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Agent-based model of Russian socio-economic system (CGE model with built-in neural networks approach)

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Abstract

The work deals with the computable general equilibrium (CGE) model of Russian socio-economic system with built in neural networks. The authors model bounded rationality of Russian households with the use of neural networks – the most popular apparatus in artificial intellect modeling. The equilibrium state, reflected in aggregate supply and demand equality in the model markets for goods and services, is reached upon iterative recalculations with the use of various equalizing mechanisms. Besides that at each iteration 3 neural networks determine labor mobility parameters, and other 2 networks find the shares of household budgets going to final goods consumption, savings and buying of currency. Neural networks teaching process was implemented with the help Russia Longitudinal Monitoring Survey (RLMS) database. The work provides a review of the major approaches in the field of artificial intellect, outlines the most noted literature on economic agents modeling on the assumption of bounded rationality of their behavior. An example of computational simulation, which determines the consequences of Unified social tax decrease, is given in the end of the work.

Keywords list (en): agent-based model, model of Russian socio-economic system, CGE model, neural networks approach

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Chapter 1. Theoretical issues.

According to the classic consumer behavior theory the decisions are made on the assumption of complete rationality. In other words, the consumer is assumed to make the best decision to maximize the utility from the goods consumed, or to optimize the income from the work the consumer is searching for. It is usually assumed that consumer has information about the possibilities of choice and knows the consequences of each alternative. Nobel prize winner Herbert Simon (2000) criticized this full rationality approach and showed that this model is far from reality. The major argument is that the behavior of a person as a worker is based not on the desire to get maximum money income, but moral satisfaction, connected with social necessities or creative opportunities. Although the notion “moral satisfaction” is not analyzed in the classic economic theory, in psychology it plays one of the most important roles. Non satisfaction of goals is viewed as the main cause of action in most psychological theories. Since the level of aspiration is non-stable and depends on life experience, therefore, achieving satisfaction becomes continual iteration process.

According to Simon (2000) the set of alternatives of a person is considerably smaller than their potential real quantity, which makes it impossible to predict consequences of each of them. It is also that there are various kinds of goals reached by a person, which can not always be measured quantitatively.

The theory of bounded rationality developed by Simon had a number of followers. Many publications of recent years provide detailed analysis of how people make decisions in real life. As an example, we can mention Gigenrenzer and Selter (2002), Rubinstein (1997), Sargent (1994).

We decided to reject the usual method of modeling human behavior by maximizing utility function in favor of non standard bounded rationality approach with the use of artificial intellect technologies.

Many scientists and policy makers have dealt with modeling human behavior, and this has become a separate field in computer science – artificial intellect. The field includes creation of systems with capacities connected to artificial intellect. It should be noted that in that kind of research economic component is not the major one, the main purpose is the issue of making autonomous substances, which can perfect and, if necessary, reproduce themselves.

There are 5 major approaches of modeling artificial intellect: neural networks, evolutionary calculations, expert systems, fuzzy logic, and genetic algorithms. Neural networks, expert systems and apparatus of fuzzy logic are appropriate for modeling

human behavior in socio-economic sphere. Evolutionary calculations are used for other purposes (for self-recovery and self-configuration of complex systems, combining simultaneously functioning modules), and genetic algorithms are used mostly for optimization problems. Since in our work we assume bounded rationality, solving optimization problems becomes inappropriate. As for the remaining 3 approaches of artificial intellect, they have equal value for the constructed model, however, due to specific considerations we preferred neural networks.

8 The model imitates behavior of many individuals combined in one "aggregate consumer". The data for actual survey of several thousand individuals were used to teach this aggregate consumer. Then aggregate consumer was built in the model. We believe that results of functioning of neural networks that were taught on a large number of observations correspond to reality more than expert systems (that calculate predicates from the base of knowledge acquired by several expert interviews) or fuzzy logic systems (that also use rules, constructed by several persons).

