Запропоновано економіко-математичну модель оптимізації змісту мультипроекта розвитку проектно-орієнтованого підприємства у загальному вигляді. Розроблена економіко-математична модель оптимізації змісту мультипроекта дозволяє сформувати мультипроект розвитку з огляду на специфіку діяльності та враховуючи ресурси і можливості компанії.

Показано, що сучасна ситуація потребує нових методів в управлінні проблемними зонами економіки, особливо гостро питання залучення та розподілення ресурсів постає для судноплавних компаній.

Експериментально досліджено економіко-математичну модель оптимізації змісту мультипроекта розвитку судноплавної компанії. Показано, що зв'язок між проектами в мультипроекті розвитку судноплавного підприємства здійснюється через ресурси та стратегічні цілі.

Досліджено зв'язки між проектами розвитку, розглянуто зв'язки між проектами в рамках мультипроекту розвитку судноплавної компанії у таких областях як: ресурсні обмеження, обмеження на рівні цілей, обмеження на рівні організації. Представлена економіко-математична модель оптимізації змісту мультипроекта розвитку судноплавної компанії дозволяє визначити в довгостроковому плані стратегічні цілі, оцінити необхідні для їх досягнення ресурси та встановити джерела їх поповнення. Економіко-математична модель дозволяє враховувати не тільки обмеження по ресурсах, але й відповідність результатів мультипроекта розвитку стратегічним цілям компанії. Отримано оптимальний зміст мультипроекта розвитку судноплавної кампанії при заданому рівню можливостей підприємства щодо фінансування проектів у поточному періоді та можливостей підприємства щодо фінансування проектів у складі мультипроекта протягом всього життєвого циклу.

Наведено підхід до формування мультипроекта розвитку судноплавного підприємства, який дає змогу досягати стратегічних цілей компанії у єдності проекта, мультипроекта та портфеля підприємства

Ключові слова: економіко-математична модель оптимізації змісту мультипроекта, розвиток судноплавної компанії, стратегічне планування

CONTENT OPTIMIZATION OF THE DEVELOPMENT OF MULTI-PROJECT OF A SHIPPING COMPANY

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1. Introduction

The socio-economic changes that have taken place in the world over the last decades require a rethinking of enterprise management approaches. It is important for companies from small forms to transnational corporate entities. In the field of water transport, however, as in other sectors of the economy, strategic problems become especially acute with the onset of long-lasting changes in the world market. The current situation requires new methods of managing problem areas of the economy. Under new conditions, the role of strategic and project management is increasing, which leads to the intensive development of project management theory. The scope of strategic and project decisions in shipping is wide: selection of the shipping company business areas, searching for long-term charterers, selection of the optimal organizational management structures, searching for the possibilities of maximum use of shipping companies' strengths, reduction of influence of shipping companies' weaknesses and manifestations of threats. Multi-projects in shipping are characterized by a significant level of investment costs. Most of such projects do not achieve their goals due to the lack of a suitable theoretical base that shipping companies could turn to.

The complexity and multitasking of the problem of forming the shipping company strategy, and as a consequence, the development multi-project, make this research topic to be relevant.

2. Literature review and problem statement

The paper [1] discusses the multi-project environment, but the author does not indicate the multi-projects' particularity and the differences between the multi-project and the portfolio. [2] establishes the relationship of project-oriented resource management in the multi-project environment with the processes of resource management of projects, programs and portfolios, but only the multi-project environment is considered. Multi-projects, as a certain number of projects to be realized, are not considered.

In [3], the technologies of complex systems and projects and programs management are investigated. The main tool for the development management is projects and programs of balanced development, but not enough attention is paid to multi-projects and parallel projects. In [4], the author is limited to considering projects within programs and portfo-

lios, which also does not give a holistic view of multi-project management. The main purpose of the research is systems where a large number of projects are executed, but the multi-project has not been considered, nor are the tools for managing parallel projects. In [5], the author considers the multi-project as a management object, but it doesn't show the combination of several projects of one area into a multi-project for the most effective strategy achievement. In [6], multi-project planning is considered, which, according to the authors, achieves maximum efficiency in reducing the consumption of shared resources, which avoids conflicts of over-allocation. But this does not provide a holistic picture of the optimal allocation of resources among projects and does not solve the problem of project selection for inclusion in a multi-project. [7] develops a local task schedule for each project of the multi-project, and then comes the stage of joint decision-making, but it does not consider how strategy and decision-making at the strategic level affect the redistribution of project resources and decision-making for each project in the multi-project.

