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Perfection of Interbudgetary Relations as a Factor of Economic Growth of Depressed Miner Territories

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Abstract. The article is devoted to the improvement of decision-making processes in the management of inter-budgetary relations between the regions and depressed mining municipalities. The tools of decision-making support in the form of economic and mathematical models included in the control circuit are proposed. Economic and mathematical tools are based on the application of the mathematical apparatus of the theory of stochastic automata in random environments. The constructed mathematical abstraction "stochastic automaton" describes the behavior of the decision-making subject in determining the norms of shared distribution of tax revenues between budgets on the vertical line of power. A stochastic automaton possesses the property of learningability of expedient behavior. The decisions made by the automaton regarding the values of the tax revenue distribution norms are quantified through interaction with the simulation model. The simulation model forms a random environment in which the stochastic automaton is immersed, and reacts to the administrative decisions made by the automaton through its encouragement and punishment. The article proposes the construction of a stochastic automaton, described by its transition function. The transition function of an automaton from state to state is formally represented by matrices. The authors derive analytical expressions for the final probabilities of the machine in each of its states. The efficiency of the economic and mathematical tools is demonstrated through the presentation of the results of the conducted experimental studies in the selection of options for decisions regarding the share of the distribution of tax revenues.

1. Introduction

At the present time, in view of the external political and economic conjuncture, Russia faces the problem of finding ways to ensure competitive advantages of the economy and national security. The most important direction of national security is to improve the management of territorial administrative units in order to ensure their financial independence by finding reserves for economic development. The financial independence of regions and municipalities is called upon to ensure the policy of economic growth. The wide range of scientific works of Russian scientists is devoted to the development and implementation of economic policies oriented to economic growth. Theoretical and conceptual bases for the development of social and economic systems formed in the works of Glazyev SY, Nizhegorodtseva RM, Sukhareva OS, Kupryashina GL, Makogonova NV, Sidorova AV, Belokrylova O .S., Belokrylova K.A. [1,2,3,4,5]. Mechanisms of socio-economic development and reducing the territorial asymmetry of socio-economic development are revealed in the works of Matveyeva LG, Chernova OA. [6,7,8,9]. The research of the influence of the institutional organization of competitive relations on the development of modern economy is devoted to the works of Ignatov VG, Ignatova TV,

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Maltseva OG [10,11,12,13]. In accordance with the stated goal of ensuring economic growth, as well as with the leading challenges and trends of world development, at present priority is given to innovation policy, in which the development of the digital economy plays a significant role. The digital segment in the management of public and municipal finance is called upon to use innovations in management decision-making technologies. Management decisions should be based on intellectualized computer technologies, adaptive ones used, having the property of learningability, appropriate behavior, economic and mathematical models. These models should have the ability to formalize, accumulate and use the knowledge of natural intelligence in the decision-making process. In this regard, in order to improve the management of public and municipal finances, it becomes necessary to use a new, non-traditional toolkit of intellectual support for decision-making that contributes to the creation of conditions for a balanced socio-economic development of administrative-territorial units.

2. Relevance

The pace of economic development in Russia is largely determined by the socio-economic status of municipalities, the main objective of which is to focus on increasing the welfare of citizens. The main challenges faced by local authorities in this regard are the creation of sufficient jobs and an increase in the tax base. The Russian economy is characterized by a significant differentiation of municipalities in terms of budgetary provision, among many recipients of which a special place is occupied by depressed mining areas. These areas due to various kinds of subjective reasons, has lost its socioeconomic importance and benefits. Their economic condition is characterized by a high level of subsidization and, as a consequence, high budget dependence. It should be noted that this problem is particularly acute in coal-mining municipalities. Therefore, the modern mechanism of management of the formation of budget revenues of coal mining municipalities is particularly in urgent need of improvement. In the composition of the instruments of this mechanism, should strengthen the active component of budgetary control through the provision of rights of use of depressive miner's municipalities collect part of their territory taxes. In this regard, the problem of the development of tools to formalize the determination of the amount of deductions to the budgets of mining cities and settlements from Federal and regional taxes intended for inclusion in the budgets of higher levels is actualized. The article offers economic and mathematical models of the formalized description of the subject's behavior in the process of decision-making on the management of the shared distribution of tax revenues.