9 Before presenting the description of the model let us offer examples of similar research. The theory of bounded rationality developed by Simon has a number of followers. Many publications of recent years provide detailed analysis of how people make decisions in real life. As an example, we can mention Gigenrenzer and Selter (2002), Rubinstein (1997), Sargent (1994). However, only authors of most recent publications share their experience of using artificial intellect within complex models for more adequate description of economic agents' activity. Although Simon (1978) mentioned that in future 20 years research in the field of artificial intellect and cognitive psychology has considerably moved forward understanding of procedure rationality. Simon believed that use of these results in economic theory could deepen understanding of dynamic rationality and influence of institutional structure choice processes.

10 This time gap is due first of all to computer incapability to solve large dimension models, while modern computers allow to make such calculations.

11 Below are the most noted publications in the field.

12 Baldassarre (1997) analyzes Bertrand model where each agent is represented by a combination of 30 neural networks make decisions on setting price for their products. The weights of synapses for these networks are regulated by genetic algorithms. During the "game" each agent chooses results produced by only one network, calculating the consequences (profit, reaction of other agents) of using results of other networks. The research was purely theoretic and did not use real statistical data. The author wanted to demonstrate capability of agents to make decisions with the use of artificial intellect technologies.

13 Zizzo and Sgroi (2000) study the game with Nash equilibrium. One of the actors is represented by neural network, taught on a set of examples of games with Nash equilibrium. In new games, which actor – neural network meets for the first time, equilibrium is achieved in most cases.

14 Grothmann (2002) builds neural network, which imitates currency market functioning. Grothmann does not use of neural networks for obtaining predictions directly. Each neuron in his network is a currency market participant and makes decision

of buying currency of a certain country. The result of simultaneous decisions of a whole set of neurons is the national currency exchange rate.

15 Kooths (1999) describes the combination of neural network and fuzzy logic system (Neuro-Fuzzy Expectation Generator – NFEG), built in economic model of goods and currency markets, as well as markets for securities and labor. According to the theory of bounded rationality the author criticizes the approach which assumes persons' complete knowledge of economic consequences of their behavior. Algorithm of neural network teaching process, changed by Kooths, allows to control actors' economic environment cognitive process to a certain extent, insufficient for complete understanding of the system (this is done consciously, to stress bounded rationality).

16 Besides the above mentioned works on artificial intellect use in economic models, the new approach in applied economics - Agent-based Computational Economics (ACE) – should also be noted. The essence of this approach is modeling virtual world "inhabited" by autonomous agents (economic, biological etc.). A number of researchers are currently involved in the project of creating these kinds of world. Their results can be found at http://www.econ.iastate.edu/tesfatsi/ace.htm. Management of created virtual world of ACE methodology is accomplished without outside intervention, in other worlds it is done purely by agent interaction (Tesfatsion (2002)). At the same time agents should have cognitive capacities.

17 The most popular applied package for modeling parallel distributed virtual world is universal package *SWARM*, created in Santa Fe Institute. *SWARM* in its essense is a set of libraries written on *Objective-C language.* These libraries serve the basis for creating complex multi-agent systems. The package can be viewed at http://wiki.swarm.org. This official site, Economic simulation in SWARM (2000), Russian language work Gutz et al. (2001) give details about *SWARM*.

18 It needs to be noted that almost all the above described models with artificial intellect are theoretical. They use abstract data and their purpose is the adequacy test of the instrument applicability. Unlike these kinds of developments, our model, as is described below, uses actual data and can give adequate results on its basis.

19 It is also that most economic models with artificial intellect technologies are iterational, and the number of iterations is restricted by developers. In our model iterative recalculations continue till the point when aggregate demand and supply coincidence.

20 In this work we decided to use Computable General Equilibrium Model (CGE model) as the basis economic structure in which a set of neural networks is built. The models of this class are the new approach in applied economics and have become widely spread in the world.

21 Combining CGE model and a set of neural networks we obtain a symbiosis of economic system and brain emulator of people in "virtual societies" in the model. Chapter 4 gives details of creating one of these societies.

22 **Chapter 2. Data.**

23 To fill the CGE model with the data mostly State Statistics Committee publications were used. However, the data necessary to teach neural network may attract more interest. For this sociologic databases of RLMS (*Russian Longitudinal Monitoring Survey*) – a series of 1992-2001 all Russia representative surveys, run in two phases, were used. The second phase includes 6 rounds, each of them with more than 3 thousand questions, grouped in adult, child and family questionnaires. On average 10000 adults, 2000 children and 4000 households participated in each survey.

