

# Cooperation of Science and Business in Order to Organize High-Tech Production in the Regions of the Russian Federation

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**Abstract**— The paper considers the selection of priority innovative programs as a plan for technical development and production organization. Various financing alternatives are reviewed in the form of mathematical models for the coordination of interests between players of relationships. The pseudo-Boolean optimization methods are used as the main method for implementing models. An optimal investment plan is the result of problems solving.

**Keywords:** *optimization, innovative programs, financing, mathematical models, principle of return formation, resources, priority*

## I. INTRODUCTION

The purpose of the study is the selection of priority investment programs as a plan for technical development and

production organization. A restructured construction enterprise with the centers of financial responsibility, unbound by the technological chain is considered. These centers are independent from each other but they compete with each other in the financial market. Their sources of financing are centralized funds of the central office, consisting of contributions from Financial Responsibility Centers (FRC), funds of financial firms, mainly coming from the external environment, investments. Due to the scarcity of financial resources, a head office should choose the priority investment programs of the Financial Responsibility Centers (FRC) that will finance partially, and also it acts as a guarantor for receiving investments from other sources [1].

## II. METHODS AND RESULTS

In modern practice of modeling management and production activities, it is agreed to use a term “business process” to designate objects of modeling [2]. Business processes modeling is an important component of projects for the business processes reengineering (reorganization) and development of large-scale software systems (software) [3]. The lack of models is one of the main reasons for some projects failures. However, even the availability of models does not guarantee success, since there are some other serious reasons leading to failure such as:

- lack of interest by management of the organization;
- incorrect formulation of project’s objectives;
- insufficient information available for the organization’s personnel regarding the objectives and results of the project;
- misunderstanding of the essence and real possibilities of the applied modeling methods;
- lack of corporate standards for the description and regulation of business processes;
- inefficient application of modeling tools.

The current situation is compounded further by the following circumstances:

- organizations are faced with the problem of selecting adequate modeling methods and tools, generated by their diversity and lack of uniform standards;
- current methods and tools use different modeling languages, terminology; they are poorly compatible with each other, expensive and time-consuming.

These circumstances contribute a lot of projects that are currently being undertaken. Their purpose is to integrate existing methods and modeling languages and develop a unified methodological and technological basis for business processes modeling [4,5,6,7].

The selection of priority investment programs as a plan for technical development and production organization is a complex problem [1]. Three main financing alternatives are possible [8].

According to the first alternative, FRCs can transfer a part of their funds to finance general investments; another part of the fund is used to implement their own organizational and technical measure. In this case, from the enterprise’s point of view, a part of the investment, its development and operation will not be effective, since from the point of view of a separate FRC it is impossible to estimate the systemic effect. Therefore, with the full or partial decentralization of financing the construction activities by the Financial Responsibility Center, the production efficiency will decrease in comparison to the solution of this problem, set for the whole enterprise [7,8,9].

According to the second alternative, the investment financing is realized within the framework of a single

technical development plan (or as a part of the annual plan or a business plan), developed as an optimal or approximately optimal organizational and technical plan for the implementation of construction orders, technical re-equipment, technological innovation, etc. A part of the investments affecting the development of the whole enterprise, for example, environmental protection, is included in the plan by decision of the labor community [10,11].

These measures should be financed by all FRCs by payback of a certain share of return in the centralized development fund of the enterprise.

For another part of the investments included in the plan, the marginal estimation of the economic effect is determined for one thousand rubles of expenditures according to the worst case or average for all investments. The fulfillment of the construction order included in the plan is financed by the department it relates to.

If financing fund for development is not enough in this particular the FRC, then expenses are paid from a centralized fund. All FRCs that have invested their funds in a centralized fund should pay interest according to the estimate calculated on the least effective measure included in the plan, or on average for all measures.

The third financing alternative can be treated as follows: FRCs transfer their entire development fund to the centralized fund and receive interest for this, the average for the enterprise.

A slightly different approach to the coordination of interests between the central office and the FRC, as well as inside the Financial Responsibility Center is possible.

This approach is presented in the form of a mechanism for coordinating interests between players of relationships.

