Запропоновано метод формування портфеля, заснований на логіко-методологічному прийомі конфігурування проектів-претендентів, які представлені S-кривими потоку витрат і очікуваних результатів. Застосування прийому дає можливість представити портфель не як статичну сукупність проектів, а як безперервні процеси накопичення потенційної привабливості різних поєднань проектів. Показано, що конфігурування дозволяє знаходити таку послідовність взаємного розташування проектів в портфелі, за якої критерій, що враховує різні види потоків, досягає максимального значення. Завдяки використанню S-кривих вдається врахувати зміни показників потоків, які залежать від часу старту проекту в портфелі, та впливають на його привабливість.

На підставі розробленої моделі формування портфеля, системоутворюючим фактором якої виступає прийом конфігурування, виявлені зв'язки між її структурними елементами, які дозволили розкрити сутність критеріального показника привабливості та критерію конфігурування портфеля. При розрахунку привабливості використовується запропонована процедура згортання S-кривих, що передбачає дисконтування накопичених потоків. Таке згортання дозволяє отримати інтегральний показник, який враховує особливості конкретних S-кривих і відкриває можливість використання будь-яких видів потоків в задачах оцінки і порівняння проектів і портфелів.

На основі показника привабливості і використання процедури нормування дисконтованих накопичених потоків розроблено критерій формування портфеля. Встановлено, що критерій адекватно відображає більшу привабливість проектів з убутним характером витрат і меншою тривалістю фінансування при однакових параметрах очікуваних результатів. Даний факт підтверджений результатами комп'ютерного моделювання. Крім того, підтверджено, що розроблений метод дозволяє враховувати стратегічну важливість проекту, особливості графіка фінансування портфеля, а також особливості характеру зміни витрат по проекту та очікуваного результату проекту

Ключові слова: привабливість проекту, реалізуємість, досяжність результату, S-криві, дисконтування накопиченого потоку, нормування

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CONSTRUCTION OF A PORTFOLIO FORMATION METHOD BY CONFIGURING PROJECT-CANDIDATES BASED ON FLOW CHARACTERISTICS

V. Rach
Doctor of Technical Sciences, Professor,
Director of Educational-Scientific Institute
Educational-Scientific Institute of Information and Communication Technologies*
E-mail: valentine.rach@i.ua

K. Abdulkadir
Postgraduate Student
Department of Mathematical Methods and Statistics*
E-mail: kabirkadir@ymail.com

O. Medvedieva
Doctor of Technical Sciences, Professor
Department of Mathematical Methods and Statistics*
E-mail: agat.lg@i.ua

O. Biriukov
PhD, Associate Professor
Department of Economics and Entrepreneurship
Volodymyr Dahl East Ukrainian National University
Tsentralnyi ave., 59-a, Severodonetsk, Ukraine, 93400
E-mail: lglg@i.ua

O. Rossoshanska
Doctor of Economic Sciences, Associate Professor,
Director of Educational-Scientific Institute
Educational-Scientific Institute for Master and Post Diploma Studies*
E-mail: olga_rossoshanskay@i.ua
*"KROK" University
Tabirna str., 30-32, Kyiv, Ukraine, 03113

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1. Introduction

Project portfolio management (hereafter referred to as portfolios) is now one of the most rapidly developing areas in project management.

According to statistics, in developed countries, between 50 and 60 % of project-focused organizations manage projects in the portfolio structure [1]. Today, it has been established that about 71 % of IT companies use flexible project management methodologies in portfolio management [2], and more than 70 % of large companies have project portfolio management offices [3].

In portfolios management activities, the "cornerstone" is their formation – the process of selecting projects from the candidates according to an assigned parameter. This is proved by prevailing papers, dealing with the portfolio formation phase, in the total volume of portfolio management publications [4–6]. Moreover, most of these papers contain mainly methodological manuals for selecting projects in the portfolio, which describe different approaches. However, "today everyone agrees that none of the methods provides an exhaustive and universal answer to the problem of portfolio selection".

Based on the generalization of numerous publications, we identified two key approaches to portfolio formation. They can be conventionally referred to as "assessing" and "configuring".

In the framework of an assessment approach, the projects-candidates are sorted. The projects that have received high ratings of experts by the separated indicators are considered to be the "best" projects. The selection criterion in this approach plays the limiting role for the selection of the best projects with "positive" estimates. Subsequent prioritization of the selected projects ensures that the portfolio is balanced and its results (values) are maximized. Over the past 15 years, this approach has become the most popular in project management. This was proved by a large number of publications, in which it is used [8–11], as well as by the content of standards and practical guidelines (The standard for portfolio management. PMI. 2006, 2008, 2013, 2017; Governance of portfolios, programs, and projects: a practice guide. PMI. 2016; Management of Portfolios. AXELOS, 2011; ISO 21504:2015. Project, program and portfolio management – Guidance on portfolio management; DIN 69909-1:2013-03 Multi Project Management – Management of project portfolios, programs, and projects) and others.

The essence of the configuring approach follows from the definition of the term "configuring" as a logical methodological technique of synthesizing diverse knowledge, different systemic ideas about the same object (different projections) [12]. When configuring, different systemic views cannot be directly matched, merged, and transformed because of their different essence. Therefore, there is no optimality criterion for such a procedure. The correlation by a decision-maker of different systemic views about the same object, bypassing the object itself, regarding the purpose of configuring, is fundamental. Based on this, within the configuring approach, each project should be presented in different projections. It is advisable to use flow representations of a project (and a portfolio) about costs, expected results, strategic importance of projects, etc. as diverse knowledge corresponding to each projection. A flow is seen as the continuous processes that are measured in units over a definite time. To describe the cost flow, they use the parameters of the characteristic flow points (time-costs), at which the rate of an increase in cost changes. That is why the costs are presented in the form of the magnitudes cumulative at a certain point in time [13]. The expected project results can be presented similarly. In the time flow of portfolio implementation, each project has its place, determined by its strategic importance.

By now, the elements of the configuring approach have already been partially implemented in theory and practice. With their help, the problems on a rucksack combinatorial optimization [14–17], the formation of portfolios of investment projects and securities [18, 19], life safety projects [20], and environmental projects [21] are solved.

However, this approach remains a non-explicit one. That is why its use is more intuitive in nature and is limited to portfolios with a small number of projects. With an increase in their number and the essential variety of expected results, the problem of the formation of a rational portfolio is complicated by orders of magnitude. And under conditions of project funding flow that is alternating in time, the problem becomes almost unsolved without specially developed software. The development of such software implies the availability of a scientifically sound and explicitly presented method of configuring. In this regard, the scientific and practical problem of development of the method of portfolio formation by configuring the projects-candidates by flow characteristics is relevant today. The expediency of solving such a problem is enhanced by the expansion of the use of management of large social-economic entities based on multi-purpose project portfolios.

2. Literature review and problem statement

Paper [22] reports the results of research into the field of project portfolio management from the point of view of their practical implementation. It was shown that an increase in uncertainty factors, management complexity level and the diversity of portfolio implementation contexts in the future will influence the approaches to their formation and management. There will be a shift from the use of theories and approaches based on optimization and sub-optimization criteria to more flexible methodologies. The tools based on cognitive theories, heuristic approaches, theories of large information arrays, methods of structuring and reconfiguring complex formations will become widespread. The tendencies outlined in paper [22] are proved by the fact that the number of scientific publications, using the heuristic approach based on the configuring procedure in management, is growing. For example, in article [23], configuring is used to identify the characteristics of performance management systems (PMS) in design organizations. It was shown that it is configuring uncertainty at the level of projects and portfolios that matters for the PMS. Based on comparative qualitative analysis of the data of 15 project companies, four configurations of PMS characteristics were identified. Article [23] emphasized the practical implementation of configuring circumstances, rather than projects and portfolios themselves. At the same time, the problems related to the method of project portfolios configuration management remained outside the article. Paper [24], which examines configuring by two aspects: control and trust, is also practically focused. The study of 265 housing construction projects made it possible to identify four equivalent combinations of control and trust in terms of attaining project success. Empirically found configuration solutions broadened understanding of the relationship of control and trust in project implementation but did not expand theoretical knowledge on project portfolio configuration. In articles [23, 24], configuring was used as a tool for tuning, combining, rather than as a holistic thinking technique for synthesizing diverse knowledge. This approach is partly revealed in [25] using the example of configuring innovative processes and resource allocation of 132 innovative projects from 72 companies. The taxonomy of eight different innovative processes with descriptions of the specific circumstances of their implementation was synthesized. This makes it possible, during the implementation of innovative projects, to move away from the simple tunneling scheme through the predetermined phase sequence and to identify different suitable configurations that are adequate to specific situations and unforeseen circumstances arising in a project.

