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ФОРМАЛЬНЫЕ МОДЕЛИ И АЛГОРИТМЫ В ПОЛИТОЛОГИИ: ТЕОРЕТИКО-ИГРОВОЙ ПОДХОД

FORMAL MODELS AND ALGORITHMS IN POLITICAL SCIENCE: GAME-THEORETIC APPROACH

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Аннотация. *Вопросы междисциплинарной интеграции методов исследования политических процессов представляют определенный интерес как с теоретической, так и с практической точек зрения. Приложение методов системного анализа, теории принятия решений, математического и имитационного моделирования к исследованию политических, социально-экономических систем задача нетривиальная, позволяющая выявить закономерности и тенденции в развитии систем, обладающих поведением, приобрести опыт прогнозирования и сравнительного анализа результатов исследования.*

В статье представлены результаты исследования, предметом которого является определение условий применимости теоретико-игрового подхода к исследованию политических процессов.

Статья, посвященная теоретико-игровому подходу к исследованию политических процессов, определяет возможности, которые открывает применение теории игр к анализу сложных систем, обладающих поведением.

Актуальность темы исследования определяется недостаточным, по мнению авторов, вниманием научной общественности к инструментальным средствам, которые готовы предоставить представители точных наук политологам и социологам. Современное состояние формального моделирования в политологии находится на этапе начального определения предмета исследования и формирования концепции.

Материалы и методы, результаты и обсуждения*. Авторами выполнен анализ возможностей, который предоставляет теоретико-игровой подход исследователю, показаны различные варианты применения игр разного класса.*

Целесообразность применения методов теоретико-игрового подхода в политологических исследованиях обусловлена современным состоянием политологической науки, верификации инструментальных средств исследования и результатов в сложных условиях роста объемов информации, подлежащей систематизации и анализу.

Заключение*. Проведенное исследование раскрывает новые возможности в развитие нового направления в системе политологических исследований, в основе которого лежат методы системного анализа и технология формального моделирования на базе теоретико-игрового подхода к анализу сложных систем.*

Теоретическая ценность идеи применения методов теории игр к исследованию политических процессов и явлений состоит в расширении предметного поля политологических исследований.

Практическая ценность идеи состоит в определении условий применимости классической теории игр в политологии, интеграции традиционных методов политологических исследований и методов формального моделирования для анализа политических процессов, явлений, поведения социально-политических систем.

Ключевые слова: антагонистические игры, игры с ненулевой суммой, коалиционные и корпоративные игры, игра с природой.

Abstract. *The issues of interdisciplinary integration of research methods of political processes are of particular interest from both theoretical and practical points of view. Application of methods of system analysis, decision theory, mathematical and simulation modeling to the study of political, socio-economic systems is a non-trivial task that allows you to identify patterns and trends in the development of systems with behavior, gain experience in forecasting and comparative analysis of research results.*

The article presents the results of the research, the subject of which is to determine the conditions for the applicability of the game-theoretic approach to the study of political processes.

The article is devoted to the game-theoretic approach in the study of political processes. The authors define the possibilities that open up the application of game theory to the analysis of complex systems with behavior.

According to the authors, the relevance of the research topic is determined by the insufficient attention of the scientific community to the tools that representatives of exact Sciences are ready to provide to political scientists and sociologists. The current state of formal modeling in political science is at the stage of initial definition of the subject of research and formation of the concept.

Materials and methods, results and discussions. *The authors analyze the possibilities that provide a game-theoretic approach to the researcher, and show various applications of games of different classes.*

The expediency of applying the methods of game-theoretic approach in political science research is due to the current state of political science, verification of research tools and results in difficult conditions of increasing volumes of information to be systematized and analyzed.

Conclusion. *The research reveals new opportunities for the development of a new direction in the system of political science research, which is based on methods of system analysis and formal modeling technology based on a game-theoretic approach to the analysis of complex systems.*

The theoretical value of the idea of applying the methods of game theory to the study of political processes and phenomena is to expand the subject field of political science research.

The practical value of the idea is to determine the conditions for the applicability of classical game theory in political science, the integration of traditional methods of political research and formal modeling methods for the analysis of political processes, phenomena, and behavior of socio-political systems.

Key words: antagonistic games, non-zero-sum games, coalition and corporate games, games with nature.

Introduction. Political science, possessing a historically established toolkit for research, which was traditionally based on methods of qualitative assessment of the objects / phenomena under study, in the context of the modern information society and the growth of the amount of information required for analysis, faced the problem of complicating political processes and, as a result, with the need improve research methods. Analysis of the history of the issue allows us to assert that the date of the appearance of formal modeling in the subject field of political science research can be considered the 50s of the XX century [1]. Thus, the historical method, which traditionally was based on non-formalized methods of studying social and political processes and phenomena, supplemented by the methods of mathematical statistics and integral calculus, makes it possible to visually display the economic and political situation using numbers and graphs, to more correctly determine the causes and consequences, for example , social inequality, correlations between the mechanisms of distribution of material wealth and social tension in society, etc. The interest in systems modeling in political science, the joint use of methods based on the analysis of behavioral principles and standard methods of analysis of random and non-random processes opens up new theoretical and applied aspects of formal modeling as applied to political science.

