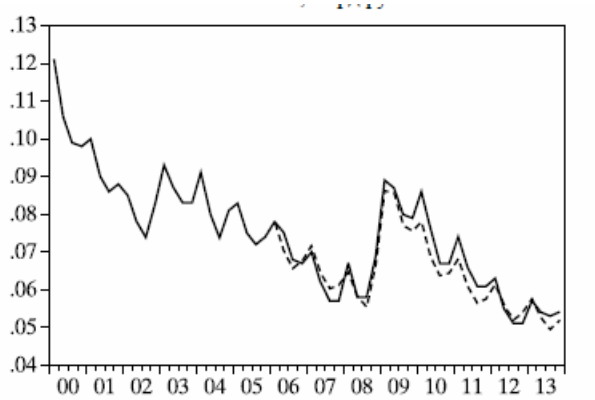

Figure A12. Inemployment, share in potential working population

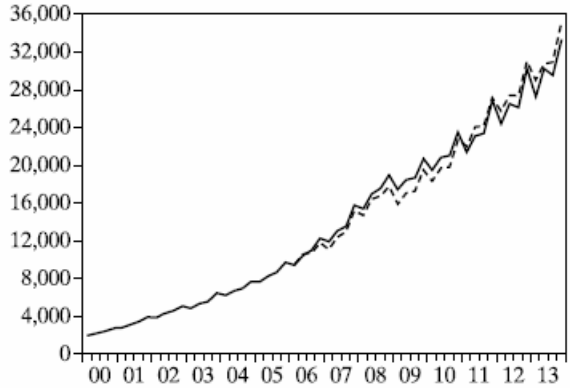

Figure A13. Avarage wage, th rub.

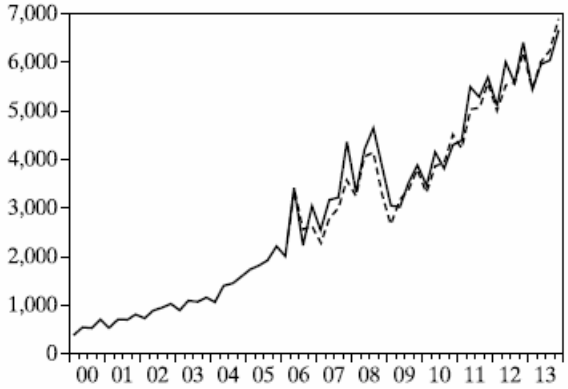

Figure A14. Consolidated budget incomes, bln rub.

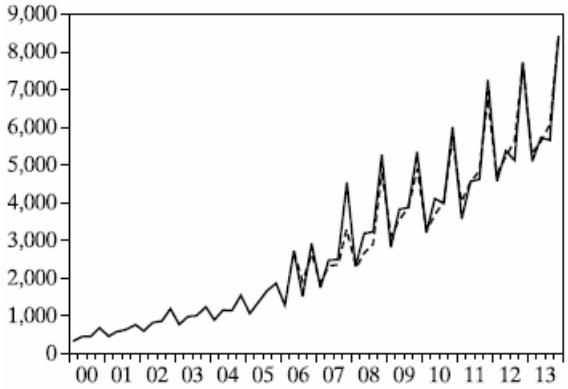

Figure A15. Federal budget expences, bln rub.

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