

Modeling of Multi-Agent Systems as a Tool for Assessing the Effectiveness of Legislative Acts (As Exemplified by Veterinary Legislation)

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Abstract — The main task necessary for maintenance of ensuring epizootic conditions as well as veterinary and sanitary wellbeing of the Russian Federation is improvement of legal regulation in the sphere of veterinary medicine, improvement of modern legal norms and rules in the sphere of veterinary activity. Considering problems of the modern Russian legal system, it must be noted that the most frequent object for criticism is lawmaking. This also includes such shortcomings as chaotic nature, lack of system in the formation of normative legal acts array, non-compliance with the priorities of legal regulation, adoption of new laws without taking into account interconnections with existing legislation and international law standards, violation of systemic links between laws and by-laws, between laws and regulatory agreements, lack of terminology unity and non-compliance with other important rules of legal technology. It is possible to describe this situation on the basis of mathematical game theory, however, its application requires consideration of a number of theoretical questions, in particular, payoff functions description, cooperation possibilities description, identification of external and internal factors affecting the behaviour of system agents (public relations participants). Also, one of the fundamental and scientifically based research methods is the construction of multi-agent systems. Recently, due to the increasing complexity, spatial distribution of modern objects under study, there is a need to construct such systems. In the process of payoff function constructing, the authors determined the optimal strategy of the state's behavior as a subject of administrative law in the formation of veterinary legislation, namely the gradual processing of the current regulatory framework. The proposed model, obtained as a result of the study, can be the basis for determining the effectiveness of legislation regulating various spheres of economic life.

Keywords: *veterinary legislation, legislative imbalance, game theory, mathematical modeling*

I. INTRODUCTION

Currently, significant changes and transformations of organizational and legal forms of agricultural enterprises are taking place in the agro-industrial complex, state support for agricultural producers is being provided, the growth rates of socio-economic development indicators are increasing [11].

One of the most important functions of the Russian state is to ensure food, veterinary and phytosanitary security. Veterinary medicine provides veterinary and sanitary security of animal origin products and protects the population from diseases common to humans and animals. Currently, the importance of veterinary medicine has increased due to the deterioration of the situation for a number of particularly dangerous animal diseases [6].

The main task necessary for maintenance of ensuring epizootic conditions as well as veterinary and sanitary wellbeing of the Russian Federation is improvement of legal regulation in the sphere of veterinary medicine, improvement of modern legal norms and rules in the sphere of veterinary activity.

To solve this problem, it is necessary to conduct a detailed study and update the current veterinary legislation, taking into account the administrative reforms carried out in the Russian Federation, as well as the harmonization of veterinary and sanitary requirements with international requirements and norms.

Veterinary activities also involve effective public administration, including planning, programming, recording and analysis of results, as well as control and supervision. Veterinary medicine is an object of administrative and legal regulation in order to solve the assigned tasks with maximum efficiency and minimum risks. Theoretical

understanding of new forms and principles of interaction with executive authorities of different levels and with organizations operating in the field of veterinary medicine is required [5]. It is necessary to develop normative legal acts that meet modern requirements.

For effective and systematic work it is advisable to construct various mathematical models.

Jurisprudence is a fairly broad field for the application of formalized, abstract-scientific methods of thinking, methods of mathematical apparatus, allowing to find unambiguous, correct solutions.

One of the main application directions in Jurisprudence and public administration of mathematical methods and models is lawmaking. This position is explained by the fact that normative legal acts have the form of logical judgments, i.e. such proposals in which something is asserted or denied about the objects and relations of reality. Therefore, to study them can and should be used mathematical logic, the application of which will allow:

- to improve the wording of normative legal acts, while eliminating vague wording, simplify cumbersome structures;
- to analyze the regulatory legal act for consistency with the current legislation;
- to model the logical structure of the regulatory legal act;
- to improve the logical completeness level of regulatory legal acts, to improve their logical structure;
- to clarify the logical meaning and content of legal norms in the process of their interpretation;
- to carry out logical examination of regulatory legal acts.

Mathematical modelling provides the opportunity to clearly and visually present the logical structure of the legal norm. This is especially important taken into account that the verbal form of legal norms can often obscure or cloud their inherent logical connections. In legislative practice, there are legal norms that violate the logic requirements, suffer from logical defects, i.e. the legal system is inherent in the emergence of a legislative imbalance. Therefore, the analysis of legal norms is important for law enforcement practice.

Since the legal system is characterized by many factors, in particular, dynamics, structure, as well as links with other processes, phenomena, factors, that is why to achieving a high degree of understanding of such a system requires deep and multifaceted research, in this regard, it is advisable to apply mathematical modelling [1].

