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Optimization of Innovation Projects According To Criteria of Time and Resource Constraints



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Abstract: Innovative enterprises are distinguished from other enterprises with high competitiveness and economic growth, of course they are leaders in a certain market. However, the development and implementation of innovative projects is carried out under the conditions of limitation: both temporal and resource (financial and labor, etc.).

Index Terms: innovation project, constraints, resource, time.

I. INTRODUCTION

Innovative enterprises are distinguished from other enterprises with high competitiveness and economic growth; of course, they are leaders in a certain market [1-3]. However, the development and implementation of innovative projects are carried out under the conditions of limitation: both temporal and resource (financial and labour, etc.) [4-8]. The purpose of the article is to solve the problems of time and resource constraints during the creation of innovative projects and to provide a methodology for solving and a practical example of the application of the proposed model. Innovative is a project that includes a system of measures in terms of time and resource constraints on the creation, implementation, implementation and promotion of innovation (technology, products, developments, etc.) in a particular market [9-11].

II. METHODOLOGY

A. The general algorithm for optimizing the limitations of innovative projects

Solving the problem of lack of time and resources during the development of innovation projects is possible due to the use of mathematical models. The methodology of the model is

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shown in Fig. 1

Initially, a division of human resources between innovative projects is being implemented, which contributes to optimizing staff costs. Further, labour resources are allocated among innovative projects, taking into account their priority (by the method of network programming). Optimization of the time for implementation promotes the selection of more qualified personnel for innovative projects with the highest priority, which creates reserves due to their execution of the above-specified term.

The next stage involves determining the degree of participation of staff and distributing them to other projects (if necessary) within the deadlines for the implementation of innovation projects and the funds allocated to them.

At the final stage, the total time for implementing innovative projects is determined.

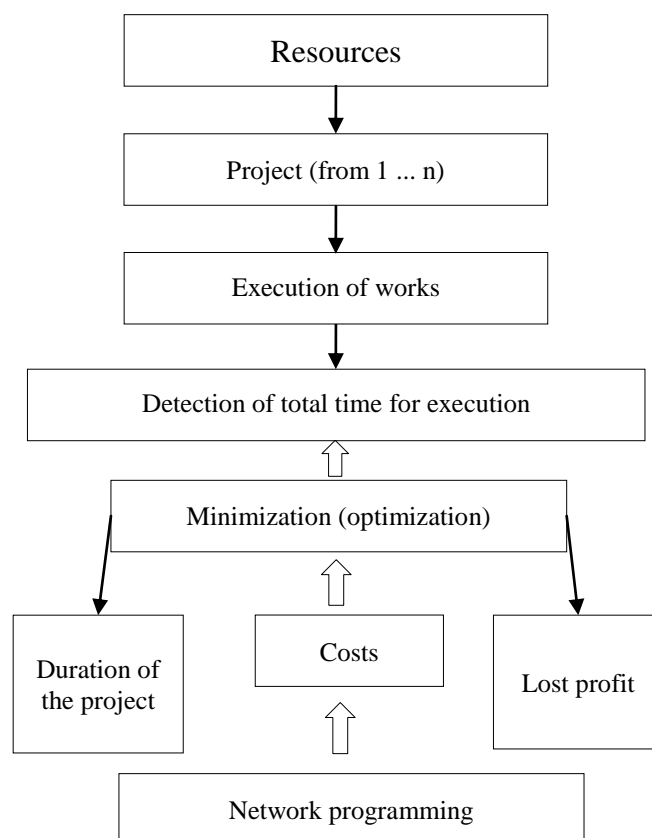


Fig. 1 Methodology for optimizing the limitations of innovative projects.

Network programming is to obtain the upper and lower ratings used when finding optimal values (the boundary/branch method).



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The disadvantages of network programming are the use of values of variables, which are predetermined and simplified restrictions and target function; is ineffective for nonlinear functions.

Advantages: accuracy of optimization solutions; search for solutions for simple tasks that are components of more complex; is the result of a generalization of dynamic programming and is less labour-consuming in comparison to it.

B. Target function and restrictions

The target function has the form:

$$CB = \sum_{t=1}^T \sum_{i=1}^n \sum_{j=1}^J Z_{ijt} (N_{ik}) \rightarrow \min \quad (1)$$

where CB - is the aggregate cost of implementing an innovation project that needs to be minimized;

t - the number of a time interval, which varies from 1 to T ;
 T - number of time intervals for the implementation of the innovation project;

i - respectively the number of the innovation project (varies from 1 to n);

Z_{ijt} - the cost of execution (j - the cost of execution, varies from 1 to J (expenses));

N_{ik} - necessary labour resources to perform k -th work.

Restrictions on the number of labour resources used:

$$\sum_{i=1}^n N_{ikt} \leq N_k \quad (2)$$

where k - the type of work to be performed; t - time interval for execution; k and t are fixed values.