The most significant results, from the point of view of project portfolio formation, using the elements of the configuration approach are presented in papers [26, 27]. In [26], it is argued that a portfolio can have many internal configurations (sets of components) that are compatible with external constraints (both in input and output). Under such circumstances, there are only a few configurations that ensure its most effective implementation. To form a portfolio, an approach, which is based on a series of provisions borrowed from the scientific areas dealing with studying unbalanced, non-permanent processes, in particular, those of statistical thermodynamics, was proposed. The main criterion for the efficiency of portfolio configuration is maximizing the value of useful costs for the equivalent cost of a unit of the used resource. To formalize the criterion, the concept of entropy of resource distribution (scattering) rate and entropy of their use in a specific portfolio configuration is used. The total of considered entropies for possible combinations should tend to the maximum. However, this approach does not take into account the change in the cost of resources over time, which is an important factor for the portfolios of projects that have been implemented for a long time. The lack of assessment of the economic impact of projects is also a significant drawback, due to which the scope of application of the proposed approach is considerably narrowed. The authors of paper [26] suggest that it should be used for projects and portfolios, in which the expected values of results in economic measurement are difficult to predict.

The specified shortcomings are partially considered in paper [27], according to which the portfolio is formed based on configuring the projects that ensure the overall maximization of its profitability while minimizing the risks. Particular attention is paid to the consideration of a portfolio as a system of interdependent projects. In this case, minimizing the cost of individual projects is not a prerequisite. A combinatorial problem is stated to evaluate the various portfolio options. Its solution, taking into account the nature of cash flow behavior over time, allows choosing the most acceptable configuration of the projects' portfolio structure. At the same time, this research left without consideration the problems of taking into account the multi-purpose focus of projects. It is assumed that all projects have the same result essence, which can be measured by profitability. This significantly limits the practical application of the proposed approach.

An option to overcome difficulties is to assess the projects and portfolios results not in the categories of cost ratio, calculation of financial benefits, income, but rather in categories of value. This is the approach used in research [28]. A distinctive feature of the above-mentioned study is the proposal to use *S*-shaped curves to describe the nature of the change in values over time, both for separate projects, and for the portfolio in general. However, the lack of recommendations for performing the quantitative assessment of values, as well as the rules for constructing and analyzing *S*-curves, is its main drawback. It should be noted that in project management, cumulative curves are becoming more widespread not only in the classical earned volume method. Thus, paper [30] shows the advantages of *S*-curves as visual diagnostic and control tools, paper [31] shows them as a model of displaying cash flows from the level of separate contracts to the portfolio level. Cumulative curves are presented in the form of voluminous surfaces [32], in projections on planes [33], which greatly increases their information value in terms of analysis of flow characteristics. It is obvious that further developments in this direction will be relevant. At the same time, the obtained results give grounds to state the possibility of presenting the parameter of projects and portfolios value as cumulative flow characteristics with the help of *S*-curves [34]. As a result, the procedures that have traditionally been used to analyze projects and portfolios by cost flow, such as discounting, can be adjusted and used to analyze the value flows. This statement does not contradict the basic provisions of research [35], according to which discounting was originally considered by I. Fischer from the point of view of assessing the value of capital benefits.

Thus, when representing flow characteristics of project costs and values in the form of *S*-curves, there arises the problem of discounting cumulative values taking into account the point of their emerging in a portfolio. This problem statement is different from the traditional one, where cash flows are discounted over periods [36]. This problem is partially addressed in article [37], where the criterion for the inclusion of a project in a portfolio is the ratio of discounted gross benefits (profits) and costs. However, the authors of article [37] did not use the procedure of discounting cumulative flows, which is of fundamental importance.

The development of the views on discounting from the perspective of analyzing the benefits and costs for programs and projects implemented in the public sector of the economy led to the emergence of the notion of a social discount rate. Research [38] shows that there are several approaches to determining discount rate values, all of them are based on the concept of risk. However, from the point of view of N. Luman's theory, the term "risk" is not applicable in the portfolio formation phase [39]. The term "risk" is applied only after making a decision to implement the formed portfolio. Until then, it is advisable to use the term "danger" when modeling flow characteristics. The approaches to determining the discount coefficient, taking into account the danger metric, have not yet been developed.

The systematization of the results from earlier studies allows us to argue that the highlighted problems belong to different stages of the portfolio formation. That is why there is a need for a holistic consideration of the systemically presented activity on its formation based on a configuring technique with the flow representation of the amount of portfolio financing and the flow characteristics of projects.

3. The aim and objectives of the study

The aim of the present research is to construct a method for portfolio formation by configuring projects-candidates based on the flow characteristics. This would provide an opportunity to represent a portfolio as the continuous processes of accumulation of potential attractiveness of different project combinations, rather than a static set of projects. Configuring makes it possible to find such a sequence of the mutual location of projects within a portfolio over time during which the criterion that takes into account the flow characteristics of projects reaches a maximum value.

To accomplish the aim, the following tasks have been set:

– to reveal the essence of portfolio formation as a holistic activity;

– to formalize the criterial indicator for portfolio formation based on flow characteristics of projects-candidates;

– to develop a portfolio configuring criterion based on the flow characteristics of projects-candidates;

– to conduct computer simulation of portfolio formation using the developed configuring criterion.

4. Methodological basis for constructing a portfolio formation method by configuring projects-candidates based on the flow characteristics

The methodological foundation for the development of the method is the conceptual provisions of a holistic approach to the consideration of any activity [40], the ordinalistic approach to the consumer behavior theory [41, 42] and the provisions from the fundamental studies by N. Luhmann on the essence of risk and danger [35]. During the development of the method's toolkit, the discounting theory [35], heuristic methods [43, 44], multi-criteria rankings [45, 46] and qualitative mathematics [47, 48] were used. The models and methodical provisions for representing project costs and results in the form of *S*-curves were used to visualize and analyze flow characteristics [30–33].

The selection of such a methodological framework meets the practical challenges that arise in the activity of the company's project management office in the formation of multi-purpose portfolios. Despite the well-known criticism of the ordinalistic approach, it gradually becomes more applied in project and portfolio management, as noted in [42, 45]. The author's quartile model of a system and the model of a holistic representation of the activity "3M Pyramid" were used as a gnoseological toolkit for the systemic research [49]. The systemic model is simultaneously a configurator for the holistic target representation of various projections of the object under consideration, "bypassing the object itself". The positive results of using the quartile model as a configurator in project management are described in papers [50, 51], and the model "3M Pyramid" as a methodological tool for structuring activity knowledge is shown in papers [52, 53].

5. Stages in the development of a portfolio formation method by configuring projects-candidates based on the flow characteristics

5. 1. Representation of the essence of portfolio formation as a holistic activity

The process model of portfolio formation in the form of a sequence of stages was developed in [54]. Each stage can be regarded to be a separate projection of the configurator. The final stage in the model is the stage of portfolio configuring. Portfolio configuring refers to the process of step-by-step synthesis of the optimal sequence of projects from the projects-candidates under conditions of the assigned funding flow. The purpose of configuring is to maximize the value of the indicator, which holistically reflects different projections of divergent projects-candidates.