In [8], the ideas of multi-projects are presented by means of the roadmap stages realization of enterprise development. But the relationship of multi-projects with the enterprise strategy is not explored. [9] examines specific quality strategies in accordance with the activities of the shipping company. However, the general strategy of the shipping company and development projects have not been considered. [10] considers the strengthening of sales potential as a major requirement for the development and competitiveness of enterprises in the modern shipping market, but does not consider specific strategies of shipping companies and does not pay attention to development projects as a tool for achieving strategic goals.

Thus, the analysis of trends in the development of project management methodology for multi-project management revealed that the issue of projects coordination with the strategy of the company, in particular of the shipping company, remains unresolved. Such a connection can be achieved by developing a method of forming a multi-project of the shipping company based on the systematic unity of strategic goals, project portfolio and multi-project. This connection is a problematic part of project management theory currently.

3. The aim and objectives of the study

The aim of the study is to determine the content of the multi-project in the unity of strategic and tactical levels of management, using an economic-mathematical model that ensures the effective development of shipping companies.

To achieve this goal, the following objectives were set:
– to formulate an economic-mathematical model of the shipping company development multi-project;
– to study experimentally the economic-mathematical model of the shipping company development multi-project.

4. Development of the economic-mathematical model of shipping company development multi-project content optimization

The basis of project portfolio management is the task of project connection with the company strategy [11, 12]. When forming a portfolio of many alternative projects, the company project portfolio is formed at the strategy level and a multi-project at the tactical level [13]. Formation of the shipping company multi-project is a multifactorial task influenced by internal and external factors. The result of it can be expressed by financial and non-financial indicators.

Due to the fact that in the financial aspect the main result of the projects' implementation is the formation of cash inflows, we will assume that receiving cash inflows is a continuous process. So, it is possible to formalize the result of the project, the intensity of which is described by the value $\varphi_i(t)$ Accordingly, over the time period $[0; t^*]$ the project implementation result will be expressed as:

$$F_i(0; t^*) = \int_0^{t^*} \varphi_i(t) \, dt. \tag{1}$$

In turn, after implementation of the multi-project, the financial results of the projects for the period $[t_k; t_{k+1}]$ will be determined:

$$F^M(t_k; t_{k+1}) = \sum_{i=1}^m F_i(t_k; t_{k+1}) = \sum_{i=1}^m \int_{t_k}^{t_{k+1}} \varphi_i(t) \, dt, \tag{2}$$

where m is the duration of the selected period.

Similarly to cash inflows, project and multi-project costs are generated within the considered time period $[t_k; t_{k+1}]$:

$$R^M(t_k; t_{k+1}) = \sum_{i=1}^m R_i(t_k; t_{k+1}) = \sum_{i=1}^m \int_{t_k}^{t_{k+1}} r_i(t) \, dt, \tag{3}$$

where $r_i(t)$ is the intensity of use of financial resources, \$/period.

Then the financial result of the multi-project is the difference between financial inflows and outflows. It can be presented as follows:

$$P^M(t_k; t_{k+1}) = F^M(t_k; t_{k+1}) - $$
$$- R^M(t_k; t_{k+1}) = \sum_{i=1}^m \int_{t_k}^{t_{k+1}} (\varphi_i(t) - (r_i(t)) \, dt. \tag{4}$$

However, a multi-project has to be formed from portfolio projects according to the priority of the company's strategic goals. Therefore, for a more complete characterization, the financial result should be supplemented by an integral indicator of compliance with the goals. It is proposed to use the following:

$$I^G = \sum_{z=1}^Z \alpha_z \frac{(I_z - I_z^M)}{I_z}, \tag{5}$$

where I_z, I_z^M are the numerical characterization of the goal z (for example, the market share of the shipping company) and the result of multi-project realization from the position of the given goal (market share that can be achieved), Z is the number of goals relevant for the given period.

$\frac{(I_z - I_z^M)}{I_z}$ is the indicator that reflects the proportion of non-compliance of the multi-project result with the given strategic goal. This value makes it possible to comprehensively account for different in nature and units of measurement goals in (5);

α_z are the weights assigned to goals based on their priority so that the higher-priority goal should have more weight.