This mechanism can be based on the following general regulations [12,13].

The principles of the financial resources allocation by the Financial Responsibility Center for investments (construction, reconstruction of the Financial Responsibility Center, equipment modernization, etc.), and their volumes to the centralized fund of the enterprise for the planning period, are agreed in advance.

Centralized funds are formed at the expense of the FRC, and at the expense of the enterprise itself, as well as with the involvement of other financing sources.

3. The principles of formation (redistribution) of profit from investments between the Financial Responsibility Center and the central office are agreed in advance by all participants in the investment of funds in the investment.

4. Profit distribution among participants of the resource investment is carried out in accordance with the return received from the sale of investments and the money allocated by them.

The priority in making return on investments is absent.

There are various sources of forming a centralized funds of the enterprise.

*A. The first alternative*

The formation of the centralized fund of the enterprise is carried out using the resources of the Financial Responsibility Center.

The mechanism of interest coordination is developed as follows.

*Stage 1.* Each FRC develops a list of investments for a planned period of time. For each investment project, annual costs, annual profits are indicated as annual profit calculated for one ruble of costs. Moreover, the FRC indicates how much money it has for the investment plan development. Each FRC calculates its optimal plan on the basis of this information.

*Stage 2.* Each FRC solves a problem to determine the optimal investment plan (1-3):

$$f(x) = \sum_{j=1}^n \Pi_j y_j \rightarrow \max \quad (1)$$

$$\sum_{j=1}^n c_j y_j \leq C, \quad (2)$$

$$y_j = \{1,0\}, \quad (3)$$

where  $\Pi_j$  is planned annual profit of the FRC from the implementation of the  $j$ -th investment project;  $c_j$  is planned annual costs of the FRC for the  $j$ -th investment project;  $C$  is funds that can be allocated by the FRC for the investments implementation in the planning year;  $y_j$  a desired parameter, showing whether the  $i$ -th investment project is planned to be included in the investment plan of the FRC: if  $y_j = 1$ , then it is planned; if  $y_j = 0$  then it is not planned.

The result of the task solving (1-3) is an optimal investment plan. The information received at the 2nd stage is transmitted to the central office by the FRC [14,15].

*Stage 3.* The main company, having received information from all FRCs, taking into account the funds allocated by them to the main company, forms an optimal investment plan, effective from the point of view of the whole enterprise.

For this, the problem is solved as (4-6):

$$f(x) = \sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} x_{ij} \rightarrow \max; \quad (4)$$

$$\sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \leq K; \quad (5)$$

$$x_{ij} = \{1,0\}, \quad (6)$$

where  $\Pi_{ij}$  is planned annual return for the  $i$ -th the FRC from the implementation in to the  $j$ -th investment;  $c_{ij}$  is planned annual costs for the  $i$ -th the Financial Responsibility Center into the  $j$ -th investment project;  $K$  is planned total volume of funds of the enterprise;  $x_{ij}$  is a desired parameter, indicating whether the  $j$ -th investment project is planned to be implemented in the  $i$ -th the Financial Responsibility Center (if  $x_{ij}$  is 1, then it is planned; if  $x_{ij}$  is 0, then it is not planned).

The planned amount of enterprise's funds includes resources of separate FRCs, i.e. (7):

$$K = \sum_{i=1}^m c_i, \quad (7)$$

where  $c_i$  is planned amount of funds allocated by the  $i$ -th the FRC for the investment plan formation.

The optimal investment plan of the enterprise, found as a result of task solving (4) - (6), will differ from the optimal plans of the Financial Responsibility Center obtained at Stage 2.

The difference is that the total profit of the enterprise, obtained as a result of task solving (4) - (7), will, as a rule, be greater than the total profit obtained as the sum of the profit of separate FRCs, i.e., based on the task solving (1) - (3) for each FRC in particular. This is achieved through the so-called system effect.