To reveal the mutually conditioned steps performed at certain stages and their structuring and semantic systematization, we will represent the portfolio formation in the form of a quartile systemic model (Fig. 1). The relations between the components in a systemic model, as well as the feedback between output and input, are important. The latter in this case provides a clear understanding of the requirements arising from the global criterion for portfolio formation, determined by its strategic goals, to all stages of portfolio formation – conceptual, preparatory, research and configuring. The proposed systemic model differs from the model developed in paper [55] by the fact that it takes into account the relations between the components. This makes it possible to match different projections within the holistic presentation of the portfolio formation activities.

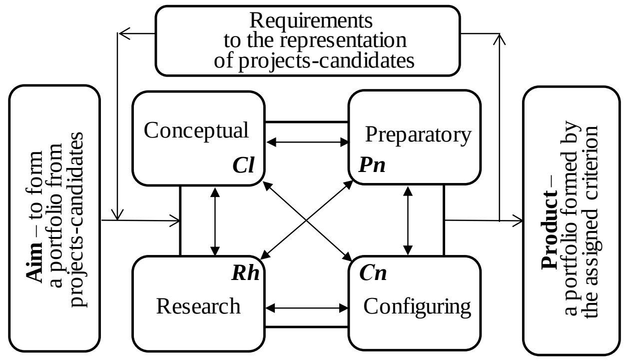

Fig. 1. A systemic model of project portfolio formation

Representation of the portfolio formation stages as components of a system allows determining the aim of their activity, defined by the aim of the system.

Thus, the purpose of the activity of the conceptual component is to develop rules (principles) that set constraints on the choice of methods, procedures, and tools for the portfolio formation, taking into account the specifics of socio-economic systems, for which it is formed.

The term "social-economic system" in this study is used in a broad sense and implies a wide range of multi-scale and multi-purpose enterprises (from small to large companies and corporations), as well as territorial entities (districts, cities, states, and regions). This involves the need to take into account in the studies the economic, as well as social parameters. The aim of the activity within the preparatory component of the portfolio formation is to create requirements for projects-candidates and to organize the collection of information about them. The purpose of the configuring activities is to determine the list of projects and the sequence of their implementation from the pre-selected projects-candidates from the position of the global criterion of portfolio formation. At the same time, projects are considered within the framework of the assigned financing flow, taking into account the maximization of their contribution to the portfolio result.

The activity within the research component is aimed at the timely synthesis and delivery of missing information (knowledge) to the other components of the system. The information reflects the specifics of the projects-candidates and the global criterion for the formation of a portfolio of a particular social-economic system.

To have a possibility to correlate the separated stages as projections of portfolio formation activities, the stages were structured based on the "3M Pyramid" model (Fig. 2). At the upper (methodological) M1 level, the rules-constraints, characterizing the peculiarities of formation and corresponding criteria for projects inclusion, grouping, etc., were separated for each component of the system (Fig. 3–5). At the mid-level M2, the methods and procedures for implementing the steps of the respective stages were separated, and the toolkit of implementing methods and procedures for them were separated at the lower (methodical) level M3.

To correlate the separated stages of portfolio formation as the activity projections, each component of the system is represented as a sequence of phases (Fig. 3–5).

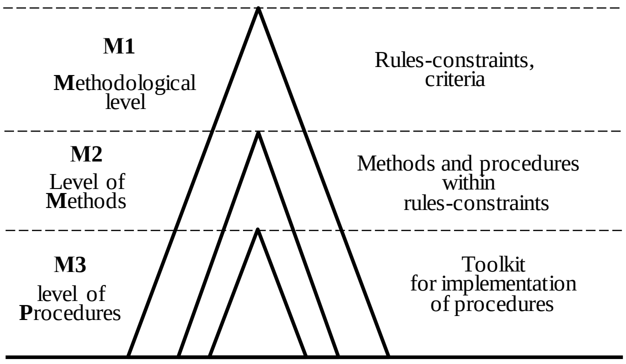

Fig. 2. Products of the activity in the context of the levels of the "3M Pyramid" model

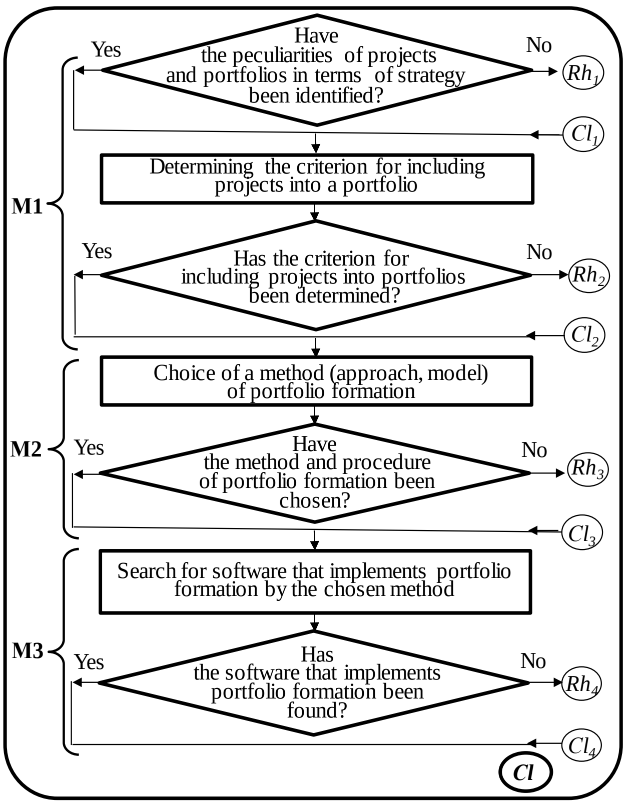

Fig. 3. Phases of implementing the conceptual component in portfolio formation

Each phase is designated with a graphic element of the block diagram, as well as inputs and outputs with indices corresponding to component designations. The zones that contextually correspond to the levels of the "3M Pyramid" model (M1, M2, M3) were separated in each component.

As Fig. 3–5 show, the knowledge synthesized in different components at the M1 level is concentrated at the phase "Portfolio formation for the developed variants of financing schedules", which is the core of the "Configuring" component. Despite the expressed practical focus of the phase, we attribute it to the methodological level. This underlines the need for systemic holistic implementation using the whole methodological toolkit synthesized in the activities of all other components of the systemic model. That is why this phase is the key phase not only for the configuring stage but also for the portfolio formation in general.

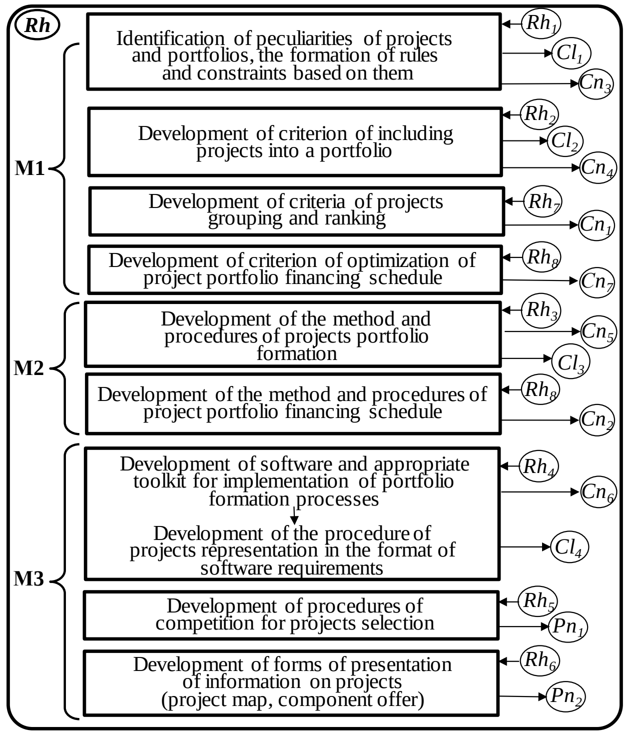

Fig. 4. Phases of implementation of activity of the research component during portfolio formation