24 In the model we decided to use five neural networks, three of them describe human behavior in choice and change of work, and the remaining two determine family budget expenditure. The selected questions constitute a large set and, therefore, can not be all described here, so we will just outline the range of questions.

25 For teaching the first three networks the questions about wages, type of employer-enterprise property and informal activity were selected. For teaching the remaining two networks the questions on details of household expenditures on final goods (92 groups of goods) were selected, as well as questions about household income and savings.

26 Chapter 4 provides an example of data selection and cognitive process for one of neural networks.

27 **Chapter 3. CGE model.**

28 The researchers currently have a complete CGE model with seven economic agents. The three agents are producers. Here we provide the major attributes of the agents.

29 *Economic agent №1* – state sector of economy. This includes enterprises with state property is more than 50%.

30 *Economic agent № 2* – market sector, consisting of legal enterprises and organisations of private and mixed property.

31 *Economic agent №3* – shadow sector, which includes “gray shadow economy”, and also “white collar”, represented by market sector final goods production for households. We do not examine black economy due to a number of reasons. Firstly, there are no reliable estimations of its spread, which are necessary for calibrating the model. Secondly, we model labor mobility between sectors of economy, and this can be implemented only for shadow and “white-collar” economy, while mobility to black sector is quite accidental and even rough estimates would be inadequate. It should be noted that technically modeling black economy has no differences from modeling other sectors of economy.

32 *Economic agent №4* – aggregate consumer, which combines all households of Russia. This economic agent is represented by a set of “virtual societies”, which make various decisions according to economic situation. These decisions include change of work and change of consumer preferences.

33 *Economic agent №5* – government, represented by an aggregation of federal, regional and local governments, and off budgetary funds. This sector also includes non

commercial organizations serving households (political parties, labor unions, public societies etc.).

Economic agent № 6 – banking sector, which includes the Central Bank of Russia and commercial banks.

Economic agent №7 – outside world.

Production possibilities of the first three agents are set by Cobb-Douglas production function. Input factors are labor and capital. The value of production function shows value added, produced by corresponding sector.

Aggregate economic behavior in the model is described by a totality of markets. Each market is determined by good, price of good and market mechanism. The prices are measured by their values with regard to base period. Below are the three ways of price setting, which determine market mechanism:

1. prices set by state (fixed prices);
2. prices determined by the market;
3. prices determined by shadow market.

Final goods for households are sold at all three prices (3 markets). Final goods for economic agent №5 are sold only at state and market prices (2 markets). Investment and capital goods are also sold only at state and market prices (another 2 + 2 = 4 markets). Therefore, there are 3 + 2 + 4 = 9 inner markets and 1 outer market, where export goods are traded. Besides markets for goods and services, 3 labor markets are also included in the model.

The total number of markets in the model is 9 + 1 + 3 = 13.

During the iteration recalculations in the model, the aggregate supply and demand are equalized in each market according to market mechanisms (in case of state price for good or service equilibrium is reached by changing the share of budget, in case of market or shadow price – by change of the price itself).

As for the consumer actions, at each iteration three neural networks determine parameters of labor mobility, and other two – the shares of budget, going to final goods, savings and currency.

Chapter 4. Data choice for neural network cognitive process.

This chapter describes the data choice and neural network cognitive process, which determines share of parameter , that is a number of state sector workers, who move to the market sector.

Here for the purpose of conciseness the description of only the simplest neural network of the model is provided. Neural networks which determine the shares of household budget are more complex.

Table 1. RLMS questions, selected to teach neural network

	RLMS questions
1	Please tell if you are currently working, you are on paid or unpaid vacation or you do not have any work?

2 How much money have you received within last **30 days** at the main place of work after taxes? Please transfer the sum you received in the foreign currency into rubles and tell the whole sum.

3 Is state owner or co-owner of you enterprise or organization?

47 The resulted set was processed in the following way:

48 **Stage 1.** Only people, who participated in all the rounds of the survey were selected (to observe a person over a period of time).

