Integrated Mechanisms of Organizational Behavior Control

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Abstract
Problems of control mechanisms integration are formulated and discussed in the framework of mechanism design for organizational behavior control. Unified schemes for control mechanisms description and design are proposed. An example of the integrated production cycle optimization mechanism is considered.
Keywords mechanism design, management theory, organizational behavior, integrated control mechanisms.

1 Introduction

According to general control methodology [1], control is the activity of subjects controlling other subjects or objects. Formal models of control in organizational systems are studied in the framework of mechanism design (see surveys in [2] and [3]), theory of contracts [4, 5] and collective choice theory [6, 7], involving results of game theory [10, 11] and operations research (see textbooks [8, 9]), and are applied in microeconomics and management theory.

A set of control mechanisms may be considered as a "kit", which contains elementary blocks, intended for solving of typical problems of planning, organizing, motivating and controlling. But in practice one faces not typical but real complex problems of organizational control (according to [12] controlled complex systems nowadays are usually decentralized, hierarchical and networked, hence, heterogeneity approach in control models would surely be in demand). Hence the technique of complexing and integrating different control mechanisms is required. Below an attempt of integrated control mechanisms construction is taken for the problem of production cycle optimization.

2 Control Mechanisms

Suppose that a man is engaged in a control loop. Then there is a need to control him or her – a controlled object which

• is subjectified and acts according to individual interests and preferences (the principle of rationality);

• appears not completely known to a corresponding control subject (the principle of information asymmetry);

• may not reveal true information and not perform the expected actions.

In the sequel, such controlled objects are said to be economic agents or, shortly, agents; the corresponding control subject is referred to as a principal.

The "principal – agent" terminology seems convenient and is traditionally used to describe control mechanisms. A control mechanism represents a certain set of rules and procedures involved by the principal for making decisions that influence on the behavior of active economic agents (in particular, on information revealed and actions chosen by them), hence the principal has to solve the problems of control mechanism design.

In Fig. 1 the typical aggregated scheme of a control mechanism structure is provided in a operational form.

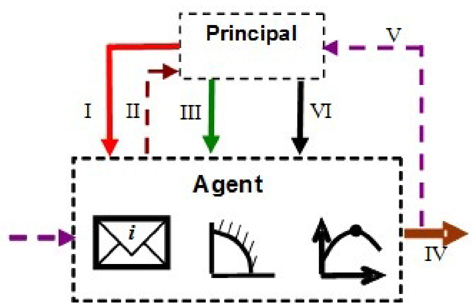

Fig. 1 Typical aggregated scheme of a control mechanism

Subjects of control are: norms and restrictions of agents' activity (institutional control), preferences of the agents (motivational control, including incentive problems) and awareness of the agents (informational control).

Sequence of moves in an organizational system (being common for all stages of a control cycle) under a fixed control mechanism is shown in Fig. 1:

Stage I: the principal makes the first move, i.e., informs the agent of a control mechanism ("rules of play") in a general form. For instance, this could be the relation between the amount of resource allocated and the reported need in the resource; alternatively, rules of play may be specified by the relationship between the reward and results achieved (the state of the agent).

Stage II: the agent reports information on uncertain parameters to the principal (e.g., submits a claim for a resource or reports information on his or her preferences).

Stage III: the principal informs the agent of control mechanism parameters. For instance, he or she assigns a plan as the result of the agent's activity expected by the principal.

Stage IV: the agent chooses an action, and the result of activity is formed.

Stage V: the principal receives information on the agent's action.

Stage VI: the principal informs the agent of his or her own action according to the control mechanism (e.g., the amount of resource allocated, the reward and so on).

Stages I-III (see Fig. 1) correspond to the planning cycle, while stages III-VI are related to the implementation cycle. The lower rectangle in Fig. 1 represents the model of an economic agent.

When solving design problems for sophisticated (complex) control mechanisms, it appears reasonable to describe the mechanisms using the notation similar to that of IDEF0 standard [13] and the input-output schemes in control science (see Fig. 2).

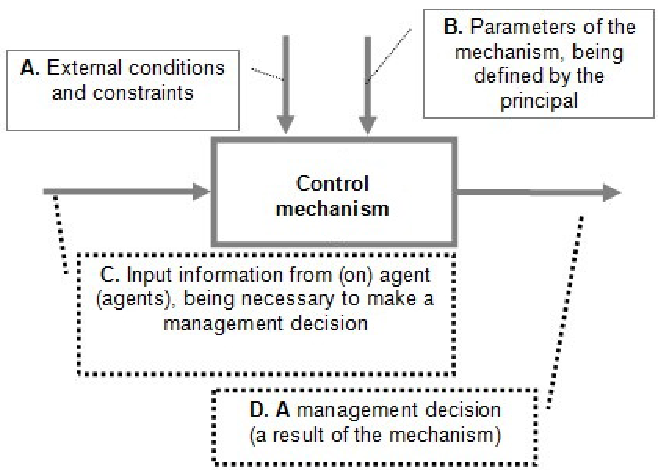

Fig. 2 The general input-output scheme of a control mechanism

Within the framework of such representation, the six general stages discussed above (see Fig. 1) could be formulated in the following way:

A. The external conditions and constraints imposed on the principal during the process of making management decisions.

B. The parameters of a control mechanism, being defined by the principal (Stages I and III).

C. The input information from (on) agent (agents), being necessary to make a management decision (Stages II and IV).

D. The result of the mechanism applied, i.e., the management decision made by the principal (Stages III and VI).

Now let's consider the technique of integrating several mechanisms, which follow the unified description (Fig. 1 and Fig. 2), in order to solve certain control problem (the production cycle optimization problem is used as an example).