In this case, condition (6) ensures maximum compliance of the multi-project results with the strategic goals, taking into account their priority:

$$I^G = \sum_{z=1}^{Z} \alpha_z \frac{\left(I_z - I_z^M\right)}{I_z} \to \min. \tag{6}$$

As an integral characteristic of goal compliance, the following formula can be used:

$$I^{G*} = \sum_{z=1}^{Z} \alpha_z \frac{I_z^M}{I_z}, \tag{7}$$

where $\frac{I_z^M}{I_z}$ reflects the compliance of the multi-project with the strategic goal. Expression (7) should be maximized while using this value as a criterion:

$$I^{G*} = \sum_{z=1}^{Z} \alpha_z \frac{I_z^M}{I_z} \to \max. \tag{8}$$

Thus, the result of the multi-project implementation is characterized by:
– financial result $P^M(t_k; t_{k+1})$;
– integral indicator of compliance with priority goals I^G or I^{G*}.

However, during the multi-project formation, one should take into account the fact that the multi-project within the considered time period consists of two subsets (Fig. 1):
– the first includes projects that are already being implemented and are ongoing (being completed) in the current period;
– the second consists of projects that are just about to be started according to the priority in the enterprise portfolio.
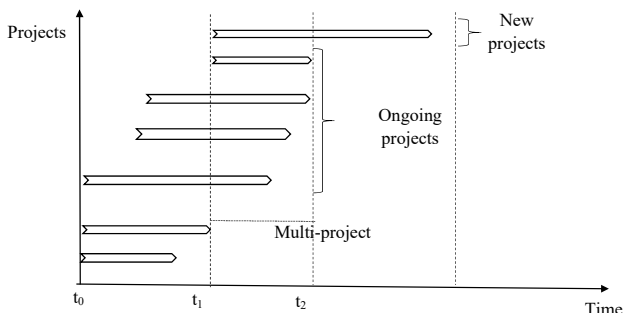

Fig. 1. Structure of the enterprise multi-project

That is why, when deciding on the multi-project content for the current time interval, one should take into account, on the one hand, the integral effect of project implementation, and on the other hand – the expediency of each subset presence in the multi-project.

Thus, in the framework of the multi-project formation task, there are two half-tasks:
– for current projects – to check the expediency of their further implementation, and in case of a negative decision to make a conclusion to suspend the projects (close them);
– for new projects – to select from the project portfolio with revision of strategic goals priority, and, as a consequence – projects priority.

Therefore, current projects are checked to ensure that:

$$F_i \geq F_i^{crit}, \tag{9}$$

where F_i^{crit} is the minimum allowed result of the project,

$$F_i = \int_0^{T_i} \varphi_i(t)\,dt,$$

where T_i is the life cycle of the i-th project. In addition, it is necessary to analyze the result that can be obtained within the multi-project review period $[t_k; t_{k+1}]$:

$$F_i(t_k, t_{k+1}) = \int_{t_k}^{t_{k+1}} \varphi_i(t)\,dt \geq F_i^{crit}(t_k, t_{k+1}). \tag{10}$$

If the project cannot provide the result, then the condition (10) reveals it. Similarly, conditions for the cost of these projects can be formed.

Thus, F_i^{crit} and $F_i^{crit}(t_k, t_{k+1})$ are "indicators" of the feasibility of further implementation of enterprise current projects.

The availability of financial resources and the result of multi-project implementation, in terms of financial indicators and achievement of priority objectives, are the main limiting conditions for solving the task of forming a multi-project. The multi-project optimality criterion is the financial result or an integral indicator of compliance with strategic goals.

It should be pointed out that the above indicator of compliance with goals (8) can be used to evaluate the formed multi-project. In the optimization, which involves searching through a variety of multi-project content options, it is difficult to use, because it involves pre-processing of a large amount of information and evaluating this indicator for all multi-project options. Therefore, we will decompose (8) for the projects as follows. We will denote the contribution of each project to the achievement of the j-th goal as $I_i^{G_j}$, then the value $\frac{I_i^{G_j}}{I^{G_j}}$ determines the proportion of compliance of the project implementation results with the j-th strategic goal. Thanks to this expression, we will obtain an integrated evaluation of the compliance of the multi-project results with the strategic goals:

$$I = \sum_{j=1}^{J} \alpha_j \sum_{i=1}^{m} \frac{I_i^{G_j}}{I^{G_j}}. \tag{11}$$