II. METHODOLOGY

Considering problems of the modern Russian legal system, it must be noted that the most frequent object for criticism is lawmaking. For this purpose, there are, first of all, objective prerequisites, among which the most obvious is a kind of "law-making boom", which began at the end of the last Millennium and has not ended up to the present

time, which means extremely intensive, which is not always justified and to the detriment of the quality of legal acts, the pace of legislative activity. This also includes such shortcomings, noted by scientists, as chaotic nature, lack of consistency the formation of normative legal acts array, non-compliance with the priorities of legal regulation, adoption of new laws without taking into account the interconnections with existing legislation and international law standards [9,10,13], violation of systemic links between laws and by-laws, between laws and regulatory agreements, lack of terminology unity and non-compliance with other essential rules of legal technology [4]. From the above list it becomes clear that consideration of the lawmaking problems in isolation from the resulting legislation is impractical and notionally impossible (as well as vice versa). Addressing the theoretical aspects, despite some differences in interpretations, it is possible to consider lawmaking as a form of state activity aimed at creating legal norms, their addition, change or abolition. In this regard, the development and approval of new legal norms are decisive [12], the formal embodiment of which are the sources of law, i.e. legislation in its broad concept [2].

It is possible to describe this situation on the basis of mathematical game theory, however, its application requires consideration of a number of theoretical questions, in particular, payoff functions description, cooperation possibilities description, identification of external and internal factors affecting the behaviour of system agents (public relations participants). It is worth noting that the qualitative solution of the problems requires the necessary knowledge in the field of functioning and enforcement of legal norms, as well as in the application of statistical analysis and optimization methods.

Also, one of the fundamental and scientifically based research methods is the construction of multi-agent systems. Recently, due to the increasing complexity, spatial distribution of modern objects under study, there is a need to construct such systems.

Also, the study was based on the law enforcement practice data, legislative and normative acts regulating veterinary activities in the territory of the Russian Federation.

III. RESULTS AND DISCUSSION

Administrative and legal regulation of veterinary activities is a complex task of the state, due to the fact that legal relations in the veterinary field are diverse and include many areas of activity. Undoubtedly, it is hardly possible to adopt a single normative legal act regulating all aspects of veterinary activity, and the establishment of a single body that oversees compliance with legislation in this area. Currently, in the Russian Federation, regulatory impact assessment is considered primarily as a mechanism to prevent the emergence of new administrative barriers to business activity or to make adjustments to the most "harmful" bylaws [7].

Improving the quality of normative legal acts preparation at all levels is becoming urgent. Such quality of normative legal acts should not constrain economic development, but, on the contrary, should promote

sustainable regional and national development of economic processes.

Game theory application is relevant in the analysis of normative legal acts and the development of the concept to improve their effectiveness, the main objectives of such a theory are:

- concepts development of reasonable (optimal, stable, equilibrium) strategies of behavior as well as methods of their detection and calculation; the possibility of cooperation and coalitions formation should be taken into account;
- analysis of optimal strategies in dynamics, when the interaction unfolds over time and requires adapting its behavior to a constantly changing situation;
- description of transition methods (and development of stimulation methods) from an arbitrary state in equilibrium one;
- clarification of laws concerning cooperation emergence according to purely personal interests [8].

Since in this study, application of game theory will be dominant in mathematical model construction, it would be logical to present the subjects of administrative law as players pursuing their own, local goals and designate them with symbols:

Player A – coordinator, represented by the state, forming the legal framework regulating veterinary activities;

Player B – state bodies performing their functions within the established competence;

Player C – legal entities, participants of legal relations in the field of veterinary medicine;

Player D – individuals, participants of legal relations in the field of veterinary medicine.

To model the current situation, it is logical to accept the condition – the operation of the law (the adoption of a new law).

In this context, it is necessary to assess the behavior strategy of players – subjects of administrative law (agents of the legal system) (Table 1).