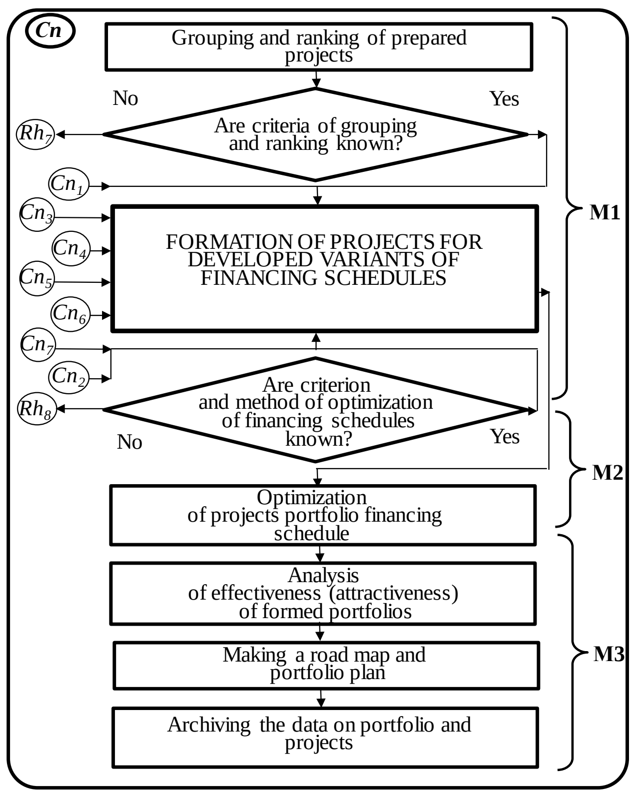

Fig. 5. Phases of implementation of activity of the configuring component during portfolio formation

5. 2. Formalization of the criterial indicator for portfolio formation based on flow characteristics of projects-candidates

The criterial indicator of project "attractiveness" is quite often used in the project formation [56]. In the context of this study, project attractiveness will be understood as an integral indicator, which is determined by the flow divergent characteristics of project costs, expected result, and its strategic importance. The attractiveness of project V_i depends on the degree of interest in a project from the portfolio management board, as well as the degree of demand for the project product from its potential users.

In the formalized form, the project attractiveness will be represented in the form

$$V^i = F\left({}^{\alpha}V^j; {}^{\sigma}V^i\left(\rho_\gamma\right); {}^{\sigma}V^i\left(\rho_\beta\right)\right), \quad (1)$$

where V^i is the indicator of attractiveness of the i-th project; ${}^{\sigma}V^i\left(\rho_\gamma\right)$ is the indicator of feasibility of the i-th project, depending on the quality of the planned processes of project implementation; ${}^{\sigma}V^i\left(\rho_\beta\right)$ is the indicator of result attainability of the i-th project, depending on the potential demands for the project product and its operating conditions; ${}^{\alpha}V^j$ is the indicator of the strategic importance of the i-th project, depending on the project contribution in attaining strategic goals of a project.

Explicate the components of the project attractiveness indicator.

The feasibility indicator is the characteristic of a project, which reflects a degree of the sufficiently innovative, competent, technical-technological and social potential of the internal environment of the project implementation to obtain the expected result within the planned costs as the flow characteristic of a project.

The result attainability indicator is the characteristic of a project, which reflects the degree of probability of attaining the expected result of a project. Its magnitude depends on the product relevance, its acceptance by potential consumers and the coherence of opinions between them regarding its value, the forecast of the resultant increase in the process of using the product.

The strategic importance indicator is the characteristic of a project, which reflects the importance of a project compared to other projects-candidates in terms of its contribution to achieving the strategic goals of a portfolio. The indicator is determined by the portfolio management board using one of the known methods of grouping and ranking and is taken into account at the "Portfolio formation" phase (Fig. 5).

The components of indicators of feasibility and result attainability directly depend on its flow characteristics. Their representation as S-curves allows reflecting holistically the nature of their change over time.

At least four characteristic points must be used to construct an S-curve of a project (Fig. 6).

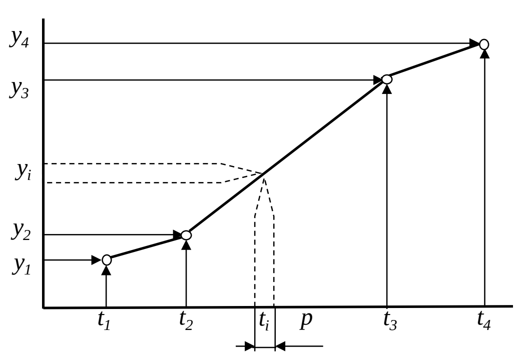

Fig. 6. Characteristic points of the S-curve of a project in the local coordinate system

The problem of determining the project attractiveness boils down to a pair-wise comparison of two projects, assigned by two S-curves (costs and result) and their rank of strategic importance. To do this, it is necessary to transform the S-curve into one number. Today, there are no generally accepted procedures of such transformation.

For the coagulation of the S-curve into a numerical value, it is advisable to apply the discounting procedure, which is widely used in project management. In this case, the cumulative value of parameter y_i will be discounted by the number of period p, where the time moment t_i. is located (Fig. 6). At first sight, the numerical value received at this time has no definite economic or other sense, unlike the calculation, for example, of net present value (NPV). However, when forming a portfolio by configuring an integrated indicator, there are two requirements – reflecting the differences between projects and the possibility of their quantitative comparison with each other. The application of the procedure of discounting the cumulative value of any flow parameter makes it possible to meet these requirements. In actual project management practice, the actual shapes of the "time-cost" curve are significantly different from the S-curve. However, this does not affect the procedures of discounting and comparing the attractiveness of the project. That is why the term "S-curves" will be subsequently used as the name of the curves reflecting the "time-parameter" dependence.

We will use a particular example to check if the above requirements for the integrated indicator are met. To do this, consider three projects that have the same amount of cash flow (ACF), but the different nature of cash flows (Table 1, columns 2–4). Take project 1 as the baseline project. Project 3 differs from the baseline one by the number of cost periods (six and eleven, respectively) and Project 2 differs by the nature of costs.

Table 1

Information about project cash flows

Period	Magnitude of cash flow		Magnitude of cumulative cash flow	
	project 1	project 2	project 1	project 2
1	2	3	5	6
0	100	20	100	20
1	80	40	180	60
2	60	50	240	110
3	40	60	280	170
4	20	70	300	240
5	20	80	320	320
Total	320	320	1420	920
Period	project 3			
1	4		7	
0	69		69	
1	56		125	
2	45		170	
3	37		207	
4	30		237	
5	24		261	
6	19		279	
7	14		294	
8	11		305	
9	9		314	
10	7		320	
Total	320		2,580	

In project 1 and project 3, the costs decrease as the number of periods of costs increases, and in project 2, vice versa, the value of costs increases as the period number increases. Table 1 also shows the accumulative values of cash flows for projects and their amounts (*AACF*) (columns 5–7).

Further analysis of the data in Table 1 shows that at the same *ACF* value of 320, the *AACF* is significantly different. At the same time, project 2, the costs of which for the periods increase at an increase in the period number, has the lowest value of the *AACF* that is equal to 920. For projects 1 and 3, which have the reverse character of costs, an increase in duration leads to an increase in the *AACF* (1,420 and 2,580, respectively).

Carry out the procedure of discounting of cumulative cash flows for the discount rate of 1–4 % and determine the amount of these flows after discounting. As we can see, at different discount rates, the amounts of discounted accumulative project cash flows (*ADACF*) differ from each other significantly (lines 2, 4, 6, 8 in Table 2). At the same time, the amounts of discounted cash flows (*ADCF*) of the projects are close to each other (lines 1, 3, 5, 7 in Table 2).

The results of the calculations prove that it is possible and advisable to use discounting of the cumulative cash flow as the coagulation procedure, in which the value of the resulting parameter reflects both the nature of the change in cash flow and the duration of the project costs. It is impossible to obtain the parameter with such properties when discounting the non-cumulative cash flow.