The game-theoretic approach to political science is an example of the integration of rational and irrational methods of complex systems. The game, as a mathematical model of a real conflict situation, allows each participant (player) to make a reasonable choice of behavior strategy, takes place in certain conditions, has a multi-aspect character: one should distinguish between descriptive, constructive and normative aspects. The behavior of the players in the game is governed by some rules established for this game, which determine the strategies of the players, stability in relation to information about the behavior of the opponent, the outcome of the game and the size of the winnings. It is proposed to consider, within the framework of this article, antagonistic games (zero-sum games), non-antagonistic games and games of one player (games with nature) and their application to models of justification of choice, which are based on methods of expert assessment. The theory of games, in its classical positions, determines the norm of the player's behavior in order to achieve his goal; the result of the game, as a rule, are recommendations to the player on the formation of an optimal strategy of behavior that maximizes the average value of the utility function when the game is repeated many times. Previously, the authors considered the possibility of using a zero-sum game in the construction of an arms race model (Richardson's model) [2]

The construction of a formal model and the development of the corresponding algorithm are carried out in stages. At the first stage, the problem that must be solved is formulated, and the subject of research is determined. So, considering the elections as an antagonistic zero-sum game for two candidates, let us formulate the problem: for each of the candidates, the main problem is the lack of information about the system of preferences of the electorate participating in the elections, and, as a consequence, the difficulty in determining the target group to which the vector will be directed pre-election program. The challenge facing the player: to develop an election program that best suits the system of preferences of the electorate and / or target group, which is characterized by activity. The peculiarity of the mathematical model of this situation is that the players do not have sufficient information about each other's behavior, they cannot change their stock of resources, the amount of gain is equal to the amount of loss. At the next stage, it is necessary, in accordance with the principles of symmetric fair entry into the game, to determine the finite number of player strategies and the size of the win / loss when implementing each of the strategies. In this case, the fairness of the entry means equal chances of the players to win, the symmetry of the entry means that the corresponding strategies of the players have the same payments. The next stage is the construction of a mathematical model: player A has strategies A_1, A_2 … A_m, and player B, respectively, B_1, B_2,… ,B_m.

The matrix of the game in which the gain of one player is equal to the loss of another player has the form

$$V = \begin{pmatrix} v_{11} & v_{12} & \dots & v_{1m} \\ v_{21} & v_{22} & \dots & v_{2m} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mm} \end{pmatrix}$$

The game-theoretic approach to the election procedure allows one to determine the optimal strategy of the player's behavior, the lower and upper game prices, that is, the guaranteed minimum win / loss. Example: Two candidates running for election and competing with each other are counting on a certain percentage of the electorate. Trying to attract electors, applicants choose alternatives: a1 (b1) – increase the activity of electors in their target group; a2 (b2) – attract media for advertising; a3 (b3) – adjust the electoral program in order to increase the attractiveness; a4 (b4) – zero alternative (no new decisive actions are taken). The solution of the situation in the form of matrix games will make it possible to determine the likelihood of success for each of the applicants, the appropriate frequency of applying a particular strategy, the dominant and most effective strategy.

The possibility of applying this model to a real situation, according to the authors, is constrained by a large number of restrictions that are introduced when constructing a model: in real practice, players may have an unequal number of strategies; the different types of resources that players will use have different "weights" and this fact violates the necessary conditions for fair and symmetrical participation.

To put it precisely, a game-theoretic approach to modeling and predicting the dynamics of development of systems with behavior is not a tool for obtaining clear instructions "what and how to do in a particular situation," but the possibility of conducting a comparative variant analysis of the characteristic functions of the system under study and analyzing the internal structure of the optimal solutions. In the absence of unambiguously specified measurable criteria and the impossibility of applying the criterion approach to a qualitative description of a problem situation, the game-theoretic approach is advisable to apply for a comprehensive analysis of the situation. So, the situation with the divergence of interests of the parties, presented above as an antagonistic game, can be considered in the same formulation of the question as a game with a nonzero sum, that is, as a variant of divergence of interests of the players, when the gain of one contender does not mean the loss of the other. Interpretation of elections as games with a non-zero sum is acceptable if there is negative feedback between the players:

– player A can directly or indirectly influence player B's choice of behavior strategy and, accordingly, influence the size of his payoff;

– with multiple choices, player B forms his strategy taking into account previous experience and information about the choice of player A at the previous step.