Time limits for execution:

$$T_i \leq T_i^0 \quad (3)$$

where i - respectively the number of the innovation project.

or actual time for implementation of the innovation project must be less than or equal to the time specified by the customer;

Restrictions related to the priority of the innovation project:

$$Z_i^l \leq \frac{pr_i * D_i}{\sum_{i=1}^n pr_i * D_i} * Z^{tot} \quad (4)$$

where pr_i - the priority of a particular innovation project;

D_i - revenue from its implementation; and is the number of the innovation project;

n - the number of innovative projects;

Z^{tot} - total costs of execution.

or admissible costs less than or equal to the share of income of an innovation project taking into account the priority.

III. AN EXAMPLE OF THE USE OF THE METHODOLOGY IN THE ACTIVITIES OF THE ENTERPRISE

Let us consider an example of solving the problem of the distribution of labour resources among the projects of a company's portfolio based on the developed integrated methodology for managing its implementation.

IT managers decided to accept the weight of the results of implementation/non-fulfilment of projects in each of the "Benefits", "Opportunities", "Costs", and "Risks" groups equivalent, which is reflected in the "Result Weight" column of Table 1.

Table 1 - Weight of the results of the implementation / non-performance of projects and the corresponding indicators in each group

Group	Effect of implementation /non-fulfilment of projects	Weight of result
Benefits	Increase market share	0.2
	Increase profits	0.2
	Achieving the strategic objectives of a company	0.15
	Expansion of the client base	0.15
	Increasing the experience of implementing a typical concerning the considered project	0.15
Opportunities	Hold valuable employees	0.15
	The increase in profits due to the provision of additional. services during the implementation of a project	0.25
	An increased market effect from the implementation of the portfolio of projects	0.25
	Improving the quality of subsequent ongoing projects	0.25
Costs	Increasing staff satisfaction	0.25
	Loss of market share	0.25
	Increased number of lost customers	0.25
Risks	The inability to obtain new experience from the implementation of the project	0.25
	Increased post-training costs	0.25
	The decrease in profits due to the free provision of additional. services during the implementation of a project	0.2
	Reducing the market effect of the implementation of a project	0.2
	Refusal to implement a project by the customer	0.2
Risks	Failure to achieve the required quality of the execution results project due to lack of staff competence	0.2
	Increased staff dissatisfaction	0.2

Conditional data on a portfolio consisting of three projects were taken on the basis of reports on the implementation of a portfolio of projects provided by a large company, excerpts from which are described in tables 2.1-2.3.

Source data for a comparative analysis of methods of dynamic and network programming

Table 2.1 - Baseline data of the first project portfolio

	The first project (workgroups)							The second project (workgroups)					The third project (workgroups)							
	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	7	8
A	A1	A2	A4	A5	A1	A4	A4	A1	A3	A4	A1	A3	A1	A2	A1	A3	A4	A2	A4	A3

B	1	1	2	2	3	4	5	1	2	2	3	3	1	1	2	3	3	4	4	5
C	4	3	2	2	4	3	2	1	4	5	2	4	2	5	2	4	3	1.5	2	1
D	3	2	1	2	3	2	1	1	2	4	1	2	1	3	1	2	4	1	2	2
E	2	1.5	2	2	1.5	1.5	2	3	2	1.5	2	1.5	4	1.5	2	1.5	2	2	1.5	1

Table 2.2 - Baseline data of the second project portfolio

	The first project (workgroups)						The second project (workgroups)						The third project (workgroups)						
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	7
A	A1	A2	A1	A5	A1	A2	A4	A2	A3	A4	A3	A4	A1	A2	A1	A2	A5	A4	A4
B	1	1	2	3	4	4	1	1	2	2	3	3	1	2	2	2	3	3	4
C	6	3	4	6	2	1	3	4	6	4	8	6	10	2	4	8	3	8	6
D	2	2	2	3	1	1	1	2	2	2	2	3	2	1	2	4	1	5	4
E	3	3	2	2	2	1	3	2	3	2	4	2	5	2	2	2	3	2	2

Table 2.3 - Baseline data of the third project portfolio

	The first project (workgroups)					The second project (workgroups)					The third project (workgroups)					
	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5
A	A5	A3	A5	A2	A3	A4	A2	A3	A2	A3	A1	A1	A4	A5	A1	A5
B	1	1	2	3	4	1	1	2	2	3	3	1	2	3	3	4
C	5	7	4	5	3	4	8	5	6	7	1	3	5	2	4	3
D	2	5	2	2	1	2	5	2	3	4	1	2	2	2	2	1
E	2.4	1.7	2	2.4	2.5	1.8	1.6	2.4	2	1.8	1	1.5	2.5	1.2	1.8	3

where A - Specialization

B - The order of execution

C - Scope of work

D - The maximum amount of human resources

E - Lead time

According to the tables, we calculate the actual amount of labour resources by type of work (Table 3.)