Table 2

Characteristics of project cash flow

No	Discount rate, %	Amounts	project 1	project 2	project 3
1	1	*ADCF*	315	310	311
2		*ADACF*	1,378	887	2,431
3	2	*ADCF*	310	301	303
4		*ADACF*	1,336	856	2,294
5	3	*ADCF*	306	292	295
6		*ADACF*	1,300	827	2,167
7	4	*ADCF*	301	284	287
8		*ADACF*	1,263	799	2,050

For indicators ${}^{\sigma}V^{i}(\rho_{\gamma})$ and ${}^{\sigma}V^{i}(\rho_{\beta})$, the parameters, for which values are accumulative, will be the cost flow and the project result flow, respectively. Costs are always represented in monetary units. However, it is not always possible to represent the project results in a monetary equivalent. First of all, this applies to the parameters of the effectiveness of project products, which affect different aspects of vital activity of the social-economic system: economic, political, social or cultural. For example, this applies to the results of such indicators of social projects as the dynamics of jobs growth, the dynamics of changing the population employment pattern, improved cultural and living conditions, etc. To date, the problem of accounting for project results in a portfolio, which is represented by indicators that are different by nature, has been solved. One of the methods of solving it (converting any parameters to a single score scale) is described in paper [57]. That is why we will subsequently consider the parameters of the results in the form of "time-points" curves.

One of the parameters of the discounting procedure is the discount rate. Initially, discounting was seen as a baseline principle for assessing the value of capital benefits [35]. The discount rate appeared when considering the difference between the benefits that a person can use instantly and the long-term benefits.

Today, the discount rate associated with benefits is called the social rate. The rate is considered from the point of view of costs and benefits for their obtaining [38]. The introduced indicators ${}^{\sigma}V^{i}(\rho_{\gamma})$ and ${}^{\sigma}V^{i}(\rho_{\beta})$ are similar in a sense to costs and benefits. It should be noted that costs and benefits are estimated values that are obtained in the context of incomplete and inaccurate information (non-factors) during the phase of modeling the process of gaining and using long-term benefits. That is why in order to distinguish it from the accepted concept of discount rate, the methods of calculation of which are based on taking into account the risks of different nature, it is proposed to use the concept of the "project unfeasibility rate" ${}^{\sigma}d^{i}$ and the "project result unattainability rate" ${}^{r}d^{i}$. These rates are determined by certain factors that, in the opinion of a decision-maker, pose a danger and may affect the project unfeasibility and project result unattainability. Based on the definitions of indicators ${}^{\sigma}V^{i}(\rho_{\gamma})$, the unfeasibility rate should be determined by indicators of the danger of the expected state of the internal environment of project implementation, and the result unattainability rate ${}^{\sigma}V^{i}(\rho_{\beta})$ – by indicators of danger, characterizing the external environment of the project product consumption. The lower the rate value, the greater the potential opportunities for successful project implementation and the degree of a real possibility of the project result attaining.

Based on these judgments, the formulas for calculating the project feasibility and project result attainability were also proposed. For the feasibility indicator, it has the form of

$$ {}^{\sigma}V^{i}(\rho_{\gamma}) = \sum_{l=0}^{n_f^i} \frac{(\sigma^i)_l}{(1+{}^{\sigma}d^{i})^{l}}, \tag{2} $$

In formula (2), index i is the period for which the cumulative amount of costs from the project is calculated (Fig. 1). And it is this amount that is discounted for this period. Given the complex nature of the change in cumulative project cash flows, it is advisable to break the entire term of project costs into equal intervals. The break with a one-month pitch is fairly accurate at the portfolio formation. When calculating the traditional project indicator NPV_i, the annual discount rate is usually set. That is why it is also advisable to assign the project unfeasibility rate based on the annual period. Given this, formula (2) will take the form

$$ {}^{\sigma}V^{i}(\rho_{\gamma}) = \sum_{l=0}^{{}^{\sigma}n_f^i} \frac{(\sigma^i)_l}{\left(1+\frac{{}^{\sigma}d^{i}}{12}\right)^{l}}. \tag{3} $$

Similarly, the formula for the indicator of project result attainability was obtained

$$ {}^{r}V^{i}(\rho_{\beta}) = \sum_{l={}^{r}n_s^i}^{{}^{r}n_f^i} \frac{(r^i)_l}{\left(1+\frac{{}^{r}d^{i}}{12}\right)^{l}}. \tag{4} $$

In formula (4), ${}^{r}n_s^i$ means the number of the period, from which the project results will start to appear.

Similar indicators of attractiveness, feasibility and result attainability are considered for a portfolio. The formulas for calculating these indicators for a portfolio are similar to those of the same project indicators. To use them, it is necessary to use the cumulative costs and cumulative results for the portfolio, the technique of calculation of which is given in paper [34].

A formalized representation of project attractiveness (1) suggests that indicators ${}^{\sigma}V^i(\rho_\gamma)$ and ${}^{\sigma}V^i(\rho_\beta)$ have a functional relationship. But it is more correct to establish this relationship at the stage of the development of the project formation criterion.

5. 3. Development of the portfolio configuring criterion based on the flow characteristics of projects-candidates

To develop the portfolio formation criterion based on flow characteristics shown in Table 2, we will introduce the following assumption: projects with a descending character of costs for periods and shorter duration are more attractive.

The assumption of the nature of costs stems from the concept of rapid innovation [58] and the understanding that financing the costs of later project periods is always riskier. The assumption about the project duration stems from the imperative of rapid entry to the market [58], according to which early acquisition of benefits of the project product use gives more advantages.

Based on the results of the comparison of projects in Table 2 taking into account the assumptions, project 1 is the most attractive (it has a descending character of costs for periods compared to project 2 and shorter duration compared to project 3). Project 3 is less attractive than the remaining ones because its duration is much longer than that of project 2.

Further analysis revealed that there was no correlation between the established degree of project attractiveness and the values of the amounts of different project cash flows. This indicates the need for introducing an additional indicator, which is calculated based on the sums of different project cash flows. In this case, it should be taken into account that the geometric interpretation of the value of the amount of cumulative cash flow is the area of the figure formed by the horizontal axis of periods of costs and the curve of cumulative cash flow.

Consider the ratio of the amount of accumulative discounted cash flow (*AADCF*) to the amount of the same but undiscounted flow (*AACF*) as an additional indicator. The amount of *AACF* is a constant magnitude for a project. And the operation of the division of the variable magnitude of *AADCF* (depending on the discount coefficient) by the constant magnitude of *AACF*, larger by value, is a rationing procedure. That is why the introduced indicator can be called the normalized accumulative discounted cash flow *NAD*, the value of which will always be less than unity

$$NAD = ADACF / AACF. \qquad (5)$$

The *NAD* analysis (Table 3) shows that its value decreases from Project 1 to Project 3. And this is correlated with a certain higher degree of project attractiveness (project 1 is the most attractive, project 2 is less attractive, project 3 is the least attractive). That is why formula (5) can be used as the basis for developing the components of attractiveness criteria related to the indicators of feasibility and result attainability.

Table 3

Normalized accumulative discounted cash flow

No.	Discount rate, %	project 1	project 2	project 3
1	1	0.970	0.964	0.942
2	2	0.941	0.930	0.889
3	3	0.915	0.899	0.840
4	4	0.889	0.868	0.795

Based on it, the component of the attractiveness criterion, associated with the feasibility indicator will take the following form:

$${}^{\sigma}W^i = \frac{\sum_{l={}^{s}n_0^i=0}^{{}^{s}n_f^i} \frac{(\sigma^i)_l}{\left(1+\frac{{}^{s}d^i}{12}\right)^l}}{\sum_{l={}^{s}n_0^i=0}^{{}^{s}n_f^i} (\sigma^i)_l}, \qquad (6)$$

where ${}^{s}n_0^i$ is the initial period of the i-th project in the local coordinate system, in which each of the projects is considered separately (independent on each other and other constraints or conditions), that is why ${}^{s}n_0^i = 0$; ${}^{s}n_f^i$ is the final (last) period of costs of the i-th project; l is the current value of the period of implementation of the i-th project $l \in \{{}^{s}n_0^i \ldots {}^{s}n_f^i\}$; $(\sigma^i)_l$ is the current cumulative value of costs in monetary units for the i-th project within period l; ${}^{s}d^i$ is the annual unfeasibility rate of the i-th project.