49 **Stage 2.** Only people who have work were selected (question 1). Among them respondents, who told about their salary (question 2) were further selected, and among those – people, who provided answers on the type of property of their organization (question 3).

50 **Stage 3.** A new parameter was included in each round of the survey. This parameter is quotient from dividing each respondent's nominal wage by consumer price index:

51 **(1)** $$Z_j = \frac{\left(W_j^{t+1} / W_j^t\right)}{\left(\left(P_{1c}^{t+1} + P_{2c}^{t+1} + P_{3c}^{t+1}\right) / \left(P_{1c}^t + P_{2c}^t + P_{3c}^t\right)\right)},$$

52 where W_j^t – wage of respondent *j*, working in the state sector at the time *t*, taken from RLMS questionnaire;

53 P_{1c}^t, P_{2c}^t, P_{3c}^t – state, market and shadow prices for final goods for households.

54 As can be seen from the formula aggregate consumer price index is used for all the three markets for final goods for households.

55 Since three are 6 rounds in the survey, there are 5 parameter of this type: 1) 1995 values to 1994 values; 2) 1996 to 1995; 3) 1998 to 1996; 4) 2000 to 1998; 5) 2001 to 2000.

56 At this stage of processing, the data set is a table, where columns are above mentioned parameters at each year, and rows are observations.

57 **Stage 4.** Only two parameters are necessary to teach neural network: 1) Z_j and 2) indicator, reflecting the type of property of enterprise-employer at time *t+1*, provided at time *t* person worked in the state sector. This indicator has two values: «1» – worker stayed in the state sector, «2» – worker moved to market sector.

58 Since the rest of the variables have been processed and are not needed for further analysis, they have been deleted. The remaining two variables were "glued" in the set of two variables with 1097 observations for the direct teaching process of the neural network.

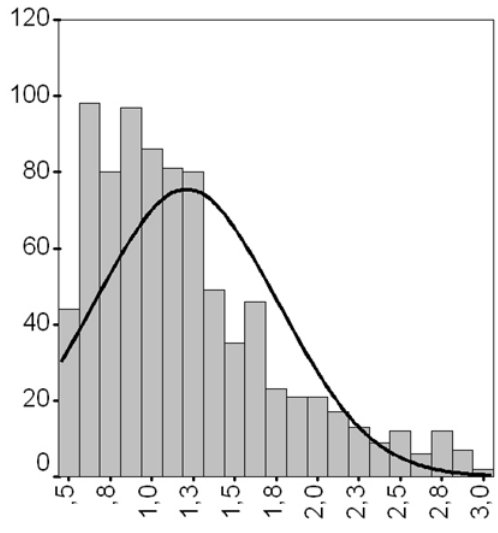
59 **Stage 5.** Let us consider another variable V_j, which demonstrates the difference between variable (1) for a particular worker and variable *Z* of "aggregate worker":

60 **(2)** $V_j = Z_j/Z$, where $$Z = \frac{\left(W^{t+1} / W^t\right)}{\left(\left(P_{1c}^{t+1} + P_{2c}^{t+1} + P_{3c}^{t+1}\right) / \left(P_{1c}^t + P_{2c}^t + P_{3c}^t\right)\right)}$$ – quotient from dividing the state sector "aggregate worker's" nominal wage price index by consumer price index.

61 Variable (2) is not necessary for neural network cognition, but it is necessary to build the network in CGE model. This would be explained later.

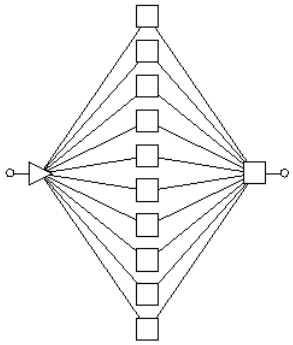
62 **Stage 6.** The final stage of data processing resulted in a set of two variables with 1097 observations. Sometimes the values of Z_j were too large, which made it necessary to clear the set from these outliers, consequently the final number of observations became 839 (picture 1).

63



Picture 1. Histogram of Z_j for all rounds of the survey

64



Picture 2. Architecture of neural network

65 Hence, neural network was taught on 839 observations. Picture 2 gives its architecture. As is seen, it consists of 3 layers, each containing 10 neurons.