Table 3 - The actual volume of labour resources by type of work

Type of work	Actual workforce		
	The first portfolio of projects	The second portfolio of projects	The third portfolio of projects
A1	6	5	3
A2	2	5	3
A3	4	2	4
A4	6	5	2
A5	1	2	4

Portfolio projects have different customers. To solve the problem of the distribution of labor resources, project priority ratios (PR_i) were found, which took into account the schedule of the project portfolio implementation using the cost minimization algorithm under labour, financial and time constraints.

The amount of the budget allocated for the first project is determined by taking into account its priority factors in each of the Benefits, Opportunities, Costs, and Risks groups according to the third equation presented in formula (4). The priority factors used in this formula are first normalized within each project, according to Table 4.

Table 4 - Portfolio project priority ratios

The name of the coefficient of priority	First project	Second project	Third project
The factor of priority from the position "Benefits."	0,075	0,065	0,12

The coefficient of priority from the position "Opportunities."	0,05	0,065	0,048
The coefficient of priority from the position "Costs."	0,15	0,035	0,164
The coefficient of priority from the position "Risks."	0,094	0,052	0,194
Sum of project priority ratios	0,294	0,152	0,406
The normalized priority factor from the "Benefits" position	0,255	0,428	0,296
The normalized priority factor from the "Opportunities" position	0,170	0,428	0,118
The normalized priority factor from the "Costs" position	0,510	0,230	0,404
The normalized priority factor from the "Risks" position	0,320	0,342	0,478
Total Priority Ratio	0.82	1.16	0.65

Let's create a schedule using the scheme of minimizing the cost of implementing a portfolio of projects. To this end, we will distribute the workforce of each specialization between portfolio projects. To do this, we find solutions for five systems of equations:

$$\begin{cases} A1 = \frac{0.82 * 9}{x_1} + \frac{1.16 * 4}{x_2} + \frac{0.65 * 3}{x_3} \\ A1 = 6 \end{cases} \quad (5.1)$$

$$\begin{cases} A2 = \frac{0.82 * 3}{x_1} + \frac{0.65 * 5}{x_3} \\ A2 = 2 \end{cases} \quad (5.2)$$

$$\begin{cases} A3 = \frac{1.16 * 4}{x_2} + \frac{0.65 * 8}{x_3} \\ A3 = 4 \end{cases} \quad (5.3)$$

$$\begin{cases} A4 = \frac{0.82 * 7}{x_1} + \frac{1.16 * 5}{x_2} + \frac{0.65 * 9}{x_3} \\ A4 = 6 \end{cases} \quad (5.4)$$

$$\begin{cases} A5 = \frac{0.82 * 4}{x_1} \\ A5 = 1 \end{cases} \quad (5.5)$$

The second and fifth systems of equations are trivial and have the following solutions, respectively: x₂=1, x₃=1 and x₁=1. Using the results of the distribution of labour resources among the portfolio projects, in Fig. 2 the schedule of its execution is formed:

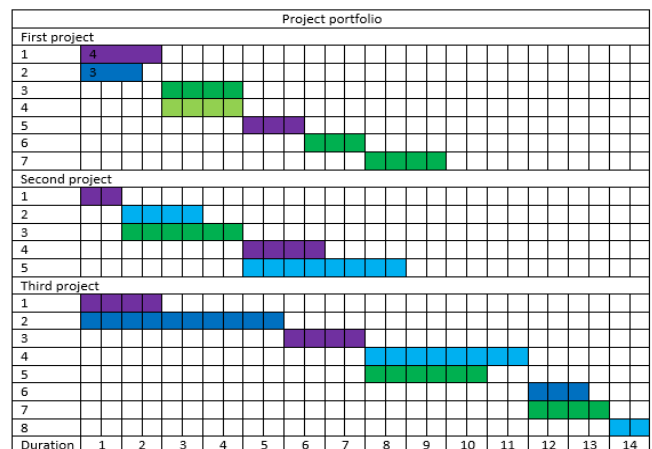


Fig. 2 - Schedule of portfolio execution

IV. RESULTS ANALYSIS

In the established calendar plan, the deadlines for the implementation of all projects established by their customers are exceeded and constitute, respectively, 95, 74 and 84 days. Therefore, it is required to reduce the duration of the execution of projects within the acceptable budget for each project, respectively: \$5505, \$2805 and \$3602. Project costs are: \$4804, \$2605 and \$3600 and do not exceed the maximum permissible values. Therefore, taking into account the budget reserve of the portfolio, we will reduce the duration of projects by increasing the intensity of the use of labour resources. Accordingly, travel expenses increase.

V. CONCLUSION

The proposed method (network programming) allows using simple algorithms to obtain an exact solution to the problem. Given the presence of a large number of jobs, it can quickly find answers in comparison with other methods. The application of the way contributes to the rational use of available resources that are limited and their effective distribution.

Prospects for further research may be the use of information systems in optimizing innovation projects by criteria of time and resource constraints.

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