Similarly, we will represent the component of attractiveness criterion, associated with the indicator of project result attainability

$${}^{r}W^i = \frac{\sum_{l={}^{r}n_0^i}^{{}^{r}n_f^i} \frac{(r^i)_l}{\left(1+\frac{{}^{r}d^i}{12}\right)^l}}{\sum_{l={}^{r}n_0^i}^{{}^{r}n_f^i} (r^i)_l}, \qquad (7)$$

where ${}^{r}n_0^i$ is the zero period of time (start) of manifestation of the result of the i-th project; ${}^{r}n_f^i$ is the final (last) period of display of the result of the i-th project; c is the current value of the period of display of the result of the i-th project $l \in \{{}^{r}n_0^i \ldots {}^{r}n_f^i\}$; $(r^i)_l$ is the current cumulative value in points of the display of the result of the i-th project within period l; ${}^{r}d^i$ is the annual rate of unattainability of the result of the i-th project.

Component (6) can be defined as the index of the potential level of project feasibility, and component (7) can be defined as the index of the potential level of project result attainability. Based on the nature of these indices, the most attractive for the portfolio will be the project, in which both indices are maximal.

When comparing projects, the beginning of funding of which coincides with a zero period, the project with the maximal attractiveness index is preferable for a portfolio.

$$ {}^{\sigma r}W^i = \left(\frac{\sum_{l={}^s n_0^i}^{{}^s n_f^i} \frac{(\sigma^i)_l}{\left(1+\frac{{}^s d^i}{12}\right)^l}}{\sum_{l={}^s n_0^i}^{{}^s n_f^i} (\sigma^i)_l} \right) \left(\frac{\sum_{l={}^r n_0^i}^{{}^r n_f^i} \frac{(r^i)_l}{\left(1+\frac{{}^r d^i}{12}\right)^p}}{\sum_{l={}^r n_0^i}^{{}^r n_f^i} (r^i)_l} \right) \to \max. \quad (8) $$

In order to be able to use the formula of attractiveness index in the portfolio formation, the designations used in the local system of project coordinates were transformed into the designations corresponding to the global system of portfolio coordinates (Table 4).

Table 4

Transformation of designations of project indicators from the local system of project coordinates into the global system of portfolio coordinates

No.	Indicators	Designation in coordinate system	
		of a project	of a portfolio
1	Project index	i	j
2	Number of a period	l	p
3	Project start	${}^s n_0^i$	${}^s m_0^j$
4	Project finish	${}^s n_f^i$	${}^s m_f^j$
5	Start of result	${}^r n_0^i$	${}^r m_0^j$
6	Finish of result	${}^r n_f^i$	${}^r m_f^j$

Based on the essence of the criterion of project attractiveness (8), we will formulate the criterion of portfolio attractiveness. We would consider optimal the portfolio, in which the flow characteristics of selected projects, taking into account the ranks of their strategic importance ${}^\alpha V^j(\ldots)$, ensure the maximization of the number of indices of project attractiveness within the assigned financing flow $S\{\ldots\}$:

$$ {}^\alpha V^j \left(\sum_{j \in T} \left(\left(\frac{\sum_{p={}^s m_0^j}^{{}^s m_f^j} \frac{(\sigma^j)_p}{\left(1+\frac{{}^s d^j}{12}\right)^p}}{\sum_{p={}^s m_0^j}^{{}^s n_f^j} (\sigma^j)_p} \right) \left(\frac{\sum_{p={}^r m_0^j}^{{}^r m_f^j} \frac{(r^j)_p}{\left(1+\frac{{}^r d^j}{12}\right)^p}}{\sum_{p={}^r m_0^j}^{{}^r m_f^j} (r^j)_p} \right) \right) \right) \to \max, \quad (9) $$

where T is the array of the selected projects.

The financing flow is assigned in the form of a multi-step schedule, each step of which is the portfolio phase

$$ S = \{S_\beta\}, $$

$$ M = \{M_\beta\}, $$

$$ \beta = 1, 2 \ldots R, \quad (10) $$

where S_β is the cumulative volume of financing from the portfolio start including phase β; R is the number of financing phases; M_β is the number of period of finishing financing of the phase β of a portfolio.

A portfolio is optimal if condition (9) is satisfied at each financing phase when the restriction is met:

$$ \sum_{j=0}^{M_\beta} \left(\sum_{p={}^s m_s^j}^{\gamma_K^j} (\sigma^j)_p \right) \le S_\beta, \quad (11) $$

where

$$ \gamma_K^j = \begin{cases} {}^s m_f^j, & \text{if } {}^s m_f^j \le M_\beta, \\ M_\beta, & \text{if } {}^s m_f^j > M_\beta. \end{cases} $$

For each j, in which ${}^s m_f^j < M_\beta$; K is the rank obtained by j project in the portfolio in the process of its formation.

Analysis (11) reveals that at each phase there can be projects, for which funding just begins, begins, and finishes, continues or finishes.

6. Discussion of results from computer simulation of portfolio formation based on the developed configuring criterion

Based on the proposed approach to portfolio formation, the computer program "SESPortfolio", registered as a copyright object, was developed [59]. Using this program, a series of computer experiments on simulating the formation of different portfolios was conducted. To do this, 18 projects, which are divided into three groups, were generated. Each group was used to configure three portfolio groups. The first group of projects has different rates of unfeasibility rates and unattractiveness. For the second and third groups of projects, these rates are the same and equal to 0.1 and 0.3, respectively (columns 5, 6, Table 5).

Table 5

Source data of projects for configuring three portfolios

No. by order	Project code in program SES Portfolio	Duration, months		Rates		Indices		
		feasibility	result display	unfeasibility	unattractiveness	feasibility	effect attainability	Attractiveness
1	2	3	4	5	6	7	8	9
Projects for configuring portfolios 10nv-16nv								
1	pr1	4	90	0.05	0.15	0.993	0.486	0.483
2	pr2	10	55	0.15	0.05	0.932	0.865	0.806
3	pr3	7	70	0.3	0.3	0.907	0.314	0.285
4	pr4	6	90	0.2	0.2	0.95	0.399	0.379
5	pr5	8	90	0.05	0.02	0.982	0.889	0.873
6	pr6	12	90	0.1	0.1	0.946	0.638	0.604

Continuation of Table 5

1	2	3	4	5	6	7	8	9
Projects for configuring portfolios 20nk1-26nk1								
7	pr1	4	90	0.1	0.1	0.985	0.612	0.603
8	pr2	10	55	0.1	0.1	0.954	0.752	0.717
9	pr3	7	70	0.1	0.1	0.968	0.664	0.642
10	pr4	6	90	0.1	0.1	0.975	0.621	0.605
11	pr5	8	90	0.1	0.1	0.965	0.564	0.544
12	pr6	12	90	0.1	0.1	0.946	0.638	0.604
Projects for configuring portfolios 30nk3-36nk3								
13	pr1	4	90	0.3	0.3	0.957	0.260	0.249
14	pr2	10	55	0.3	0.3	0.87	0.448	0.390
15	pr3	7	70	0.3	0.3	0.907	0.314	0.285
16	pr4	6	90	0.3	0.3	0.927	0.266	0.247
17	pr5	8	90	0.3	0.3	0.9	0.202	0.182
18	pr6	12	90	0.3	0.3	0.849	0.294	0.250

The portfolio financing schedule contains three phases, which differ in duration and volume of financing (Table 6).