TABLE I. BEHAVIOUR STRATEGY OF LEGAL SYSTEM AGENTS

Behaviour model of agents	Causes of behaviour
1. Shows no reaction	A. The agent is not aware of this law existence
	B. The agent does not enter into this type of legal relationship, so the law does not apply to him
	V. He behaved in the same way before the adoption of this law
	D. Does not know the execution procedure of this law
2. Breaks the law	A. Violation of the law is beneficial to the agent (the amount of fines is compensated by the amount of received economic benefit)
	B. Protest behavior
	V. Negligence
	D. Looks for ways to avoid the law (adapts)

Behaviour model of agents	Causes of behaviour
	E. Believes (hopes, that he will not be punished)
3. Avoids the law by legal means	A. Compliance with the law does not benefit him
	B. Breaking the law does not benefit him
	V. There are other laws regulating a similar process, compliance with which is most beneficial for him
4. Complies with the law	A. Law-abiding
	B. Adapts in order to make law compliance beneficial for him
	V. Breaking the law does not benefit him
	D. Enforced compliance

The following designations will be adopted to describe the behaviour strategy of players:

- 1) Shows no reaction (X1)
- 2) Breaks the law (X2)
- 3) Avoids the law by legal means (X3)
- 4) Complies with the law (X4)

The results of the strategic behaviour of the players, taking into account the reasons for such behaviour, are presented in Table 2.

TABLE II. ANALYSIS OF STRATEGIC BEHAVIOUR OF PLAYERS TAKING INTO ACCOUNT THE REASONS FOR SUCH BEHAVIOUR

Model of strategic behaviour	Consequences of agent behaviour
X ₁ A	the consequences of such behaviour can lead to the imposition against the player sanctions for legislation violation or economic damage (such as lack of vaccination resulted in the death or illness of the animal), uncompensated by the state or insurance companies, the recoverability of economic damage, if such actions led to losses of other legal relations participants (item 2 of article 23 of Law of the Russian Federation "On Veterinary Medicine" No 4979-1 dated 14 May 1993 states that "Fining and other forms of penalty does not deliver the offender from the obligation to make up for the damage in accordance with the legislation of the Russian Federation»)
X ₁ B	no consequences
X ₁ C	no consequences
X ₁ D	the consequences of such behaviour can lead to the imposition against the player sanctions for legislation violation or economic damage (such as lack of vaccination resulted in the death or illness of the animal), uncompensated by the state or insurance companies, the recoverability of economic damage if such actions led to losses of other legal relations participants (article Xof Law "On Veterinary Medicine"). After getting appropriate advice (knowledge, he began to comply with the requirements of this law), i.e. there was a change in the behaviour model of the agent
X ₂ A	Violation of legislation is beneficial to the agent because in the context of administrative sanctions imposition for veterinary legislation violation there is often a disproportionate use of sanctions because sanctions for the offence are covered by the profit earned during law violation activities. Such a situation may lead to a reaction of the state regarding the tightening of sanctions.
X ₂ B	meeting, introduction of legislative initiative, sanctions for legislation violation, the reaction of the state to legislation change.
X ₂ C	sanctions for law violation, regardless of the guilt form in the commission of an offence
X ₂ D	the consequences depend on the control intensity by the supervisory authorities

Model of strategic behaviour	Consequences of agent behaviour
X ₃ A	Compliance with the law is associated with economic costs that will not be repaid later, sanctions for law violation are minimal, i.e. they do not cause serious economic consequences. May be followed by voluntary termination of the activities
X ₃ B	Law violation will lead to serious economic damage, costs associated with law compliance will be repaid, the agent benefits by compliance with the law, beyond the economic benefits, law violation will cause sanctions that are not commensurate with the result
X ₃ C	Direct law violation will lead to serious economic damage, the existence of a law regulating similar legal relations is most beneficial to the agent (including economically). He continues to act under the authority of another law or withdraw into the shadows.
X ₄ A	The consequences may be both positive (obtaining economic benefits from engaging in a certain type of activity, the absence of sanctions for law violation) and negative (high costs for the activities implemented within the framework of the existing law)
X ₄ B	Law violation will lead to serious economic damage, costs associated with law compliance will be repaid, the agent benefits by compliance with the law, beyond the economic benefits, law violation will cause sanctions that are not commensurate with the result
X ₄ C	Law violation will lead to serious economic damage, costs associated with law compliance will be repaid, the agent benefits by compliance with the law, beyond the economic benefits, law violation will cause sanctions that are not commensurate with the result
X ₄ D	Law violation will lead to serious economic damage, costs associated with law compliance will be repaid, the agent benefits by compliance with the law, beyond the economic benefits, law violation will cause sanctions that are not commensurate with the result

Civil disobedience should also be considered as part of the X₂B strategic behaviour model.

Civil disobedience is defined as a political action that manifests in a deliberate and open law violation in order to initiate changes in legislation or government policy that are perceived by citizens as unjust and illegitimate. Civil disobedience must satisfy several conditions: it must be public, nonviolent, rationally based, appeal to the majority's sense of justice, and protesters must be prepared to be punished. [3] The fundamental difference between the X₂B strategy and civil disobedience is that civil disobedience will always entail bringing the subject of law to responsibility.

