MODELING INFORMATION-RECEIVING SYSTEMS AND PROCESSES IN THE TAX CONTROL SYSTEM

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МОДЕЛИРОВАНИЕ СИСТЕМ И ПРОЦЕССОВ ПОЛУЧЕНИЯ ИНФОРМАЦИИ В СИСТЕМЕ НАЛОГОВОГО КОНТРОЛЯ

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Tayanch so‘zlar: soliq tekshiruvlari, tavakkalchilikka moyillik, axborotni tarqatish, tarmoqdagi Markov jarayonlari, fikrlar dinamikasi.

Rezyume. Ushbu maqolada soliq to‘lovchilarning tavakkalchilik holati va soliq to‘lashdan bo‘yin tovlashning yakuniy taqsimlanishiga ta‘sirini Markov jarayoni asosida o‘rganildi. Tarmoqlarni va ulardagi axborotni tarqatish jarayonini modellashtirish bo‘yicha bir qator tajribalar o‘tkazildi. Olingan natijalarning qiyosiy tahlili keltirilgan.

Ключевые слова: налоговые проверки, склонность к риску, распространение информации, Марковские процессы в сети, динамика мышления.

Резюме В данной статье изучается влияние статуса риска налогоплательщика и уклонения от уплаты налогов на окончательное распределение на основе Марковского процесса. Был проведен ряд экспериментов по моделированию сетей и процесса распространения информации в них. Представлен сравнительный анализ полученных результатов.

Key words: tax audits, risk-propensity, information dissemination, Markov processes on the network, dynamics of opinions.

Summary. This article studies the impact of the taxpayer's risk status and tax evasion on the final distribution based on the Markov process. A number of experiments were conducted to model networks and the process of information dissemination in them. A comparative analysis of the obtained results is presented.

Introduction. Currently, it is impossible to underestimate the influence of information on many areas of human activity – the economy, healthcare, business processes, education, etc., including the tax system, which performs fiscal, social, regulatory, incentive and control functions. All participants in the tax system, both tax authorities and taxpayers, strive to use information about each other's behavior to their advantage. In studies [1-4], game-theoretic and probabilistic approaches to tax modeling were used, which strictly mathematically showed the ineffectiveness of a general tax audit. Based on the previously obtained results, as a tax regulation tool, this paper considers a model that includes the process of disseminating information about future tax audits among the taxable population in order to stimulate tax payments. On the one hand, tax revenues play a very important role in many social institutions and increase the efficiency of the distribution and social functions of the tax system [5], on the other hand, individual economic agents prefer to evade taxes by deliberately understating their declared income.

In this paper, an evolutionary model of tax control is constructed and the behavior of agents is analyzed using the Markov process presented in the De Groot model. *A* series of experiments were conducted to illustrate possible economic scenarios.

Static model. Applying the results of [4,6], consider a population consisting of n taxpayers. We will consider an individual as a taxpayer and, accordingly, his income tax as a tax. Each agent of such a population can be characterized by the true level ξ of his income and at the same time declare it as η in the current tax period, $\eta \leq \xi$. To simplify further reasoning, let us assume that both variables - true and declared income levels - can take three values: L, M and H, where $0<L<M<H$ (which is a simplified modification of the models [3,10]). Because of this, the population consists of three groups: agents with a high level of true income H (number of agents in the group n_H), agents with an average level M (number of the group n_M) and a group of agents with a low level L (number of n_L):

$$n_L + n_M + n_H = n.$$

Thus, within the framework of the model under study, the following profiles of tax evasion are possible [3,16], formally represented as follows:

1) $\eta(\xi)= L(H)$; 2) $\eta(\xi)= L(M)$; 3) $\eta(\xi)= M(H)$.

Tax audits of those who declared $\eta = L$ are carried out by tax authorities with probability *PL* during each tax period; those who declared $\eta=M$ are checked with probability *PM*. There is no need to check those who declared $\eta = H$, since they are a priori not evaders. Let us assume that tax audits are absolutely effective, i.e. identify the existing deviation in all cases under consideration. If the audit reveals existing tax evasion, the evader must pay his tax arrears and a fine proportional to the level of evasion, i.e. $(\theta + \pi)(\xi - \eta)$, where the constant coefficients θ and π are the tax and penalty rates, respectively. The cost of one tax audit is also constant and amounts to c.

