# Game-theoretical Models and Methods of the Organizational Systems Control Theory

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## 1. INTRODUCTION

The theory of organizational systems control studies mathematical models of functioning an organization and mechanisms of organizational control (decision-making routines). It is applicable to a wide range of organizational systems – from a particular department, firm or bureau to a region or a country as a whole.

The foundations of the theory of organizational systems control ("active systems theory") were developed in the 70s of the XX century in the works of soviet researchers V. Bourkov, V. Kondratyev, and others [1].

The theory of organizational systems control combines the methods of classic optimal control theory and system analysis with the techniques of operations research, decision-making theory, and game theory. The approach of the theory of organizational systems control is similar in spirit to the theory of the firm and the theory of markets under asymmetric information (especially, contracts theory and mechanism design [9, 11]).

An objective of the report is to illustrate the role of game-theoretical models in setting and solving organizational control problems. We introduce a classification of game-theoretic models presently used in organizational control theory and outline the perspectives of game theory in the context of organization control theory.

## 2. GAMES AND MECHANISMS OF ORGANIZATIONAL CONTROL

According to currently accepted methodology [14] an organizational system is defined by:

1. its staff (a set of members of the system);
2. structure (command structure and other relations between members: informational, technological, etc);
3. feasible actions sets for the members of the system;
4. preferences (objectives) of the members;
5. information awareness of the members (information about significant internal and external variables);
6. operation procedure (sequence of decision-making).

Organizational control is understood as an impact on the controlled system for the purpose of maintaining its desired behavior. Control may affect any of the six elements of the organization system enumerated hereinabove. So, one may distinguish between the following types of organizational control mechanisms: staff management [8], structure management [12], institutional management (control of the feasible actions and behavioral norms) [14], incentives management (preferences manipulation) [13], informational management (awareness manipulation) [2, 15], and operation procedure management [12, 16].

Game-theoretical models are widely used to design the mechanisms of organizational control [6]. For instance, the study of the basic organizational system model – principal-agent problem – adds up to the analysis of a hierarchical game [4] (normally of type Γ1 or Γ2). The primary role of game-theoretical models as applied to organizational control problems is to provide the principal (in whose behalf the control mechanism is designed) with the forecast of controlled system response to a certain control action. For instance, in two-tier organizational system consisting of the principal and several agents, the principal forecasts the agents' game outcome given the control action is known. Then she chooses the control action to maximize the minimum of her objective function by the set of all game outcomes forecasted (e.g., the set of Nash equilibria).

Such approach imposes some restrictions on game-theoretical models and concepts used. Existence of solution of the game becomes a criterion for organizational system controllability. Uniqueness of solution is equivalent to the quality of forecast and directly influences the appropriateness of control action chosen.

Up to now the most thoroughly studied areas of organizational control are the incentive mechanisms in complete information framework along with the models of adverse selection and moral hazard. In solving these problems the classical models of non-cooperative [13] and cooperative [5] games are widely applied. However, the long-term principal-agent relation is an intrinsic feature of organizations. Thus its

analysis (for instance, modeling of adaptation effects) demands using the models of dynamic games (see [16] for reference). Herewith the well-known "folk theorems" turn to be the negative results as they enlarge extremely the set of the solutions of the game. The assumption of agents' bounded rationality (i.a. of agents' improvidence) gives one of possible workarounds for this problem.

Game-theoretic models play a minor part in the problems of staff and structure management. They make it possible calculating the operational effect under a certain structure. The ability to write an analytic formula for the effect sufficiently facilitates the subsequent solution stage when the most effective structure (or staff) must be chosen from the enormous set of feasible ones [8, 10, 12].

An analysis of certain game-theoretic models of control (e.g. the extensions of classical Downs model of voting [3]) is hindered by the absence of Nash equilibria in pure strategies. The investigation of such games required the development of a variety of special solution concepts (see [7]).

The models of informational management also demanded the elaboration of new game-theoretic models – the so-called "reflexive games" [15]. In them common knowledge about environment is replaced by information structure – a tree of subjective beliefs. The original concept of informational equilibrium is taken as a basis for the mechanisms being developed for active forecast and informational regulation [2]. The area of current interest is dynamics of agents' informational structures when new information arrives.

## 3. CONCLUSIONS

Thus, the following lines of game-theoretical research seem perspective from the organizational control theory's point of view: the elaboration of refined solution concepts and investigation of dynamic games in the presence of bounded rationality (specifically, in the absence of common knowledge). The solution concepts are also desired to be simple enough to yield the analytical solution of game when a problem is stated analytically.

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