66 ***Building neural network in the model***

67 All the above used observations for teaching neural network are interpreted as 839 people of "virtual society", who make decision of moving to market sector or of continuing to work in the state sector. The decision made with the help of neural network is based on considering the necessity of further work in the sector, according to the change in purchasing capacity. In other words, each member of "virtual society" receives the following information in the process of CGE model work:

68 **(3)** $U_j = ZV_j$ – input variable of neural, where V_j – "people differences" constant, calculated according to formula (2), and Z – common variable for all workers, which changes during iteration process.

69 Output variable of neural network is determined by the following equation:

70
$$N_j = \frac{\sum_{k=1}^{10}\left(\frac{1}{1+e^{-\left(\left(U_j \cdot r_{scale}^{in} + r_{shift}^{in}\right) w_{2k} - \tau_{2k}\right)}} \cdot w_{3k}\right) - \tau_3 - r_{shift}^{out}}{r_{scale}^{out}}, \quad \textbf{(4)}$$

71 where r_{scale}^{in}, r_{shift}^{in}, r_{scale}^{out}, r_{shift}^{out} – the shift and scale scaling factors for input and output parameters of neural network;

72 W_{2k} τ_{2k} – synapse weights and activation threshold value for neuron k=1…10 of the second layer;

73 W_{3k} – the strength of synapse link between neural k of the second layer and output neural;

74 τ_3 – output neural activation threshold.

75 Each member of 839 people "virtual society" "makes decision" on the basis of equation (4).

76 In *Excel*, neural network is a table $839 \cdot t$ (t– number of years). Each cell of this table uses formula (4), which in its turn uses other table of the same dimension, containing input data U_j.

77 Obviously, neural network does not produce output with values exactly equal to «1» or «2», therefore, in the model they are rounded till the closest integer. Hence, output value of the network N_j is transformed in the following way:

78
$$N_j = \begin{cases} 1; & 1{,}5 \le N_j < 2{,}5 \\ 0; & 0{,}5 < N_j < 1{,}5 \end{cases}$$

(5)

79 This transformation is necessary to calculate the shares of workers, shifted to market sector, from their total number L:

80

$$I = \left(\sum_{j=1}^{839} N_j \right) / 839$$

(6)

81 As was mentioned, this chapter does not give information on construction and architecture of other neural networks, as well as the calculated values for synapses and thresholds for their elements. Certain moments from neural network theory are also omitted here.

82 **Chapter 5. Test of model adequacy.**

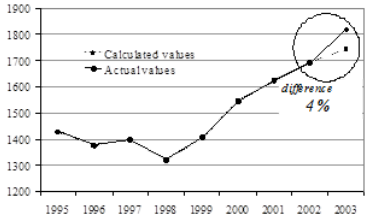
83 Test of model adequacy is necessary before computational simulations in order to understand the capacity of the model to give true predictions.

84 The model was calibrated for the period 1995-2002. The actual values of integral parameters (GDP, consumer price inflation) are known till 2003. To test the adequacy of the model we prolonged all exogenous parameters (shares of budget, share of the product sold at the market etc.) for the tested period. At this time they were not calibrated. Moreover, the adequacy of the model was tested twice:

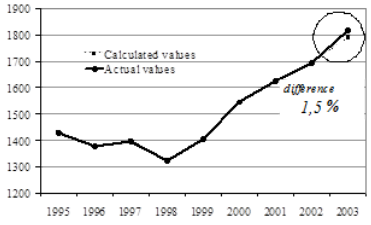
85
- With fixed shares of labor force mobility and household shares of budget, that is without neural networks. In this case consumer behavior is inertial and does not change in response to economic situation.
- With the use of neural networks.

86 Therefore, we can examine the change of calculated data from their actual values, comparing two instruments –standard CGE model and CGE model with neural network.

87 The tables below give estimated and actual values of GDP since 1995 till 2003 in 1995 prices for these two instruments:

88 

Picture 3. Russia's GDP in 1995 year prices (billion rubles), calculated on the basis of standard CGE model

89 

Picture 4. Russia's GDP in 1995 year prices (billion rubles), calculated on the basis of CGE model with built in neural networks

90 As is seen, second result is better than the first one, which underlines the necessity of building neural networks in CGE model. Adequacy of such model demonstrates insignificant differences between estimated and actual values.