Table 6

Characteristic of the flow of portfolio by the financing of phases

Parameter of the financing phase	Financing phase		
	I	II	III
Duration, month	4	5	12
Number of a period of the end of phase financing	4	9	21
Financing volume, cond. units	300	250	150
Cumulative amount of financing, cond. units	300	550	700

project pr3 started, 253 cond. units had been reserved from the total amount of financing of the phase of portfolio I for the three previous projects. That is why project pr3 on phase I received funding of 47 cond. units. Based on this amount and the conditions for ensuring continuity of the project funding flow throughout its implementation, the moment of its start was determined. Based on similar conditions, the start of project pr1 in phase II was determined. The implementation of projects pr5, pr3 is completed in phase II, and project pr6 – in phase III. The rest of the monetary funds in phase II after funding the above projects allowed financing project pr1, which proved to be more attractive than project pr4 by the criterion of maximizing the amount of project attractiveness indices (9).

The indicator of the strategic importance of a project served as a variable magnitude in the computer experiment. It was assigned by giving a certain rank of strategic importance to a project before the start of the portfolio formation procedure. And in the process of portfolio formation, each project was given a rank corresponding to the serial number of its financing in the portfolio.

Fig. 7 shows the graphic file of the "SES-Portfolio" program with the results of configuring portfolio 10nv (Table 7) provided that the ranks of the strategic importance of all projects are equal.

As one can see, project pr2 ranks first in the portfolio, project pr5 ranks second. The rest of the projects are arranged in the following sequence: pr6, pr3, pr1, pr4. This order of project arrangement is reflected in the information about the formation of portfolio 10nv (line 1, column 2, Table 7).

Analysis of *S*-curves of project costs within the portfolio shows that they have vertical jumps in the points of transition from one phase of portfolio financing to another. The example of the pr2 project, which started during the first period of portfolio financing, shows that the jumps are due to the fact that the project duration (10 months) exceeds the duration of the first two phases of financing (9 months). In the first phase, the project receives funding of 80 cond. units. The remaining funding is sufficient to start financing of two more projects at the same time as the pr2 project – pr5, pr6, and from about the middle of the period – financing project pr3. By the time funding of

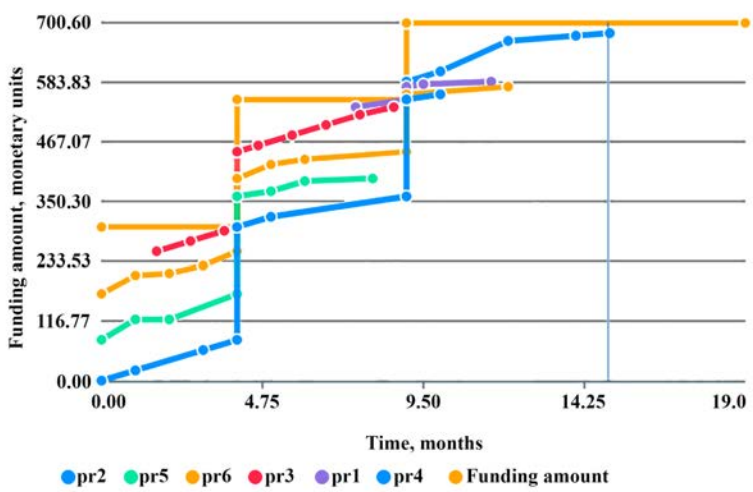

Fig. 7. Results of configuring the projects in portfolio 10-nv at equality of the ranks of the strategic importance of projects

Similar calculations were made for portfolios 20nk1 and 30nk3 (lines 8 and 15 of Table 7), in which, like in portfolio 10nv, all projects have the same strategic importance. At the same time, the sequence of financing projects in these portfolios is different. For example, for portfolio 10nv, projects are financed in sequence 2, 5, 6, 3, 1, 4, for portfolio 20nk1, in sequence 5, 4, 2, 1, 3, 6, and for portfolio 30nk3 – 6, 1, 2, 4, 5, 3. The considered portfolios differ from each other only in the values of the annual rate of unfeasibility and unattractiveness of projects. Based on this, it can be concluded that the value of rates of project unfeasibility and unattractiveness significantly affects the attractiveness of a particular project compared to other projects-candidates in the portfolio.

Table 7

Variants of portfolios configurations

No.	Configuration of portfolio No.	Portfolio indices			Duration	
		feasibility	attain-ability	attrac-tiveness	of port-folio	of display of portfolio results
Group of portfolios based on portfolio 10nv						
1	10nv-pr(2-5-6-3-1-4)	0.892	0.475	0.424	15	103
2	11nv-pr(4/6-1-3-2-5)	0.934	0.559	0.522	15	106
3	12nv-pr(1-4/6-3-5-2)	0.904	0.548	0.495	17	102
4	13nv-pr(3-1-4/6-2-5)	0.934	0.559	0.522	15	106
5	14nv-pr(6-1-4-3/2-5)	0.934	0.559	0.522	15	106
6	15nv-pr(6-3-4-5-1/2)	0.897	0.515	0.462	17	101
7	16nv-pr(6-3-1-2-4/5)	0.936	0.562	0.526	17	108
Group of portfolios based on portfolio 20nk1						
8	20nk1-pr(5-4-2-1-3-6)	0.918	0.597	0.549	19	99
9	21nk1-pr(6/5-4-2-1-3)	0.939	0.597	0.561	14	99
10	22nk1-pr(3-6/5-4-1-2)	0.923	0.596	0.549	17	99
11	23nk1-pr(1-3-6/5-4-2)	0.923	0.597	0.551	17	99
12	24nk1-pr(2-6-1-3/5-4)	0.934	0.587	0.548	14	103
13	25nk1-pr(4-2-1-3-6/5)	0.926	0.578	0.535	16	107
14	26nk1-pr(5-2-1-3-6/4)	0.93	0.596	0.555	15	96
Group of portfolios based on portfolio 30nk3						
15	30nk3-pr(6-1-2-4-5-3)	0.831	0.238	0.198	14	102
16	31nk3-pr(3/6-1-2-4-5)	0.8	0.226	0.181	17	108
17	32nk3-pr(3-5/6-1-2-4)	0.821	0.242	0.199	14	99
18	33nk3-pr(3-4-5/6-1-2)	0.8	0.241	0.193	17	99
19	34nk3-pr(3-2-4-5/6-1)	0.789	0.228	0.18	18	104
20	35nk3-pr(3-1-2-4-5/6)	0.769	0.237	0.182	19	102
21	36nk3-pr(6-3-2-4-5/1)	0.819	0.228	0.187	15	106

In order to verify the impact of the rank of the strategic importance of projects on the portfolio attractiveness, the portfolios were configured based on projects-candidates that had ranked first or second in terms of strategic importance. Portfolios 10nv, 20nk1, 30nk3 were taken as original portfolios. In them, the sequence of projects was determined based on the fact that all the projects-candidates had the first rank of strategic importance. Then according to the logic presented in Table 8, using the example of a sequence of projects in portfolio 10nv, six more portfolios were formed. For portfolio 11nv, the first five projects of portfolio 10nv, which were assigned the second rank of strategic importance, and the sixth project, which was assigned the first rank, were projects-candidates. For portfolio 12nv, the first four projects-candidates from the sequence of portfolio 10nv were assigned the second rank, and the last two were assigned the first rank. Portfolios 13nv–15nv were formed following the same logic. For portfolio 16nv, unlike portfolio 15nv, the second rank was assigned not to the first, but the second project in the sequence of the projects of portfolio 10nv.

Based on the project-candidates grouped by the rank of strategic importance, portfolio configuration was performed and the ranks of projects in portfolios (lines 3, 6, Table 8) were determined, as well as the corresponding indices and indicators of portfolio duration and results display were determined (columns 3–7, Table 7). The data on the projects ranks in the portfolio and the ranks of strategic importance in Table 8 were reflected in Table 7 in column 2 (lines 1–7). The projects with the first rank of strategic importance are separated by a slash from the projects with the second rank. Similar procedures were performed for portfolios 20-nk1 and 30-nk3 (lines 8–14 and 15–21, Table 7).

Analysis of data in Table 7 reveals the essential influence of the rank of the strategic importance of projects on the value of the portfolio attractiveness index (column 5). The reason for this is the changing indices of feasibility and result attainability of the portfolio (columns 3, 4, Table 7).