Then, we indicate the variable that is responsible for the inclusion of the i-th project to the multi-project as $x_i = \{0; 1\}$ and as an optimization criterion we will use the integral evaluation of the compliance of the multi-project results with the strategic goals of the enterprise:

$$\sum_{j=1}^{J} \alpha_j \sum_{i=1}^{m} \frac{I_i^{G_j}}{I^{G_j}} x_i \to \max. \tag{12}$$

Maximization of this indicator is ensured by the multi-project content, which is most closely corresponds to the priority strategic goals of the enterprise. In order to ensure that the resulting compliance ensured acceptable limits, a constraint (13) should be introduced into the multi-project composition model (overall compliance at the A level). We also introduce a system of constraints (compliance with each goal at the A^j level) (14):

$$\sum_{j=1}^{J}\alpha_j\sum_{i=1}^{m}\frac{I_i^{Gj}}{I^{Gj}}x_i \geq A, \tag{13}$$

$$\sum_{i=1}^{m}\frac{I_i^{Gj}}{I^{Gj}}x_i \geq A^j, \quad j=\overline{1,J}. \tag{14}$$

It should be noted that some local goals may be exceeded as a result of the parallel implementation of projects in the multi-project. If the goals are exceeded, you must specify the level to which the goal can be exceeded. If exceeding the goals contributes to the development of the company, then such goals are left unchanged. It is also necessary to limit the goal achievement by 1, supplementing the model with the following restrictions:

$$\sum_{i=1}^{m}\frac{I_i^{Gj}}{I^{Gj}}x_i \leq A\overline{j1,J}_{\max}, \tag{15}$$

$$Aj=\overline{1,m}_{\max}. \tag{16}$$

If for the j-th goal, the following holds:

$$\sum_{i=1}^{m}\frac{I_i^{Gj}}{I^{Gj}}x_i = 1, \tag{17}$$

then the goal is 100 % achieved.

Restrictions (18), (19) take into account the possibility of financing projects within a multi-project in the current period and in the future, during their life cycles (if the duration of the projects exceeds the considered time period):

$$\sum_{i=1}^{m}x_i\int_{t_k}^{t_k+1}r_i(t)dt \leq R^{k,k+1}-\sum_{l=1}^{L}R_l(k,k+1), \tag{18}$$

$$\sum_{i=1}^{m}x_i\int_{t_k}^{t_k+T_i}r_i(t)dt \leq R^{k,k+\max_i\{T_i\}}-$$
$$-\sum_{l=1}^{L}R_l\left(k,k+\max_{i,l}\left\{T_i,\left(T_l-k_l^{st}\right)\right\}\right), \tag{19}$$

where $R^{k,k+1}$ is the enterprise's ability to finance projects in the current period;

$R^{k,k+\max_i\{T_i\}}$ is the enterprise's ability to fully finance projects of the multi-project throughout its life cycle;

$\sum_{l=1}^{L}R_l(k,k+1)$ are total costs for current (already implemented) projects in the considered time period;

$\sum_{l=1}^{L}R_l\left(k,k+\max_{i,l}\left\{T_i,\left(T_l-k_l^{st}\right)\right\}\right)$ are total costs of ongoing projects for the period of full completion of all projects of the multi-project.

In this case, the duration of the multi-project lifecycle is the time period from the start of the planning period to the completion of all projects (both current and new), which is equal to:

$$\max_{i,l}\left\{T_i,\left(T_l-k_l^{st}\right)\right\}, \tag{20}$$

where T_l, k_l^{st} are the duration and start of implementation of current (implemented) projects, respectively.