91 **Chapter 6. Example of computational simulation – Unified social tax decrease.**

92 Unified social tax (UST) goes to off budgetary state funds (Pension fund, Social insurance fund, Federal and territorial funds for mandatory health insurance). The money are used for realizing the right of citizens for state pension, social provision and health care.

93 Taxpayers of UST are employers, who pay to wage-earners, and individual businessmen. The objects for taxation for UST are:

94 1. Payments on labor contracts;
2. Compensations for accomplished work;
3. Compensations in the form of welfare;
4. In kind compensations.

95 Table 2 gives the current UST rates, according to tax base for each worker. These rates are regulated by Chapter 24 of the Tax Code of the Russian Federation.

96 Table 2. Current UST rates, %

Tax base(*W*) per worker, thousand rubles a year	**UST rate**
$W \leq 100$	35,6%
$100 < W \leq 300$	20%
$300 < W \leq 600$	10%
$W > 600$	2%

97 The Government of the Russian Federation adopted a program of Russian economy development for the future 10 years. The main goals of the program are improvement in the level of life of citizens, reduction of social inequality and reestablishing of economic and political role of the Russian Federation in the world. The following tasks were formulated to reach these goals: 1) development of legislative foundation promoting entrepreneur activity and investment; 2) considerable decrease of tax burden and providing for financial stability in the middle run.

98 In the framework of the above set tasks the President of the Russian Federation has signed Federal law "On entering changes to chapter 24 of the second part of the Tax Code of the Russian Federation", adopted by the State Duma on June, 23, 2004 and the Council of Federation on July 7, 2004.

99 The documents provides for the following UST rate decrease and regression scale change (table 3).

100 Table 3. UST rate chnges, proposed by the government, %

Tax base(*W*) per worker, thousand rubles a year	**UST rate**
$W \leq 100$	26%
$100 < W \leq 280$	
$280 < W \leq 600$	10%
$W > 600$	2%

101 The government of the Russian Federation thinks that UST rate decrease will provide for extra **0,5%** of economic growth. According to Aleksei Kudrin words at the state Duma plenary session during the 2005 budget project, the government considers that UST rate decrease will give extra impulse to economic growth of approximately 0,5% if compared to the situation without UST decrease. Each year these kind of measures are expected to sustain inner factors of economic growth, so that they depend less on favorable external environment. It is also that government calculations show that UST decrease will give extra capital investment growth of **1,5%**. (Source: RIA "Novosti"(29.09.2004)) .

102 Ministry of Finance predicts 280 billion rubles decrease of off budgetary funds' revenues, which would be compensated from the following sources:

103 1. Moving a part of wages from "gray sector". UST will decrease employer costs and will promote legalization of a part of salary, which is now paid "in envelope". Besides that the prime minister M.Fradkov expressed confidence that "the sources, which remain to enterprises will mostly go to increase of salaries and investment".
2. Proficit of the federal budget. Ministry of Finance prognosis for 2005 says that the profit of budget will be 1% of GDP. This means that in case of unexpected circumstances the state would be able to finance diminishing revenues of off budgetary funds.
3. Rejecting part of citizens accumulative part of pensions (people born in 1957 – 1967).
4. Growth of taxes on oil sector. The government of the Russian Federation has adopted the new scale of import duty on oil. According to this scale the government will receive extra 1 billion dollars from oil companies at 24 dollar per barrel price. Except that 414 million dollars will be obtained from the tax on minerals increase (from 347 till 400 rubles per ton). In the total the government expects to receive at least 1,4 billion dollars of extra revenue a year.
5. Increase of excises.
6. Abolishing UST privilleges for small business
7. Redistribution of profit tax between regional and federal budgets.

104 To test the proposed measure of UST rate decrease we conducted the following experiment:

105 In the model we changed UST rate from 35,6% till 26% since 2005. Since the current version of the model studies aggregate consumer, not divided into income

groups, and average annual salaries of workers in the state and market sectors are fewer than 280 thousand rubles, for future calculations UST rate was the same for all workers (26%).