3 Integrated Mechanism of Production Cycle Optimization

Production cycle optimization (PCO) appears an important factor in improving the efficiency of a manufacturing process and in reducing the demand for circulating assets. PCO represents an integrated mechanism, since the underlying process includes four primary stages as follows.

Stage 1. Data acquisition regarding capabilities of PCO (such information is supplied by units, i.e., shop floors and offices).

Stage 2. PCO planning to ensure the required rate of optimization (what operations should be optimized and at what rates).

Stage 3. Incentive scheme design (what rewards should be assigned to the units for reducing operation time of a manufacturing process).

Stage 4. Implementation of PCO plan and providing the rewards to the units.

A simplified description of the PCO-mechanism is shown in Fig. 3.

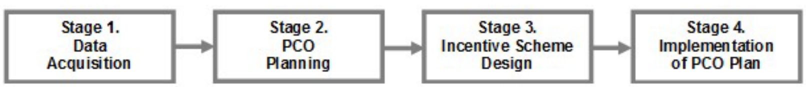

Fig. 3 Stages of production cycle optimization

According to the stages mentioned, one would observe that (at least) four basic mechanisms are necessary:

• Stage 1 (Data Acquisition) – the mechanism for counter plans, which motivates the units to report higher capability estimates for PCO;

• Stage 2 (PCO Planning) – the coordinated planning mechanism, which guarantees the required rate of PCO in the sense of the minimum total costs to motivate such optimization;

• Stage 3 (Incentive Scheme Design) – the incentive mechanism for a unit as the result of a certain optimization rate achieved; the mechanism must ensure truth-telling of all units;

• Stage 4 (Implementation of PCO Plan) – the mechanism of predictive self-control, which serves for well-timed informing of possible frustration of the plans.

The mechanisms for counter plans ensure better estimates of feasible work time optimization (reported by the units) via coordinating the rewards for tense plans, the penalties caused by plan non-fulfillment and the rewards for plan overfulfillment.

When an agent is paid merely for fulfillment (or overfulfillment) of the plan assigned by a principal, the agent is not interested in having a high ("tight") plan. The reason is performing it would require additional efforts (costs) of the agent. For instance, an agent may inform the principal of his or her preferences, eo ipso reporting his or her estimate of the plan (referred to as a "counter plan").

Within the framework of incentive scheme for counter plans, an agent is given rewards for reporting counter plans that better meet the principal's interests (yet, are "tighter" for the agent).

The planning mechanism enables solving an optimization problem of defining the planned rates of operation time optimization to minimize the total optimization rate; this mechanism is also used to evaluate a reward norm for a unit optimization rate.

For example, resource allocation mechanism is intended to distribute a specific resource based on claims of control objects (agents) for a desired quantity of the resource. Note this is done under the conditions of deficiency (the resource is limited), while a control subject (a principal) has no information on optimal quantity for every agent. The mechanism ensures truth-telling of the claims submitted by the agents. Modifying the mechanism parameters (priorities of the agents, prices, rates, etc) allows the principal to minimize his or her losses caused by the gap between actual distribution and its optimal counterpart (the latter could be achieved if the principal knew exact quantities of the resource needed by the agents).

Another example is a transfer price mechanism, which is involved to perform mutual payments within a company (in the system of internal accounting) or between companies that enter the same corporation. In the case of vertical integration, a transfer price is a tool to distribute profits between participants of a technological chain. Horizontal integration being considered, a transfer price provides a tool of coordinating interests between the enterprises (units – agents) and a principal. The latter acquires from the former information on the price and quantity of a product they are ready to supply; in other words, the principal finds the relationship between an optimal output (or a plan) and a transfer price. Based on the acquired information, the principal establishes a transfer price of the product such that the total output of the agents equals the required one. Under a sufficiently great number of the agents, the mechanism of transfer prices ensures, first, truth-telling (since the agents benefit from reporting the actual dependence between the optimal output and the transfer price) and, second, minimum manufacturing costs for the products.

The corresponding incentive mechanism could be represented by a proportional unified incentive scheme; here the income (bonus) of a unit equals the product of the reward norm and the planned rate of optimization.

Collective incentive scheme is designed for situations when a principal turns out unable to separately observe the action of every agent (the principal merely knows a certain aggregated rate, e.g., the result of collective activity). Imagine that the principal can evaluate the minimum costs to-be-incurred by the agents to achieve the required result of collective activity. In this case, the efficient incentive scheme takes the following form. The minimum costs of each agent are compensated (provided that the result of collective activity agrees with the requirements of the principal). Moreover, sometimes the principal has no costs related to observing individual actions of every agent; thus, the principal's workload to acquire and process information is substantially reduced.