In addition to resource constraints, the multi-project formation model must take into account the financial in-

terests of the enterprise, during the current period (21) and throughout the life cycle of the multi-project (22).

$$\sum_{i=1}^{m}x_i\int_{t_k}^{t_{k+1}}\left(\varphi_i(t)-r_i(t)\right)dt +$$
$$+\sum_{l=1}^{L}\int_{t_k}^{t_{k+1}}\left(\varphi_l(t)-r_l(t)\right)dt \geq P_{k,k+1}^{crit}, \tag{21}$$

$$+\sum_{l=1}^{L}\int_{t_k}^{t_k+\max_{i,l}\left\{T_i,\left(T_l-k_l^{st}\right)\right\}}\left(\varphi_l(t)-r_l(t)\right)dt \geq P^{crit}, \tag{22}$$

where

$\int_{t_k}^{t_{k+1}}\left(\varphi_l(t)-r_l(t)\right)dt$ is the financial result of the implemen

tation of current projects in the planned period;

$\int_{t_k}^{t_k+\max_{i,l}\left\{T_i,\left(T_l-k_l^{st}\right)\right\}}\left(\varphi_l(t)-r_l(t)\right)dt$ is the financial result of the

implementation of current projects within the multi-project life cycle;

$P_{k,k+1}^{crit}$ is the lower bound of the required total financial result of the multi-project in the current period;

P^{crit} is the lower bound of the required total financial result of the multi-project within the life cycle.

Thus, (8)–(22) allows optimizing the inclusion of projects to the multi-project from the enterprise portfolio, taking into account current projects.

So, the project management methodology is universal and its theory and methods are applicable to all fields of activity, including shipping. The efficiency of the national economy, economic growth, sustainability of development of territorial complexes and foreign economic activity are traditionally determined by the functioning of transport. Shipping companies are the most important components of the transport complex of the country.

In modern conditions, the enterprises of the Ukrainian transport complex are experiencing the most intense competition from foreign companies, as a result of which the volume of foreign trade cargo transportation by Ukrainian water transport decreases annually. Also, as a result, foreign exchange earnings for cargo transportation in export-import connection leave abroad. That's why it is very necessary to involve the project management methodology in the development of shipping companies.

5. Experimental research of the economic-mathematical model of the shipping company development multi-project

Each area of activity has its own specificity, which is reflected in the content of goals and in the formation of financial indicators. The economic-mathematical model (8)–(22) has a universal character and is focused on the development of project-oriented enterprises of any specialization. However, in its practical use, attention must be paid to the specificity of the enterprise, which is reflected in the optimization criteria and constraints. The shipping industry is very resource-intensive and the markets in which shipping companies operate are very competitive; also, shipping companies are under constant pressure from foreign competitors.

Therefore, the goals and related development projects of shipping companies can be varied. For example: choice of directions of activity, search of charterers, choice of optimum organizational management structures, search of opportunities for the maximum use of strengths, reduction of influence of weaknesses, etc.

Thus, the main point is to ensure the rational use of the resources of the shipping company in development projects. Thus, while making a management decision to include a particular shipping company development project in a multi-project or not, projects with a higher financial result are most preferred.

From the set of priority goals and projects of the portfolio, at the strategic level of the shipping company, a subset was identified. It corresponds to the considered time period. For example, the priority goals of the shipping company are:

– Goal 1 is to achieve 20 % of the market share of maritime transport of ore and grain, the priority of this goal is 0.4: project 1 is to charter a vessel with a deadweight of 40 thousand tons in a time charter, project 2 is to charter a vessel with a deadweight of 20 thousand tons in a time charter;

– Goal 2 is to increase the total tonnage of the fleet up to 300 thousand tons, the priority of the goal is 0.35: project 3 is to purchase of a vessel with a deadweight of 40 thousand tons, project 4 is to purchase of a vessel with a deadweight of 20 thousand tons;

– Goal 3 is to achieve a profit (for 3 years) of 1,240 thousand of dollars, the priority of the goal is 0.25: project 5 is creation of a company branch (crewing), project 6 is the creation of a company branch (technical management).

Thus, the three strategic goals were complied by six projects that are candidates for inclusion in the multi-project.

Table 1 shows the results of calculations of integral indicators of compliance of expected results with the company's goals after the project implementation.

Table 1

Integrated indicators of project compliance with goals

Project	$\sum_{j=1}^{J}\alpha_j \dfrac{I_i^{G_j}}{I^{G_j}}$
Project 1	0.318
Project 2	0.330
Project 3	0.548
Project 4	0.410
Project 5	0.070
Project 6	0.158

Note that $\sum_{j=1}^{J}\alpha_j \dfrac{I_i^{G_j}}{I^{G_j}}$ can be more than 1, that is, the results of all alternative projects may be redundant in terms of goals. But each project makes its own contribution to the local goal, which is taken into account in the respective model constraints for each goal, and this controls the unwanted redundancy in their achievement. Therefore, to understand the results of the experimental studies better, we transform the integrated indicators of project compliance so that their sum is 1.