3. Problem statement

As a control object is considered budgetary fund of the municipality in the aspect of the dynamics of admission processes, use of funds, as well as their storage budget. The nature of these processes during the time interval of the object functioning T clearly observed the existence of a number of the successive time behavior modes. These modes are due to changes in the list of taxes transferred by the region established standards $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_k(t)\}$, where $\varphi_i(t)$ is the value of the norm of allocations to the local budget from the tax type *i*. Regime change is due to changes in the structure of the revenue part of the budgets of all levels, caused by changes in the components of the vector of structural states $\varphi(t)$. In this regard, the entire time interval T existence of the system is naturally divided into many sub-intervals $T_1, T_2, ..., T_{\chi}$, $T_i = (t_i, t_{i+1})$, during which the proportion of allocation of taxes and fees, determined by variables $\varphi_i(t)$, are permanent. Changing the nature of receipt of the input signals, depending on the changes in the values of the components of the vector $\varphi(t) = \{\varphi_1(t), \varphi_2(t), \dots, \varphi_k(t)\}$ leads to a change of the space of generalized coordinates (changing input alphabet due to inventory changes and standards of tax payments and fees) and, consequently, a change in the phase trajectory, the point of which correspond to the different the values of the phase states. As the phase state of the taken value of Q(t) residues of funds in the budget at the municipal level, accumulated in the budget system at the municipal level in time t. The multi-mode nature of the processes of functioning of a control object (budget fund) causes problems in their modeling, as well as in the formulation object management tasks in which they occur. In this regard the task of creation of the mathematical model containing mechanisms of the operated change of interactions with the budget of regional level and also mechanisms of adaptation of laws of her functioning to change of the modes of functioning is set. Such models can be useful not only for the solution of problems of share distribution of financial resources between levels of the budgetary system.

4. Methodological problems of modeling

The solution of methodological aspects of modeling of difficult behavior of object of management of an objective have demanded abstract representation of difficult dynamics of the budgetary streams passing through budgets of the budgetary system of the Russian Federation in the form of transformation of alphabets difficult dynamic system. In the researches conducted now formalization of statement and the solution of problems of management of material streams is carried out on the basis of application of theoretical developments of the theory of dynamic systems [14]. Within the framework of this theory formalization staging dynamic systems management tasks is built on the basis of the application of the principle of coordinate control Bellman, formulated as follows: u(t) Dynamic Control system on the entire time interval of its existence T is a function of the phase state of $u(t) = \xi(t, Q(t))$ [14]. But use of the principle of coordinate management of R. Bellman doesn't give the chance to consider variations of discrete structural states and leads at the formal description of a problem of management to violation of the principle of a necessary variety of Eshbi. This paper proposes a new control principle based on the principle of extended Bellman - the principle of co-ordinate the structural control. The principle is formulated as follows. Management of difficult dynamic system on all an interval of her existence is function of streamlining of structural states within which management is function of a phase state. Throughout the existence of a time interval T considers the complex dynamic levels is a superposition of two different nature areas: the continuum in a finite space of generalized coordinates and countable set of structural states. Conceptual model of the functioning of these systems is presented as a family of two dynamic systems of the $\Sigma = \langle \Sigma_1, \Sigma_2 \rangle$, where Σ_1 is a continuous dynamic system of undertaking management in the field of finite-dimensional space continuum of income and expenses; Σ_2 – discrete dynamical system, which control the counting on the set of structural states, defined by the vector $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_k(t)\}$. Transition function Σ_2 systems represents $\lambda: T \times \{\varphi(t)\} \rightarrow \{0,1\}$ predicate. Management u(t) in system $\Sigma = \langle \Sigma_1, \Sigma_2 \rangle$ is the piecewise and continuous function containing a calculating set of transitions on all T interval. Suppose that $\hat{U} = \{\hat{u}(t)\}$ - set of continuous functions, which each represent a range of T function self continual dynamic system Σ_1 . Then self-government of u(t) on all an interval of T represents piecewise and continuous function. On the range T may countable set of switches in the operation of the system Σ . Switchings happen on logical conditions of $\lambda(T, \varphi(t))$ to area of values {0,1}. Then piecewise and continuous function u(t) of self-government is described as sequence of continuous functions:

$$u(t) = \sum_{i=1}^{k} \lambda(T_i, \varphi(t_i)) \cdot \hat{u}_i(t); \ \lambda: T \times \varphi(t) \to \{0, 1\};$$

$$\lambda(T_i, \varphi(t_i)) \wedge \lambda(T_j, \varphi(t_j)) = 0; \ i \neq j.$$

$$(1)$$

Organized thus difficult dynamic system $\Sigma = \langle \Sigma_1, \Sigma_2 \rangle$ during each of subintervals of T_i behaves as continuous dynamic system. The behavior of system on all an interval T existence is continuous and discrete, or hybrid.