The performed analysis suggests that the key factor influencing feasibility and result attainability of the portfolio is the degree of projects "packing" in a portfolio in terms of costs and results. "Packing" by costs is indirectly characterized by the duration of its financing (column 6, Table 7), and packing by results – by the duration of portfolio result display (column 7, Table 7). This assumption is correlated with the indicators of portfolios II, III, in which the values of unfeasibility and unattractiveness rates for all projects in the portfolio are the same. Thus, for example, for portfolios 21nk1 and 24nk1 at the financing duration of 14 months, the feasibility index is equal to 0.939 and 0,934, and for portfolios 22nk1 and 23nk1 at the financing duration of 17 months, feasibility index is equal to 0.923. Similarly, feasibility indices for portfolios 30nk3 and 32nk3 (14 months) are equal to 0.831 and 0.821, and for portfolios 31nk3 and 33nk3 (17 months) – 0.8. The same is observed for result attainability index (for portfolios 20nk1–23nk1 at the duration of result manifestation of 99 months, feasibility index is equal to 0.597, and for portfolios 24nk1, 25nk1 at the duration of 103 and 107 months – 0.587 and 0.578).

Table 8

Grouping of projects-candidates by the rank of strategic importance for portfolios based on portfolio 10nv

No	Rank in portfolio 10nv	I-(2-5-6-3-1-4)		
1	No. of portfolio	11nv	12nv	13nv
2	Groups of projects by ranks of strategic importance	I-(4); II-(2-5-6-3-1)	I-(4-1); II-(2-5-6-3)	I-(4-1-3); II-(2-5-6)
3	Rank in the portfolio	4-6-1-3-2-5	1-4-6-3-5-2	3-1-4-6-2-5
4	No. of portfolio	14nv	15nv	16nv
5	Groups of projects by ranks of strategic importance	I-(4-1-3-6); II-(2-5)	I-(4-1-3-6-5); II-(2)	I-(4-1-3-6-2); II-(5)
6	Rank in the portfolio	6-1-4-3-2-5	6-3-4-5-1-2	6-3-1-2-4-5

To prove the assumption that was put forward we will make a pair-wise comparison of the portfolios, in which five out of six projects-candidates have the first rank of strategic importance (portfolios 25nk1 and 26nk1, 35nk3 and 36nk3). The difference between the compared portfolios is similar to the difference between portfolios 15nv and 16nv described above. Table 7 shows that portfolios 26nk1 and 36nk3 have shorter financing duration than portfolios 25nk1 and 35nk3, and the values of feasibility indices that are higher by 0.4 % and 6.5 %. That is, the first portfolios are more "packed". The same applies to the attractiveness index. Portfolios 25nk1 and 26nk1 have the duration of result manifestation of 107 and 96 months, respectively, and the attainability index is 0.578 and 0.596, respectively. And portfolios 35nk3 and 36nk3 have a duration of 102 and 106 months, and feasibility index – 0.237 and 0.228.

Analysis of the values of indices of portfolio feasibility and result attainability, duration of the financing and manifestation of portfolio results for portfolios 10nv–16nv, the projects of which have different ranks of unfeasibility and unattractiveness, showed that dependences established for portfolios with the same rates are not traced. This is due to the fact that the magnitudes of indices are affected by many parameters that were non-constant in these portfolios. That is why the search for some patterns of their change at a change of a particular parameter, and, first of all, of the type of S-curves of costs and the project result, has no practical value.

The obtained results of computer simulation prove the effectiveness of the proposed method of project portfolio formation based on the configuring projects- candidates by their flow characteristics. The method allows taking into account both the strategic importance of each project and the nature of increasing the values of their flow characteristics, which are represented in the form of S-curves.

Such results have been achieved due to the holistic consideration of project portfolio formation within the proposed systemic model, in which the configuration component is the basic one. By applying the quantitative representation of project costs and the results of using its product in the form of S-curves as cumulative flows, it was possible to apply a unified procedure of their coagulation in one number through the discounting procedure. At the same time, the turn from the traditional concept of the discount rate to the concepts of "the project unfeasibility rate" and "the project result unattainability rate" allowed taking into account the indicators of the danger of the internal environment of project implementation and the external environment of product consumption of each individual project-candidate in the portfolio. Due to the identity of the mathematical models used during the consideration of costs and results of projects, the portfolio optimality criterion by the attractiveness index is proposed.

It should be noted that during computer simulation, the portfolio "package" parameter at its different assigned financing schedules was not studied. This requires further development of special procedures for rating and grouping of project-candidates when conducting additional research.

The method was designed to form portfolios from separate projects-candidates. More research is needed if some programs are necessary to include in the portfolio. The use of other flow characteristics of projects, other than the characteristics of costs and expected results discussed in the article, also required additional studying. This is due to clarification of the peculiarities of representation of new characteristics in the form of S-curves, as well as coagulation of more than two separate divergent cumulative flows in one number.

7. Conclusions

1. The essence of portfolio formation as a holistic activity, based on the logical-methodological technique of synthesizing diverse knowledge about the projects-candidates (configuring), was revealed. Configuring was implemented by representing projects in the form of flow characteristics of different entities (costs and expected results), as well as the strategic importance of projects. Portfolio formation activities based on project configuring is represented holistically through the proposed quartile systemic model. This has made it possible to structure the phases performed at each portfolio formation stage (conceptual, preparatory, configuring, research) not as successive phases within each stage, but as mutually conditioned phases within the framework of portfolio formation in general. It was shown that on each stage, the rules-restrictions, characterizing the peculiarities of formation and corresponding criteria of projects including, grouping, etc. (methodological knowledge), methods and procedures for implementing the stages of the respective phases (methodical knowledge), the toolkit for implementing methods and procedures (practical knowledge) are synthesized. It was revealed that within the framework of the proposed systemic-holistic structuring of the portfolio formation activities, the phase "Portfolio formation for the developed variants for funding schedules" is basic not only for the configuring stage but also for the formation of the portfolio in general.

2. The basic criterial indicator for portfolio formation from projects-candidates, which is based on the attractiveness characteristic was proposed. Its structure was developed based on the interpretation of attractiveness as an integral characteristic of the rates of feasibility and result attainability of projects in a portfolio. These figures reflect the divergent flow characteristics of a project, represented as S-curves: financial (project costs) and socio-economic (result from the use of the project product). In order to represent the criterial indicator in the form of a single number, the coagulation operation of cumulative cost-and-results flows based on the discounting procedure was proposed.

3. The criterion for portfolio formation in the form of the project attractiveness index, which is equal to the product of indices of feasibility level and result attainability, was developed. Indices are the rationed values of discounted cumulative flows, the value of which is always less than 1. For the portfolio that is assigned by the financing flow in the form of a step schedule, we proposed the formulas that allow determining the rational priority of the project location, taking into account the rank of their strategic importance by the criterion of maximization of attractiveness index at each phase of the financing schedule.

4. The results of computer simulation of portfolio formation based on the flow characteristics of projects-candidates with the use of the developed configuring criterion proved the effectiveness of the proposed portfolio formation method. The method allows taking into account the peculiarities of the nature of changing the project costs, the expected project result, the strategic importance of a project, as well as the specifics of the portfolio financing schedule. Thus, for example, the change in the unfeasibility of six projects of equal strategic importance and the unattainability of their results from 0.1 to 0.3 significantly changed the portfolio configuration (from 5-4-2-1-3-6 to 6-1-2-4-5-3). At the same time, the portfolio financing duration decreased from 19

to 14, the portfolio result duration increased from 99 to 102, and the portfolio attractiveness index decreased from 0.199 to 0.198. When configuring a portfolio of six projects of different strategic importance (of the 1st or 2nd rank), there are no patterns of changing portfolio attractiveness, financing duration and appearance of portfolio results at a change in the strategic importance of projects. The only identified significant factor that affects portfolio attractiveness is the rates of project unfeasibility and their result unattainability. This proves the uniqueness of the configuration of each separate projects' portfolio and, in this regard, the practical value of the proposed method.

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