At the moment, the company is already implementing a project of purchasing a vessel with a deadweight of 45 thousand tons. The financial result of the current project is:

$$\sum_{l=1}^{L}\int_{t_k}^{t_{k+1}}\left(\varphi_l(t)-r_l(t)\right)dt=140 \text{ thousand dollars,}$$

$$\sum_{l=1}^{L}\int_{t_k}^{t_{k+\max_{i,l}\{T_i,(l-i^{st})\}}}\left(\varphi_l(t)-r_l(t)\right)dt=260 \text{ thousand dollars.}$$

The total cost of the current project in the considered period is:

$$\sum_{l=1}^{L}R_l(k,k+1)=100 \text{ thousand dollars.}$$

The amount of financing for the current project for the period of completion of all projects in the multi-project is:

$$\sum_{l=1}^{L}R_l(k,k+\max_{i,l}\{T_i,(T_l-k_l^{st})\})=100 \text{ thousand dollars.}$$

Table 2

Integrated indicators of project compliance with goals

Integrated project of project compliance with goals (after conversion)
$\sum_{j=1}^{J}\alpha_j \dfrac{I_i^{G_j}}{I^{G_j}} / \sum_{i=1}^{m}\alpha_j\sum_{j=1}^{J}\dfrac{I_i^{G_j}}{I^{G_j}}$

Project 1	0.173
Project 2	0.180
Project 3	0.299
Project 4	0.224
Project 5	0.038
Project 6	0.086

Then the main characteristics of the applicant projects are presented in Table 3.

Set the allowable value of the integral indicator of compliance with goals as $A=0.75$. Such an indicator means that the multi-project must achieve at least 75 % of the goals. In addition, each local goal must be reached by at least 50 %, however, exceeding each local goal is allowed. Note that the project lifecycle is a multiple of the planning period, that is, the length of time $[t_k, t_{k+1}]$. The company's ability to finance projects in the current period is $R^{k,k+1}=3,100$ thousand dollars, during their life cycles is $R^{k,k+\max_i\{T_i\}}=4,100$ thousand dollars. Lower bounds of the financial result of the multi-project implementation are $P_{k,k+1}^{crit}=400$. thousand dollars, $P^{crit}=800$ thousand dollars.

Table 3

Main characteristics of the project applicants for inclusion in the multi-project, thousand dollars

Pro-ject	T_i, Year	$\int_{t_k}^{t_{k+\max_{i,l}\{T_i,(l-i^{st})\}}}\left(\varphi_i(t)-r_i(t)\right)dt$	$\int_{t_k}^{t_{k+1}}\left(\varphi_i(t)-r_i(t)\right)dt$	$\int_{t_k}^{t_{k+1}}r_i(t)dt$	$\int_{t_k}^{t_{k+T_i}}r_i(t)dt$
Pr$_1$	1	500	450	200	200
Pr$_2$	2	300	300	150	250
Pr$_3$	3	500	250	2,000	3,000
Pr$_4$	3	500	150	900	2500
Pr$_5$	2	160	40	100	150
Pr$_6$	3	350	100	150	150

Once the necessary conditions have been established, the economic-mathematical model is formed in numerical form. The efficiency criterion, according to Table 2, has the following form:

$$3x_1 + 0.180x_2 + 0.299x_3 + 0.224x_4 + \\ +0.038x_5 + 0.086x_6 \to \max.$$

The minimum value of the integral indicator of compliance with goals is:

$$0.173x_1 + 0.180x_2 + 0.299x_3 + \\ +0.224x_4 + 0.038x_5 + 0.086x_6 \ge 0.75.$$

Goals restrictions are:

$$0.4x_1 + 0.3x_2 + 0.4x_3 + 0.3x_4 + 0x_5 + 0_6 \ge 0.5;$$

$$0x_1 + 0x_2 + 0.5x_3 + 0.25x_4 + 0x_5 + 0_6 \ge 0.5;$$

$$0.45x_1 + 0.6x_2 + 0.75x_3 + \\ +0.65x_4 + 0.2x_5 + 0.45_6 \ge 0.5.$$

Resource restrictions in the current period are:

$$200x_1 + 150x_2 + 2,000x_3 + 900x_4 + \\ +100x_5 + 150x_6 \le 3,100 - 100.$$

Resource restrictions over the multi-project lifecycle are:

$$200x_1 + 250x_2 + 3,000x_3 + 2,500x_4 + \\ +150x_5 + 150x_6 \le 4,100 - 100.$$

During the experimental studies, optimization was carried out for different values of the lower limit of goals and opportunities for project financing in the current period and throughout the multi-project period. As a result, the following optimal plans were obtained (Table 4).