*Stage 4.* In accordance with the optimal task solving (4) - (6), the main company develops investment plans for the FRC. They are formed according to values  $x_{ij}^* = 1$ . For separate

FRCs, optimal plans differ from those that were obtained on the basis of task solving (1) - (3). At the same time, they calculate the funds that are allocated to the investment plan from the funds of the Financial Responsibility Center themselves, i.e., they calculate (8):

$$c_i = \sum_{j=1}^n c_{ij} x_{ij}^*. \quad (8)$$

*Stage 5.* This stage is the main one. It determines the essence of the proposed economic mechanism for coordinating interests of the FRCs with each other and with the central company. It includes the following calculations:

1. Calculate the total profit of the Financial Responsibility Center, corresponding to the optimal values  $y_j^* (j=\overline{1, n})$ ,

and designate it as  $\pi_1$ ; this profit will be called as the profit in the decentralized use of monetary resources by each Financial Responsibility Center.

2. Calculate the total profit of the Financial Responsibility Center, corresponding to the optimal values  $x_{ij}^*$ , and designate it as  $\pi_2$ . This return will be called as return in the centralized application of funds of the FRC.

3. Calculate the mean return per one ruble of costs in the decentralized and centralized use of funds according to the formulas (9-10):

$$\Pi_{mean1} = \sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} y_{ij}^* / \sum_{i=1}^m \sum_{j=1}^n c_{ij} y_{ij}^* \quad (9)$$

$$\Pi_{mean2} = \sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} x_{ij}^* / \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}^* \quad (10)$$

Obviously that  $\pi_{mean2} \geq \pi_{mean1}$ .

4. Determine the return growth obtained by money concentrating at the central office and their optimal redistribution among the Financial Responsibility Centers of the enterprise, i.e., they calculate the system effect  $\Delta\pi = \pi_2 - \pi_1$ .

A system effect  $\Delta > 0$  will always be with the limited funds and, therefore, the impossibility of including all construction activities, improvement of technical development and organization of production submitted to consideration into FRC investment plans.

5. Calculate the amount of funds that the Financial Responsibility Center transfers to the central office in accordance with the optimal plan of the task (1) - (3) for the group interests of the enterprise, and designate them by (11):

$$S_i = c_i - \sum_{j=1}^n c_{ij} y_{ij}^* \quad (11)$$

and calculate the total amount of funds on the basis of these values and designate it as (12):

$$S = \sum_{ij} S_i \quad (12)$$

6. Calculate the mean profit per 1 ruble of costs, intended for the group interests, according to the formula (13):

$$\Delta \Pi_{mean} = \Delta \Pi / S \quad (13)$$

Obviously,  $\Delta \pi_{mean} \geq \pi_{mean2} \geq \pi_{mean1}$

7. Form (redistribute) the profit received due to the system effect among the Financial Responsibility Center of the enterprise.

There are various principles for the return formation of the Financial Responsibility Center. The simplest principle is that planned return is distributed in proportion to the resources invested by the Financial Responsibility Center. According to this principle the return distribution of the FRC will be (14):

$$\overline{\Pi}_i = \Pi_{mean2} * C_i \quad (14)$$

Here, FRCs are more advantageous, with large funds and less effective investment alternatives.

Another principle for generating profit of the Financial Responsibility Center is also possible.

FRCs form their return from the return they would receive at the expense of investments secured by their own funds, and would arrive for the provision of funds to the centralized fund of the enterprise and their use by other FRCs. The return of the FRC according to this principle formation is as follows (15):

$$\overline{\Pi}_i = \sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} y_{ij}^* + \Pi_{mean2} \Delta C \quad (15)$$

where  $\Delta C_i$  is the amount of unused resources with their decentralized distribution, calculated as (16):

$$\Delta C_i = C - \sum_{i=1}^m \sum_{j=1}^n c_{ij} y_{ij}^* \quad (16)$$

The amount of funds of the Financial Responsibility Center transferred to the centralized fund and received from the centralized fund are (17):

$$\beta_i = \sum_{j=1}^n c_{ij} x_{ij}^* - C \quad (17)$$

(if  $\beta_i > 0$ , then this means that the Financial Responsibility Center receives funds from the centralized fund; if  $\beta_i < 0$ , it transfers funds to the centralized fund).