Here are the payoff functions of taxpayers for various ways of their behavior:

$u(L(L)) = (1 - \theta) \cdot L$, $u(M(M)) = (1 - \theta) \cdot M$, $u(H(H)) = (1 - \theta) \cdot H$,

$u(L(H)) = H - \theta L - P_L(\theta + \pi)(H - L)$, $u(M(H)) = H - \theta M - P_M(\theta + \pi)(H - M)$, $u(L(M)) = M - \theta L - P_L(\theta + \pi)(M - L)$.

In [2–4], a "threshold" value P^* of the probabilities of checking P_L and P_M was obtained, which, under conditions of agents being informed about their values, are critical for making a decision to evade ("Threshold Rule"). According to this rule, risk-neutral agents can change their decision to evade:

1) from H to M, if $P_M = P^*$;

2) 2) from M to L, if $P_L = P^*$;

3) from H to L, if $P_L = P^*$ and $P_M = P^*$ simultaneously, where

$$P^* = \frac{\theta}{\theta + \pi}. \qquad (1)$$

However, since the tax authorities' budget is significantly limited, achieving these audit probability values is practically impossible. Thus, tax authorities need to turn to additional means to encourage taxpayers to pay taxes in accordance with the true level of their income. As such a method of stimulation, we will choose the dissemination of information about future audits, which overestimates the real indicators of the share of taxpayers planned for audit. Due to the model's assumption that three levels of taxpayer income are considered, two types of information can be inserted: $PL \geq P^*$ and $PM \geq P^*$.

Each agent of the system strives to increase personal well-being. At the same time, providing the population with social benefits is one of the functions of the tax system [5]. Because of this, the main quantitative characteristic of the effectiveness of taxation is the net income of the tax system, received as the total tax collected from the population, minus the total expenses aimed at ensuring tax control.

Let us determine the net income of the tax system for two different situations. In the first case, *TT R1*- is the net income of the tax authorities in the absence of information, when the only non-evading taxpayers are risk-avoiding agents, whose share among the entire population is ν_a:

$$\begin{aligned} TTR_1 &= n_L\theta L + \nu_a\theta(n_M M + n_H H) + \\ &+ (1-\nu_a)(\theta+\pi)(P_L(n_M(M-L) + \\ &+ n_H(H-L)) + P_M n_H(H-M)) - \\ &- n(P_L + P_M)\,c. \end{aligned} \qquad (2)$$

In the second case, TTR_2 is the net income of the tax authorities in a situation where at the initial point in time an information dump was carried out, then the information received about the audits was disseminated by agents when communicating with each other, after which the entire system stabilized after some time (the dissemination of information was completed):

$$\begin{aligned} TTR_2 &= n_L\theta L + \nu_a\theta(n_M M + n_H H) + \\ &+ \nu^T_{inf}\theta(n_M M + n_H H) + \nu^T_{ev}(\theta(n_M + n_H)L + \\ &+ (\theta+\pi)(P_L(n_M(M-L) + \\ &+ n_H(H-L)) + P_M n_H(H-M))) - \\ &- n((P_L + P_M)\,c + \nu^0_{inf} c_{inf}). \end{aligned} \qquad (3)$$

Here ν^T_{inf}, V^T_{ev} are, respectively, the shares of those who perceived the information and ignored it and continue to evade at the final moment (in the stationary state of the system), V^0_{inf} is the size of information dumping (the share of those informed at the initial time $V^0_{inf} = V^0_{inf}(t0)$), *Cinf* is the specific the price of such stuffing. At the same time, one of the main assumptions of the model is that stuffing costs the tax authorities significantly less than a tax audit: $c_{inf} << c$.

Network model. Note that the social connections of each taxpayer can be represented in the form of networks with different topologies [9–10]. Each population agent treats the information received depending on his personal risk appetite and the surrounding social environment.

To model the process of disseminating information about checks in the network taxpayers that occurs following an information leak, we consider an algorithm based on a Markov process similar to that described in [10]. Within the framework of this model, we will explore the possibility of injecting two types of information: $P_L \geq P^*$ and $P_M \geq P^*$. Consequently, we get the following options for information impact:

throw in both types of information alternately, thereby stimulating taxpayers not to evade only one of the groups;

throw in both types of information at the same time, incentivizing everyone to pay taxes in accordance with their true level of income.