It should also be noted that, despite a number of identical consequences of X₂A and X₂B strategies, these are strategies that could not be combined when considering the game in dynamics, due to various further reactions of the state.

The analysis of Table 2 makes it possible to reduce the number of considered strategies by combining due to the similarity of their consequences. It is possible to combine X₁A, X₁D, X₂C; X₁B, X₁C; X₄A, X₄B, X₄C, X₄E. Thus, nine strategies of behaviour should be distinguished.

From the perspective of consequences, it is possible to consider benefit (gain) from behaviour strategy of players "Compliance with the law" as follows (Table 3).

TABLE III. GAIN OF AGENTS DEPENDING ON THE STRATEGY OF "COMPLIANCE WITH THE LAW"

Participants of legal relations (subjects of law)	Gain
1. The state (priority)	a. regulates legal relations, as it is beneficial to the state
	b. obtaining economic benefits (formation of the revenue part of budgets at different levels)
	c. respect interests beyond economic benefits (compliance with international norms, the construction of the law, the solution of social problems)
	d. by means of the law performs supervising functions
2. Government agencies	a. performance of imposed functions
	b. implementation of competences
	c. exercise of public authority
	d. exercise of powers to manage public affairs
3. Legal entities	a. the law is aimed at their interests protecting
	b. adoption of the law regulates a number of legal relations in which they enter
	c. adoption and compliance with the law provides them with economic benefits
	d. compliance with their interests, beyond the economic benefits (the solution to the employment question, opportunity for career growth, the realization of entrepreneurial skills, etc.)
4. Private entities	a. the law is aimed at their interests protecting
	b. adoption of the law regulates a number of legal relations in which they enter
	c. adoption and compliance with the law provides them with economic benefits
	d. compliance with their interests, beyond the economic benefits (the solution to the employment question, opportunity for career growth, the realization of entrepreneurial skills, etc.)

Despite the fact that Player B and Player E have an equal gain, they should be considered as different subjects of legal relations, because the consequences can be different.

Let us consider the game:

$$\Gamma = \langle \{X^i\}_{i=1,2,3,4}, \{H^i\}_{i=1,2,3,4}, K \rangle \quad (1)$$

where, 1 – the state as a subject of administrative law, the set X¹ consists of eight elements described above, 2 – government agencies, 3 – legal entities, 4 – private entities.

The set X² consists of two elements corresponding to X₂C and X₄A, X₄D of Table 2, as noted above, the elements of X₄A, X₄D are combined into one strategy. Sets X³ and X⁴ contain nine elements, described with regard to the combination in Table 2. K – coalition of the first and second players gain (the state and public authorities).

The payoff function will be described as the sum of three components – security (b), economic effect (e), tax revenues (n) – each of which will be evaluated expertly. Each addend will be included in the payoff function of a player with some value, which characterizes the priority of the corresponding component for the player.

Veterinary legislation of the Russian Federation consists of Law of the Russian Federation "On Veterinary Medicine" No 4979-1 dated 14 May 1993 and adopted in accordance with it other normative legal acts of the Russian Federation, laws and other normative legal acts of constituent entities of the Russian Federation. Veterinary legislation of the Russian

Federation regulates relations in the field of veterinary medicine in order to protect animals from disease, production of safe livestock products in veterinary respect and protection of population from diseases common to humans and animals. Thus, the main purpose of the veterinary legislation formation is to ensure veterinary and phytosanitary safety, component (b) will have the highest value ratio (0.8), the other components will not be a priority from in the context of veterinary legislation functioning, their value coefficients will be 0.1 each.

The function of the first and second players will be described as follows:

$$H_1(x^1, x^2, x^3, x^4) = H_2(x^1, x^2, x^3, x^4) = 0,8b + 0,1e + 0,1n \quad (2)$$

The function of the third and fourth players will be considered in the following form:

$$H_3(x^1, x^2, x^3, x^4) = 0,1b + 0,8e + 0,1n \quad (3)$$

$$H_4(x^1, x^2, x^3, x^4) = 0,2b + 0,7e + 0,1n \quad (4)$$

Next, the gains matrix for player H₁ should be built (Table 4).