Non-zero-sum games can be non-cooperative, where the players make decisions on their own, without colluding, and cooperative, where decisions are made after certain agreements have been reached.

Elections, as a part of the political life of society from the standpoint of formal modeling and system analysis, is a procedure for agreeing a system of electors' preferences on a finite / infinite set of alternatives, which can be single and multiple, be one- and multilateral. If the selection procedure involves a finite set of experts / electors, it makes sense to talk about the group selection procedure, for the study of which it is advisable to use other game-theoretic models.

Statement of the problem of multi-sided choice: there is a finite set of comparable alternatives A, on which a finite set (community) of electors needs to make a reasoned, consistent choice in accordance with their preferences. If each of the participants has their own preference system (profile), then the task is reduced to creating a common (collective) profile and finding an alternative with properties that correspond to this profile. This selection mechanism, in fact, is an analogue of direct democracy and the main difficulty, according to the authors, lies in the formation of a general profile of the applicant that meets the preferences of each elector. The second possible variant of the search for the optimal alternative involves the formation of a collective profile of preferences after the available alternatives are ordered, this is the so-called representative democracy. Example: a lot of electors and applicants for vacancies in government. The electors, not knowing in advance what sphere of activity in the power structure will be determined by their "chosen one", arrange alternatives in descending order of attractiveness; on the basis of this list, a unilateral choice is made by a certain representative of the electors. A group choice is possible based on the use of previously accumulated experience, the so-called precedent method [3], which involves the adaptation of a tested optimal strategy to new conditions with the reuse of algorithms, models and rules to solve the current problem.

The seeming simplicity of the model has at least two pitfalls: the first is the influence of the well-known voting paradoxes that electors encounter in the process of agreeing on the preference profile and / or ordering alternatives [4]; second – the need to choose the "best" method that will ensure equilibrium and fair entry of players into the game, the symmetry of their participation in the game; by an equilibrium entry we mean the presence of conditions under which it is unprofitable for the participants in the game to change their decision unilaterally.

The variety of models used by game theory has expanded the subject field of research. If antagonistic matrix games assume directly opposite goals of the participants and the presence of no more than two parties participating in the game, then it is obvious that this is a special case that has limited application.

It is advisable to consider a more general case that takes place in real socio-political practice, when a conflict situation is interpreted as a non-antagonistic divergence of interests, while there may be more than two participants in the game. The term non-antagonistic divergence of interests means that the gain of one participant is not the loss of another, which can be explained by the example of the "prisoner's dilemma" model [5] or the exam, as a conflict situation in which a student has two options for behavior: prepared – not prepared, the teacher also two options for behavior, took the exam, did not. In this model of a conflict situation, four outcomes are possible: 1. learned – passed; 2. did not learn – did not pass; 3. did not learn – passed; 4. learned – did not pass. Obviously, the gain of one person is not the loss of the other: a mark obtained by a student fraudulently does not mean a loss of the teacher.

In the event that players can make a decision based on mutual agreements, which they make as a result of a pre-game discussion of possible strategies of behavior, game theory speaks of so-called coalition games, that is, games with a voluntary association of participants for cooperation. From the point of view of game theory, such collusion means the formation of a certain subset on a finite set of game participants, for which a set of behavior strategies, game outcomes and win-sharing rules must be formed. So, political parties that do not collect the required percentage of the electorate's votes can create coalitions, the formal representation of which is as follows: if S = {s} (s = 1,2, ... n) is a set of players, then their union is an arbitrary coalition C , and the number of subsets of such coalitions is defined as the number of combinations of C from m to n, where m is the number of participants in the conspiracy (coalition):

$$C_n^m = n!|(n-m)!*m!$$

Each of the coalitions has its own set of strategies, the choice of which determines the outcome of the game. For each outcome of the game, at the stage of coalition creation, a winning sharing scheme is determined, in which the rules of collective and individual benefit must be observed. The collective benefit rule normalizes the distribution of the

winnings: all winnings must be distributed among the participants. The rule of individual benefit is that the payoff of each participant must be no less than the payoff that he could get without joining the coalition, making decisions on his own.

The coalition game model can be projected onto the group choice problem.

Results/Conclusions. The study reveals new opportunities for the development of a new direction in the system of political science research, which is based on the methods of system analysis and the technology of formal modeling based on the game-theoretic approach to the analysis of complex systems.

The theoretical value of the idea of applying the methods of game theory to the study of political processes and phenomena lies in expanding the subject field of political science research.

The practical value of the idea lies in determining the conditions for the applicability of the classical game theory in political science, integrating traditional methods of political science research and methods of formal modeling for the analysis of political processes, phenomena, behavior of socio-political systems.

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