5. Theoretical aspect of modeling

In order to implement the operation of the law, flowing in a dynamic system, the Σ_1 , developed a simulation model, which reproduces the dynamics of the operation of the budget flows through the municipal education budget fund [3,4]. Functioning of system Σ_2 is realized by means of functions of an

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exit and transition of the stochastic automatic machine functioning in casual environments [15,16,17,18,19,20]. As elements of the set of states $\varphi^{(1)} = \{\varphi_1^{(1)}, \varphi_2^{(1)}, ..., \varphi_n^{(1)}\}, \quad \varphi^{(2)} = \{\varphi_1^{(2)}, \varphi_2^{(2)}, ..., \varphi_n^{(2)}\}$ stochastic automaton A values are considered vectors of $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_n(t)\}$, acting as structural states. The submachine gun A as output signals to the being able $\varphi(t)$ considers sizes $Q(t,\varphi(t))$. The values of $Q(t, \varphi(t))$ are the phase states of a dynamic system Σ_2 . These output signals cause response of the environment in which the submachine gun A is shipped. The set of reactions of the environment is broken into two classes: class of reactions favorable and class of reactions adverse. The set of reactions of the environment is divided into two classes: class of reactions favorable and class of reactions adverse. If the output signal of the submachine gun A of the being able $\varphi(t)$ is equal to Q(t) < 0, then Wednesday makes an adverse effect. If its action at time t machine has led to a surplus in the system Σ_1 , ie, to the value of Q(t) > 0, then Wednesday reacted favorably. Estimates of probabilities of favorable p_i and adverse q_i reactions of the submachine gun A of the being able $\varphi_i(t)$ allow to consider the submachine gun A shipped on casual Wednesday with estimates of probabilities of penalties $p = (p_1, p_2, ..., p_n)$ [21,22,23,24,25]. The fact that the automaton A makes decisions about ongoing operations on the environment under the conditions of uncertainty, makes it necessary to choose a structure in which its behavior has a maximum expediency. Expediency consists in increase in number favorable and reduction of number of adverse effects irrespective of sizes of characteristics of the casual environment $p = (p_1, p_2, ..., p_n)$. In [21,22,23] developed a machine design that defines the transition function using transition matrices from one state under the influence of the input signals $\delta = 0$ (matrix $a_{ii}(0)$) and $\delta = 1$ (matrix $a_{ij}(1)$). Matrix and have the form:

$$\|a_{ij}(1)\| = \begin{vmatrix} 1 & 0 & 0 & \dots & 0 \\ 0 & 1 & 0 & \dots & 0 \\ 0 & 0 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & 1 \end{vmatrix}$$
(3)
$$\|a_{ij}(0)\| = \begin{vmatrix} 0 & 1 & 0 & \dots & 0 & 0 \\ \gamma & 0 & 1 - \gamma & \dots & 0 & 0 \\ \gamma & 0 & 1 - \gamma & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & 0 & 1 - \gamma \\ 0 & 0 & 0 & \dots & 1 & 0 \end{vmatrix} .$$
(4)

In modern researches [20,21,22,23] also other designs of stochastic automatic machines which behavior differs in transition not only to the next states are known. Such structures require simulation of behavior of automata in random media constituents. The adequacy of the chosen machine structure depends on the conditions of the functioning of municipal budgets. The proposed article automaton model is characterized by a simplified structure, and, as will be shown below, has the property of purposeful behavior. In matrixes $a_{ij}(0)$ and $a_{ij}(1)$ variables γ selectivity of strategy of the automatic machine at a penalty is designated. The matrix of transitional probabilities of $||p_{ij}||$ has an expression appearance:

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	q_1	p_1	0		0	0
<i>p_{ij}</i> =	γp_2	q_2	$(1-\gamma)p_2$		0	0
	0	γp_3	q_3		0	0
	0	0	0	\mathcal{P}_{N-1}	q_{N-1}	$(1-\gamma)p_{N-1}$
	0	0	0	0	p_N	q_N

Then the system of the equations for definition of final probabilities $r_1, r_2, ..., r_N$ stay of the automatic machine in a certain state will register in the form of [21,22,23]:

$$\begin{cases} r_1 = q_1 r_1 + \gamma p_2 r_2, \\ r_2 = p_1 r_1 + q_2 r_2 + \gamma p_3 r_3, \\ \dots \\ r_N = (1 - \gamma) p_{N-1} r_{N-1} + q_N r_N. \end{cases}$$
(6)