The third principle of profit generation means that within the framework of a centralized distribution of resources, an economic and mathematical model is built to find optimal plans for investment formation and profit distribution among the Financial Responsibility Centers simultaneously. It is a more complex principle, and it goes beyond the framework of this approach to constructing a mechanism of interest coordination.

*B. The second alternative*

nFormation of the centralized funds of an enterprise is carried out both at the expense of the Financial Responsibility Centers and of the company [16].

Taking into account the funds of the main company, the formation of an optimal investment plan with a centralized distribution of funds is presented as a task (18-21):

$$f(x) = \sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} x_{ij} \rightarrow \max; \tag{18}$$

$$\sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \leq C + M; \tag{19}$$

$$\frac{\sum_{i=1}^m \sum_{j=1}^n \Pi_{ij} x_{ij}}{\sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}} \leq r; \tag{20}$$

$$x_{ij} \in \{0, 1\} \tag{21}$$

In addition to the previously accepted designations:

$M$  is funds of the central company that it can allocate in the plans for the investments formation of the Financial Responsibility Center;

$r$  is the permissible average profit per one ruble of the cost of resources (a rate of return on the capital).

The restriction (21) was introduced into the economic and mathematical model in order to protect the enterprise investment plan from its inefficiency in terms of external conditions (interest rates of banks, competitors, etc.).

The mechanism for reconciling interests in this three-link system of relationships is the same as in the two-link system.

The funds usage of the central company increases the amount of resources, expands the scope of investments used by the Financial Responsibility Center of the enterprise. This leads to the increase in the projected annual profit of the enterprise. But the third participant in the three-link interconnection system, the central office, is now claiming this profit.

The return generation in the Financial Responsibility Center and the central office is carried out according to the average return in accordance with the formula (22):

$$\bar{\Pi}_i = \Pi_{mean2} * C_i \Pi_{rc} = \Pi_{mean2} * L, \tag{22}$$

for additional return: in accordance with the formula (23-24):

$$\bar{\Pi}_i = \sum_{j=1}^n c_{ij} y_{ij}^* + \frac{\Delta \Pi}{\sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}^*} * \left( \sum_{j=1}^n c_{ij} y_{ij}^* - C_i \right); \tag{23}$$

$$\Pi_{rc} = \frac{\Delta \Pi * M}{\sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}^*}, \tag{24}$$

where  $\Pi_{rc}$  is return of the central company.

The comparison of the numerical results of the profit distribution among Financial Responsibility Centers and a central office shows that the second method provides greater transparency and objectivity of return formation. If, when distributing profits by average return, all FRCs and the enterprise have the same rate of profit, then when distributing profits by added return, FRCs and the company itself have different return rates. These rates of profit correspond to the efficiency of the planned investments of the Financial Responsibility Center of the enterprise.

### III. DISCUSSION

Various alternatives for the profit formation and distribution among participants could be considered applying a system of models with integral optimization criteria. It is shown that the alternative of forming a centralized fund of the company, both at the expense of the Financial Responsibility Centers and the company's funds is optimal; it provides greater transparency and objectivity of profit generation. The restrictions application (9) helps to protect the enterprise investment plan from its inefficiency in terms of external conditions (interest rates of banks, competitors, etc.). Within the framework of the centralized distribution of resources, an economic and mathematical model is being developed for the simultaneous finding optimal plans for the investments formation and the profits distribution among Financial Responsibility Centers. It is a rather complex principle, and it goes beyond the framework of this approach to developing a mechanism for interests' coordination.

### IV. CONCLUSIONS

The analysis of the modified models, which helps to take into account the real properties of the planning processes of building production more flexible, shows that the optimization problems they form have the properties that make them difficult to solve by known methods such as heterogeneous variables (real, integer, combinatorial), non-linear (possibly algorithmically defined) target functions and restriction functions.

Thus, it is necessary to develop algorithms for solving mixed optimization problems with algorithmically defined non-linear functions, as well as algorithms for dynamic scheduling in the conditions of irregular orders to increase the validity of decision-making in managing the resources distribution of construction organizations.

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