106 Table 4. Annual salary of worker in state and market sector, thous. rubles

Sector	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
State	57,5	67,3	76,4	86,5	97,3	109	122	135
Market	89,5	105	119	135	151	170	189	211
Prediction of the Ministry of Economic Development and Trade for 1 worker regardless of sector	66,1	81,16	97,9	116	135			

107 The values for 2003 were taken form State Statistics Committee sources, and for the following years were calculated with the help of the model. For comparison, the predictions by Ministry of Economic Development and Trade (www.economy.gov.ru) are shown in the table.

108 As a compensation mechanism we added the value of 1% of GDP to off budgetary funds revenues, simultaneously subtracting it from consolidated budget. This operation corresponds to compensation mechanism №2.

109 We can not realize compensations №№ 3, 5, и 7 in the current version of the model, due to the following restrictions:

110
- «Aggregate consumer» is not divided into demographic groups.
- Excises are not separated as a special tax, and enter a group of «other taxes».
- Regional and federal budgets are not separated and represented by consolidated budget.

111 At the same time an annual sum of 1,4 billion dollars (42 billion rubles) will be subtracted from the budgets of agents №№ 1-2 since 2005) and go to off budgetary funds. This operation corresponds to compensation mechanism №4.

112 It should be noted that compensation mechanisms not analyzed in the model are not of major importance, therefore we can predict the consequences of UST decrease with high degree of confidence.

113 The results of the above described «reforms» are demonstrated in table 5.

114 Table 5. Values of Russia's macroeconomic parameters before and after UST decrease

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Russian GDP in 1995 prices **before UST decrease**, billion rubles.	2026	2126	2230	2339	2454	2574
Russian GDP in 1995 prices **after UST decrease**, billion rubles.	2022	2130	2240	2353	2471	2593
Russian GDP growth **after UST decrease**, percent.	-0,215	0,201	0,440	0,588	0,685	0,759
Consumer price inflation **before UST decrease**.	1,075	1,065	1,050	1,050	1,050	1,050
Consumer price inflation **after UST decrease**, billion rubles.	1,062	1,064	1,051	1,050	1,050	1,050
Annual salary of state sector worker **before UST decrease**, thousand rubles.	76	86	97	109	122	135
Annual salary of state sector worker **after UST decrease**, thousand rubles.	76	86	97	109	122	135
Annual salary of market sector worker **before UST decrease**, thousand rubles.	119	135	151	170	189	211

Annual salary of market sector worker **after UST decrease**, thousand rubles.	118	136	154	174	194	216
Number of shadow sector workers **before UST decrease**, million of people	9,54	9,61	9,68	9,75	9,81	9,88
Number of shadow sector workers **after UST decrease**, million of people	9,54	9,61	9,68	9,74	9,81	9,88
Budget of aggregate consumer in current prices **before UST decrease**, billion rubles.	14119	16055	18152	20433	22905	25569
Budget of aggregate consumer in current prices **after UST decrease**, billion rubles.	13907	15874	18010	20314	22799	25474
Consolidated budget of the Russian Federation in current prices **before UST decrease**, billion rubles.	5727	6482	7295	8177	9126	10143
Consolidated budget of the Russian Federation in current prices **after UST decrease**, billion rubles.	5701	6467	7289	8178	9134	10160

115 As is seen from the table, UST decrease caused a small growth of GDP (till 2010 the growth resulted in 0,759%). The annual salary of the state sector worker has practically not changed, and in market sector has increased (on 2,8% in 2010). Since the values of consumer price inflation remain the same, extra revenues are not “eaten” by growth of prices.

116 The budget of households has slightly decreased. This is likely to be attributed to the use of not all of the compensation mechanisms in the model and consequently, off budgetary funds did not receive enough money to pay pensions and allowances.

117 Despite the values of certain parameters, it can be concluded that UST decrease has a favorable impact on the economy. Authors understand that the resulting values of macro parameters in the experiments may not correspond to actual values due to the two main reasons: firstly, the model does not include all compensation mechanisms and secondly, one can not predict how long oil prices remain high. In other words would it be possible to compensate the revenues of off budgetary fund with the help of oil industry?

Агентная модель российской социально-экономический системы

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