Expressions for the final probabilities r_i , $i = \overline{1, N}$ obtained by solving the system of equations are [21,22,23]:

$$r_{1} = \frac{1}{1 + p_{1}\Theta}, \ r_{2} = \frac{p_{1}}{\gamma p_{2}\Theta}, \ r_{N} = \frac{p_{1}(1 - \gamma)^{N-2}}{\gamma^{N-2} p_{N}\Theta},$$
(7)

where
$$\Theta = 1 + p_1 \sum_{i=2}^{N-1} \left(\frac{1}{p_i} \frac{(1-\gamma)^{i-2}}{\gamma^{i-1}} + \frac{p_1}{p_N} \frac{(1-\gamma)^{N-2}}{\gamma^{N-2}} \right)$$
 (8)

In [24,25] the proof of theorems of expediency of behavior of the automatic machine and an asymptotic optimality of sequence of automatic machines of the offered structure is provided. Expediency of behavior means that when functioning the automatic machine will win more often and less often to lose.

6. Experimental studies and the theoretical significance of simulation results

The constructed automaton model, describing the behavior of the subject of decision-making on interbudgetary regulation, was programmed and used in the process of experimental research. A random environment in which a stochastic automaton is immersed is created by an imitation model that allows us to determine the size $Q(t, \varphi(t))$ of the budget stock at the current time and at the end of the planned period with different combinations of the values of the vector components $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_n(t)\}$. This makes it possible to evaluate the quality of the decisions made with respect to the vector $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_n(t)\}$ by determining the quantities p and q. In the course of experimental studies of the simulation model, a complete factor experiment was performed with a factor $\varphi(t) = \{\varphi_1(t), \varphi_2(t), ..., \varphi_n(t)\}$ variation at two levels [0,1]. Thus deductions from payment of taxes of the following types were defined: X_1 – the income tax of physical persons; X_2 – the property tax of the organizations; X_3 – the unified imputed income tax for separate types of activity; X_4 – the uniform tax levied in connection with the simplified tax system. According to the collected statistical data, the laws of distribution of random variables X_1 , X_2 , X_3 , X_4 , X(t), Y(t) and determined the magnitude *p*, *q* and the final probability $i = \overline{1,4}$ (table 1). The variable table shows the value of the standard deduction from the tax type X_i . The number of experiments was determined as 2^n equal to 16 at n = 4.

N⁰	the c vecto	$\begin{array}{c} \text{ompo} \\ \text{or} \varphi(t) \end{array}$	nents	of the	<i>p</i> _i	№	the components of the vector $\varphi(t)$				P_i
	ϕ_1	ϕ_2	ϕ_3	ϕ_4			ϕ_1	ϕ_2	ϕ_3	ϕ_4	
1	0	0	0	0	0,835	9	1	0	0	0	0,525
2	0	0	0	1	0,772	10	1	0	0	1	0,581
3	0	0	1	0	0,674	11	1	0	1	0	0,332
4	0	0	1	1	0,627	12	1	0	1	1	0,317
5	0	1	0	0	0,593	13	1	1	0	0	0,332
6	0	1	0	1	0,365	14	1	1	0	1	0,330
7	0	1	1	0	0,248	15	1	1	1	0	0,324
8	0	1	1	1	0,263	16	1	1	1	1	0,322

Table 1. The results of the active experiment.

Graphs of changes in the probability of winning at different values of strategy selectivity are shown in Fig.1. Expressions (7,8) was determined final probabilities, the graphics changes are listed on pисунке2. In [20,21,22,23] the model of stochastic automata game is developed, which allows to determine compromise values of norms of deductions to the budget of depressive municipality from taxes X_1 , X_2 , X_3 , X_4 (table 2).



$$\gamma = 0,4$$
, $\gamma = 0,5$, $\gamma = 0,6$, $\gamma = 0,7$

Figure 1. Graphs of the final probabilities when the values of the selectivity tactics.

Table 2. Compromise values of tax deductions to the local budget.

The selectiv- ity of the tactics of the machine	Norms of X_1	of deduction X_2	X_3	<i>X</i> ₄	The selec- tivity of the tactics of the ma-	Norm X_1	s of dedu X_2	X_3	<i>X</i> ₄
					chine				
$\gamma = 0.4$	0,008	0,03	0,01	0,2	γ = 0,6	0,9	0,74	0,61	0,59
$\gamma = 0,5$	0,2	0,18	0,25	0,3	$\gamma = 0,7$	0,99	0,95	0,83	0,69

7. Practical relevance of the Toolkit

IOP Conf. Series: Earth and Environmental Science 272 (2019) 032164 doi:10.1088/1755-1315/272/3/032164

The practical significance of the research results lies in the possibility of using the constructed economic-mathematical models to solve practical problems. The created economic and mathematical tools can be used both in financial institutions and in various organizations to support decision-making in the allocation of various resources.

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