To solve this task, we propose to use a simplex method for solving linear mathematical programming problems, which is implemented in Microsoft Excel. The simplex method is used to optimize a linear mathematical programming model, the restriction of which is reduced to a standard form.

Table 4

Optimal content of the shipping company development multi-project for different financing conditions

Project	Current funding restriction options, thousand dollars				
	Basic is 3,100	3,000	2,300	2,000	4,000
Pr_1	1	0	0	1	1
Pr_2	1	1	1	0	1
Pr_3	1	1	1	0	1
Pr_4	0	0	0	1	1
Pr_5	1	1	0	1	1
Pr_6	1	1	1	1	1
Lower bound of goals achievement	0.75	0.5	0.5	0.5	0.8
Criterion function	0.776	0.602	0.564	0.521	1
Finance limitation (for the entire multi-project period)	Basic is 4,100	3,400	3,100	3,000	7,000

Thus, under the basic financing option, the multi-project should include all projects except project 4. With possible funding in the current period of 2,300 thousand dollars, the multi-project content will be as follows: Project 2, Project 3, Project 6; the achievement of the goals will be ensured by 0.564, with a given lower limit of 0.5. With these funding options, it is not possible to achieve goals by at least 75 %. A similar situation is with the possibilities of financing in the current period at the level of 2,000 thousand dollars with overall funding of 3,000 thousand dollars: goals can be reached by 0.52; in this case the multi-project will include project 1, project 4, project 5, project 6. If funding is raised up to 4,000 thousand dollars in the current period, all projects will be included in the multi-project, and the achievement of goals will be met by 1 (all goals will be fully achieved).

Thus, with decreasing funding opportunities, it is necessary to reduce the lower boundary for achieving the non-zero solution.

According to the optimization results, reducing the multi-project financing leads not only to changes in the multi-project content (for those projects that have to be included in the multi-project), but also to the inability to achieve the goals in the required volume. Thus, in Table 4, the lower limit for achieving the goals should be reduced from 0.75 to 0.5 when funding is reduced.

Graphical interpretation of experimental results of the model with different financing options in the current period and for the multi-project period (regarding Table 4) is presented in Fig. 2, 3.
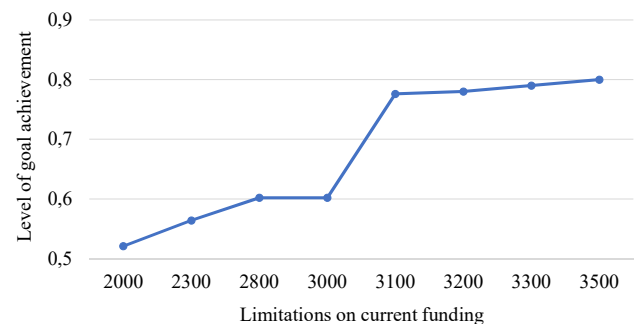

Fig. 2. Dependence of the multi-project goals achievement on financing opportunities in the current period (with a constant value for financing limitation for the entire period of the multi-project is 4,000 thousand dollars), according to Table 4
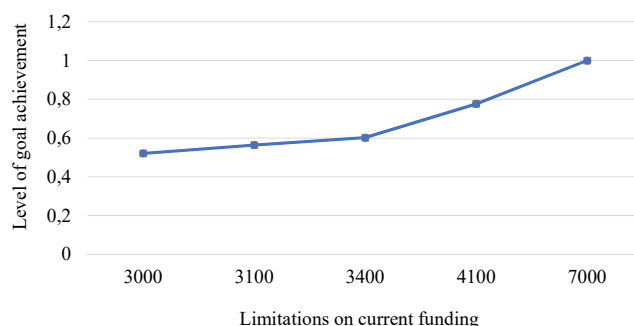

Fig. 3. Dependence of the multi-project goals achievement on financing opportunities for the whole period of the multi-project (with a constant value of financing limitation in the current period is 3,500 thousand dollars), according to Table 4

Obviously, with decreasing funding opportunities, it is necessary to reduce the lower bound for achieving goals. It is possible to predict the achievement of the multi-project goals by fixing funding for current periods or for the multi-project as a whole. The results of experimental research of the developed model make it possible to conclude on the adequacy of the optimization processes to the logic of multi-project formation described by the model; as well as the efficiency of the model and the reliability of results.