TABLE IV. GAINS MATRIX FOR PLAYER H₁ IN THE "NEGLIGENCE" BEHAVIOUR STRATEGY

X ² \ X ³	1	2	3	4	5	6	7	8	9
1	-5	0	-5	-5	0	-5	0	5	5
2	-2	0	-3	-2	3	0	0	5	5

Comparing the results it is obvious that the government agencies, regardless of the state strategy, the "Negligence" behaviour strategy in the implementation of Law of the Russian Federation "On Veterinary Medicine is not profitable. Therefore, due to the fact that there is a coalition of the state and government agencies (because they are united by goals), the state will by all means force government agencies to ensure that they adhere to the strategies of X_{4A}, X_{4E}.

The actions of the state as a coordinator of the players in the framework of the centralized multi-agent system functioning in the veterinary legislation formation can be described as follows:

- adopt law
- experiment
- implementation of control and supervision functions
- development of by-laws
- amendments and additions to the law
- abolition of law

Strategies of state behaviour related to changes in veterinary legislation are presented in Figure 1.

Strategy 1. Complete revision of the current veterinary legislation, which consists in the existing legal norms abolition and the development of a new legal framework regulating veterinary activities in the territory of the Russian Federation.

Strategy 2. Phased revision – in the framework of which legislative acts should be revised in order of priority.

Strategy 3. Amendments and additions to the current legislation, which is currently happening in the Russian Federation. As the conclusion formulated in the study, which the company "Garant" conducted by order of the "Center for Strategic Research" of Alexei Kudrin, this situation interferes with both citizens and business [14].

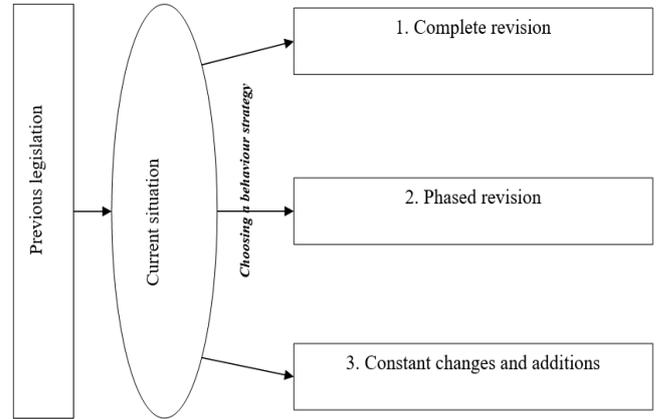


Fig. 1. Possible strategies of the state in the transformation of veterinary legislation.

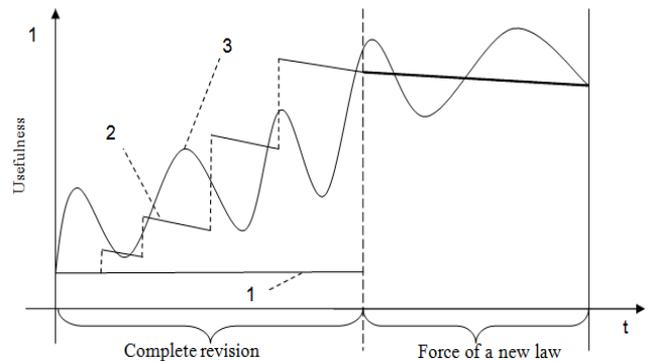


Fig. 2. Construction of the payoff function with regard to the above state behaviour strategies.

At the first behaviour strategy, after complete revising and adoption of the new legislation, there are abrupt changes that provide evidence of the general efficiency of the legislation. In the second strategy, due to the fact that the legislation is not completely changed, the subjects of legal relations take advantage of this imperfection, coalitions re-emerge, so there is a peripheral decrease in efficiency. In the case of complete revision, the new law will increase the efficiency only at a specific time, as over time due to changes in the economic situation, transition of the Russian Federation on new technological mode and the like, legal entities, adapting to the new legislation or will not change the set out above strategy, or will change it insignificantly, which again will lead to the existing problems in the field of veterinary.

At strategy 3 the periodic function characterizing fast adaptation to changes in the current legislation and smooth efficiency increase of normative legal acts application is built.

IV. CONCLUSION

Analyzing the total usefulness of various options for state action, it should be formulated, that the first strategy is the least advantageous for the coordinator. Comparing the second and third strategies, it should be noted that the total efficiency is approximately equal. However, the problem of the result achievement when choosing the third strategy is significantly higher, which increases the risks of applying legal acts, makes it difficult to predict the final result, increases the time for which the system comes to an equilibrium state. Thus, the second strategy should be recognized as the best behaviour strategy of the state – phased revision of the current legislation. The essential assumption of such a conclusion is the coincidence of the time frame of the complete legislation update.

The proposed model, obtained as a result of the study, can be the basis for determining the effectiveness of legislation regulating various spheres of economic life.

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