An algorithm based on a Markov process on a network. We will consider the taxable population as a directed network $G = (N, P)$, where N is a set of economic agents (in the current study this is a finite but large set $N = \{1,..., n\}$), and P is a stochastic matrix of connections : its elements depend on the presence of social connections between agents that are not strictly deterministic. In the case when there is a social connection between taxpayers i and j, the element of this matrix is strictly positive: $pij>0$ $(i, j \in N)$;

Moreover, the value of this parameter is close to 1 if the i-th agent has reason to assume that the j-th agent has expert knowledge about the probability of verification, and close to 0 otherwise. Matrix P can have different modifications, which determine the corresponding options for the network structure. These options can be summarized and classified.

Let us assume that at the initial moment of time each taxpayer from N has some idea $f_{L}{}^{0}_{i}$ and $f_{M}{}^{0}_{i}$ aboity threshold for all taxpayers in the population. In accordance with the “threshold ut the values of the audit probabilities P_L and P_M respectively. Such parameters characterize the initial (natural or psycho-logical) propensity of the i- th agent to take risks. Moreover, we will assume that he makes a decision on tax evasion, comparing $f_{L}{}^{0}_{i}$ and $f_{M}{}^{0}_{i}$ with the audit probability value (1), which is the sensitivity threshold for all taxpayers in the population. In accordance with the “threshold rule”, one of the formulations of which was presented in [3] and generalized in paragraph 2, we obtain that the i-th taxpayer evades paying taxes under the conditions $f_{L}{}^{0}_{i} < P^*$ and $f_{M}{}^{0}_{i} < P^*$, and if the threshold P^* is exceeded, he prefers not to take risks.

The interaction of taxpayers leads to an update of their ideas about the likelihood of an audit at each iteration:

$$f_{L}{}_{i}^{k} = \sum_{j=1}^{n} p_{ij} f_{L}{}_{j}^{k-1},$$

similarly for $f_{M}{}^{k}_{i.}$

The interaction continues indefinitely or until the moment when, for some k, the conditions are not met for all i

$$f_{L}{}_{i}^{k} \approx f_{L}{}_{i}^{k-1} \tag{4}$$

and

$$f_{M}{}_{i}^{k} \approx f_{M}{}_{i}^{k-1}. \tag{5}$$

Changes at each iteration of the values of $f_{L}{}^{k}_{i}$ and $f_{M}{}^{k}_{i}$ lead to a revision of the risk status by the i-th agent: the smaller $f_{L}{}^{k}_{i}$ and $f_{M}{}^{k}_{i}$, the higher the risk appetite of a given taxpayer.

In order to carry out information injection about the possible values of the probability of future audits, the tax authorities need to properly in form at least one agent from the population. Moreover, if there is a taxpayer in good standing on the network whose knowledge of the audit probability value may be considered by others to be an expert opinion, tax authorities can use this to increase their influence over the information dissemination process across the network.

The role of such an information center can be performed by any of the taxpayers $l \in N$. Let S be the set of agents for which the condition $plj > 0, l \neq j$ is satisfied. Let us assign the parameter $\alpha\mu l$ to the information center, expressing the degree of its confidence in the value $f\mu 0\ l$, where $\mu \in \{L, M\}$. Then, after implementing the information center, the updated elements of the l-th row of matrix P will have the following form:

$$p_{lj} = \begin{cases} \alpha_{\mu_l}, & l = j, \\ \frac{1-\alpha_{\mu_l}}{|S|}, & j \in S, \\ 0, & j \notin S, l \neq j, \end{cases}$$

where μ takes one of the values from the binary set $\{L, M\}$ depending on what type of information is distributed by this information center.

Using the described model, one can imagine the desire of tax authorities to inflate the perceptions of the taxpayer population about the values of the probabilities of a future audit. In this case, the parameters of the information center are $f_{\mu}{}^{0}_{l} = 1$, $\alpha_{\mu l} \approx 1$.

Numerical modeling. The proposed approach to modeling tax control, taking into account the dissemination of incentive information among taxpayers, provides many different scenarios for analysis. For this purpose, within the current framework, numerical experiments were carried out using specially prepared software product, a detailed description of the operation of which is presented in [10].

Cases of information dissemination over a network without information centers, as well as with one and two information centers distributing various types of information about the probability values of P_L and P_M checks were considered.

Experimental parameters. The numerical experiment is carried out under the assumption that all taxpayers have different risk appetites. Based on the results of a psychological study devoted to the attitude towards risk of various social groups, we will use the following distribution: the share of risk-prone agents among the entire population of taxpayers reaches 18%, the share of risk-neutral agents is 65%, and risk-avoidants are 17%.