Unified incentives mechanism is employed in situations when a principal has to motivate large groups of agents, to involve "democratic" management methods and to decrease the amount of processed data. Under unified incentives, the relationship between the reward and labor intensity of the agents (alternatively, the results attained by them) is identical for all agents. In several cases, the described unification leads to no loss of efficiency, while the wages fund is spent in an optimal way. Yet, unified control may be inefficient, when non-consideration of individual features of the agents results in inefficient spending of financial resources.

The mechanism of predictive self-control allows a principal to obtain well-timed information on possible deviations from the planned rates of PCO; this is done by coordinated assignment of the penalties for plan correction (they depend on the moment a certain unit reports of such correction) and the penalties for plan non-fulfillment. Mechanism of predictive self-control is intended for well-timed informing a principal of possible deviations (from a plan) in the agents' activity. The earlier the principal gets aware of possible deviations from the plan (e.g., in due dates, financial investments, etc), the more efficient and well-timed would be his or her decision (e.g., additional measures to eliminate deviations and reduce losses, or plan correction); note the agents report deviations. The matter is that the penalties of the agents (in the case of plan correction) depend on the moment the agents report of the correction (they are smaller if the report is early); moreover, these penalties are less than in the case of plan non-fulfillment.

Detailed description of these mechanisms may be found in [3].

Fig. 4 shows a block diagram of the integrated mechanism of PCO.

The algorithm of PCO-optimization mechanism operation:

(1). Each unit informs the principal of an optimization rate of the corresponding operations in a manufacturing process (depending on the reward norm).

(2). The principal determines a minimum reward norm such that the duration of the manufacturing process is reduced to a required rate. The principal defines an optimization rate of the corresponding operations, using a rank-order tournament in the case of multiple-valued solution.

(3). The units implement the tasks regarding production cycle optimization.

(4). The principal computes the rewards of the units and pays them to the latter.

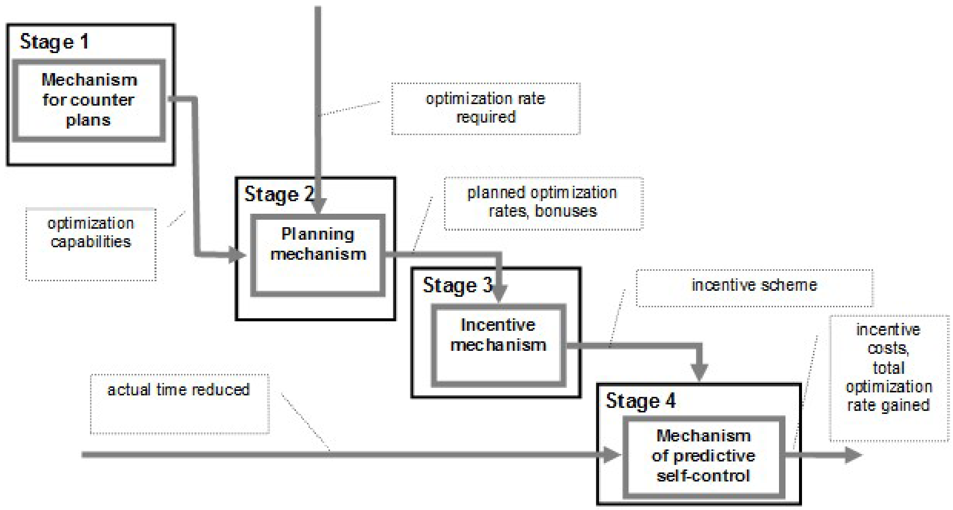

Fig. 4 The block diagram of PCO-optimization mechanism

4 Conclusions

The theory of control in organizations traditionally studies a certain system of nested control problems (solutions to "special" problems are widely used to solve more "general" ones) [3]. Today, there are two common ways to describe an organizational system model (as well as to formulate and solve the corresponding control problems). They are referred to as the "bottom-top" approach and the "top-bottom" approach.

According to the first ("bottom-top") approach, particular problems are solved first; using the obtained solutions to the particular problems, general ones are treated then. For instance, a particular problem could be that of incentive scheme design. Suppose this problem has been solved for any possible staff of the organization. Next, one may pose the problem of staff optimization, i.e., choosing a certain staff to maximize the efficiency (under a proper optimal incentive scheme). An advantage of this approach lies in its constructivity. A shortcoming lies in high complexity due to the large number of possible solutions of the upper-level problem, each requiring the solution of the corresponding set of particular subproblems.

The second ("top-bottom") approach eliminates this shortcoming; this approach states that the upper-level problems must be solved first, while their solutions serve as constraints for the particular lower-level problems. In fact, we doubt whether (e.g., when creating a new department) a manager of a large-scale company would first think over the details of regulations describing the lowest-level employees' interactions. Quite the contrary, he would delegate this task to the head of the department (providing him with necessary resources and authorities).

Construction of an efficient control system for an organization requires combining both approaches in theory and in applications. As well, both approaches may be applied when designing certain integrated control mechanism. The challenge is to develop a simple and efficient technique of integration.

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