6. Discussion of the results of the economic-mathematical model of shipping company development multi-project content optimization

The economic-mathematical model of the shipping company development multi-project is developed, the particularity of the model is that the optimal multi-project content corresponds to the complex of ranked company goals (8) that fits the practice of modern business. As can be seen from Table 4, the economic-mathematical model allows changing financial restrictions for the entire period of the multi-project and it shows us changes in company's goals achievement. At the same time, model restrictions allow specifying minimum acceptable limits of achieving every goal and their integral unity, as presented in Table 4, Fig. 2, 3.

The main advantage of the model is the ability to distribute the shipping company's resources among development projects so that the strategic goals of the company are reached fully.

Experimental researches of the model are carried out. They have grounded its reliability and applicability for solving specific practical tasks regarding the achievement of the shipping company's goals according to its strategy. The dependence of multi-project goals achievement on financing opportunities in the current period and during the whole multi-project is shown (Fig. 2, 3).

The economic-mathematical model of shipping company development solves the issue of resource allocation among several projects in the development multi-project at the tactical level of the company, which wasn't implemented earlier. As a result, this gives the possibility to formulate the shipping company development multi-project based on the strategic vision and project portfolio of the shipping company.

The proposed model allows taking into account not only new projects, but also projects that are being realized by the shipping company, according to its strategy. This gives an opportunity to realize such development projects on the tactical level that do not contradict the general strategy and project portfolio of the shipping company.

Restrictions of the given research are resource limitations during the multi-project life cycle and during the current period. As was noted already, the peculiarity of the shipping company as an object where a management decision is made is that new circumstances are constantly emerging, which are significantly related to the enterprise. The economic-mathematical model of content optimization of the development multi-project of the shipping company allows making a decision which consists in determining the content of new projects or in adjusting an already implemented strategy taking into account new circumstances and resource constraints.

The disadvantages of this study are that the economic-mathematical model of the shipping company development multi-project allows considering only financial resources. Thus, further development of the project management theory in terms of content optimization of the development multi-project can be implemented in terms of supplementing the model by restrictions on different types of resources.

7. Conclusions

1. The proposed economic-mathematical model of multi-project content optimization allows forming the multi-project of enterprise development. This model takes into account not only resource constraints, but also the compliance of the multi-project results with the strategic goals of the whole enterprise. It also considers the turbulence of the environment in which the shipping company realizes its development. Structurally, the proposed economic-mathematical model within the considered time period can be represented as two subsets:

– the first one includes projects that are already being implemented and are ongoing (being completed) in the current period;

– the second consists of projects that are just about to be started according to the priority in the enterprise portfolio (at the strategic level).

This gives an opportunity to characterize the result of the implementation of the shipping company development multi-project with a financial result and an integral indicator of compliance with the priority goals The control parameter of the proposed economic-mathematical model is a Boolean variable, which is responsible for including or not including a particular development project in the shipping company development multi-project.

This approach has not yet been implemented in models of resource allocation among projects in a multi-project, and the peculiarity of the economic-mathematical model is that it allows including and excluding projects at the tactical level. It allows the shipping company to quickly respond to changes in external and internal environment.

2. The experimental studies confirmed the effectiveness of the proposed model in the real conditions of today. The possibility of using the model to form a multi-project of the shipping company development is proved. The model allows allocating resources among projects, according to their priority and participation in achieving strategic goals throughout the life cycle of a multi-project. The model revealed the content of optimal project plans for inclusion in the development multi-project of the shipping company with various opportunities for financing the multi-project as a whole (4,100 thousand of dollars, 3,400 thousand of dollars, 4,100 thousand of dollars, 3,400 thousand dollars, 7,000 thousand dollars) and of each project. This made it possible to find out which projects will be implemented within the multi-project, in accordance with the financing and strategic goals, and which projects will be excluded from the shipping company development multi-project.

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