In accordance with the model under consideration, we will combine groups of the taxable population, presented by official statistics, into three groups by income level: low, medium and high (L, M and H). Next, for each of these groups, the average income levels L, M and H are calculated as the mathematical expectations of uniform distribution and Pareto distribution and the shares of the total population corresponding to these levels (Table 1).

Table 1. Three Modeled Groups and Average Income

Group	Interval, sum. per month	Average income	Population share, %
L	Below 17000	*L*=8500	23.1
M	17000 - 50000	*M*=33500	56.0
H	Over -50000	*H*=100000	20.9

For all experiments carried out, according to the economic meaning inherent in the model, the following parameters were recorded:

the value of the tax rate θ = 12 % is equal to the personal income tax rate in the Republic of Uzbekistan;

the value of the penalty rate π = 12 % is equal to the tax rate (thus, if evasion is detected, the tax arrears double);

with parameters θ = 12% and π = 12%, the threshold value of the audit probability, calculated according to formula (1), is equal to $P*$ = 0.5, which is difficult to achieve from the position of the tax authorities' budget;

the actual values of the probabilities of checking those who declared *L* and *M* are assumed not to exceed P_L = 0.1 and P_M = 0.1, respectively;

he specific cost of one inspection c = 747.3 thousand soums was assumed to be equal to the minimum wage in Uzbekistan in 2020.

the specific cost of information dumping does not exceed 10% of the specific cost of verification cinf = 10% c = 747,3 thousand soums within the framework of the assumption that the dissemination of information is significantly cheaper than carrying out a tax audit.

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As conditions for stopping the iterative process (4) and (5), the experiment considered the fulfillment of the inequality.

$$\sqrt{\sum_{i=1}^{n}({f_L}_i^k-{f_L}_i^{k-1})^2+\sum_{i=1}^{n}({f_M}_i^k-{f_M}_i^{k-1})^2}\leqslant 10^{-3}.$$

Experimental results. To analyze possible scenarios of behavior of taxpayers in response to information disseminated in their population, a number of renewable experiments were carried out to simulate networks of various configurations and the injection of information of various types. In order to take into account the randomness factor, for any network whose structure was represented by a random graph, a series of experiments were carried out. With each new start of the experiment under the same specified initial conditions, a a new network in which the process of information dissemination was simulated. This approach allows us to evaluate the repeatability of agent behavior in a network with a specific structure.

Conclusion. The constructed model for the d issemination of information about future tax audits among the taxable population and the numerical modeling carried out on its basis demonstrate that for fixed values of the model parameters, the experimental results obtained depend on the following factors. The final distribution of risk statuses of taxpayers and their tax evasions depends significantly, firstly, on the topology of the network, simulating the population of such agents, secondly, on the presence of risk statuses and tax evasions of information centers in the network under consideration, thirdly, on the types disseminated information.

Thus, using the model constructed in the work and the scenario analysis of a random process on the network carried out on its basis, it was revealed that the dissemination of information about future tax audits among taxpayers is one of the tools to improve the quality of government management of tax processes. In the future, the proposed approach can be adapted to existing tax systems, taking into account the peculiarities of legislation and economic practice.

References

1. Chander P., Wilde L. L. A general characterization of optimal income tax enforcement . // Rev.of Econ. Studies. 1998. Vol. 65. – P. 165-183.

2. Самуэльсон П. Э., Нордхаус В. Д. Экономика / пер. с англ. О.П.Пелявского и др. 18-е изд. – Москва: «Вильямс», 2007. (Samuelson P. A., Nordhaus W. D. Economics.)

3. Gubar E., Kumacheva S., Zhitkova E., Kurnosykh Z., Skovorodina T. Modelling of information spreading in the population of taxpayers: Evolutionary approach. // Contributions to Game Theory and Management. 2017. Vol. 10. – P. 100-128.

4. Yakubov M.S., Jamalova G.B. Methods for adaptive control of objects with variable parameters. "E3S Web of Conferences" e3s-conferences.org 2021.

5. Жамалова Г.Б. Информационное моделирование с применением искусственных нейронных сетей. // Scientific Journal "ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES". VOLUME 1 | ISSUE 3 | 2020. ISSN: 2181-1385. Impact Factor (SJIF) 2020: 4.804. www.ares.uz –C. 730-742