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DISSERTATION

Project portfolio configuring based on discounted cumulative flows

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The dissertation contains the results of own research. The use of the ideas, results and texts of other authors is followed by appropriate citation.

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TABLE OF CONTESTS

INTRODUCTION

Research relevance. Project portfolio management is one of the most rapidly developing areas in project management nowadays. In portfolios management activities, the "cornerstone" is their formation. Matter is that none of the existing methods provides an exhaustive and universal answer to the problem of projects selection to the portfolio.

Over the past 15 years, traditional "assessing" approach has become the most popular in portfolio management. This reflected in a large number of publications, as well as by the content of standards and practical guidelines. Nevertheless, increasing complexity of portfolios, their multi-purpose character activated appearance of new "configuring" approach to the portfolio selection based on a logical methodological technique of synthesizing diverse knowledge, different systemic ideas (projections) of the same object. 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.

For portfolios of large socio-economic entities (large firms, enterprises, districts, regions, states) flow representations of a project (and a portfolio) about costs, expected results, etc. matter as diverse knowledge corresponding to each projection. As flows, the costs traditionally are presented in the form of the magnitudes cumulative at a certain point in time. Similarly, projects expected result can be presented in flows form. In relation to portfolio, it is necessary to consider costs and results flows that are formed by respective individual projects flows totality included in its structure. Portfolio flows general characteristics depend on project implementation sequence over time that in turn, is determined on at least two factors basis: projects priority (strategic importance) and resources for their implementation adequacy.

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, the formation of portfolios of investment and security projects, life safety projects, and environmental projects were partially solved. Key contributions were made by Vaezi F., Sadjadi S. J., Makui A., Jafarzadeh M., Tareghian H., Rahbarnia F., Ghanbari R., Abramov A., Radygin A., Chernova M., Havrys A., Khrutba V., Evdokymova A. and others.

However, the configuring 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 nowadays. 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.

Despite fruitful researches made by Martinsuo M., De Rooij M.M.G., Janowicz-Panjaitan M., Mannak R.S., Ning Y., Salerno M.S., Gomes L.A. de V., Silva D.O., Bagno R.B., Freitas S.L.T.U., Valavanides M.S., Fernandes E., Valdiviezo L.E., Molokanova V., Warburton R.D.H., Cioffi D.F., Mavrotas G., Caloghirou Y., Koune J., Maravas A., Pantouvakis J.-P., Rach D., Leyman P., Vanhoucke M., Ofosu M.K., Amponsah S.K., Erdem S., Hale A., Holmström S. and others, nowadays there are no investigations focused on framing multi-reason venture portfolios utilizing configuring approach. Main theoretical problematic within the configuring approach still relates to system-holistic vision of forming a multi-purpose project portfolio activity and understanding the appropriate place for configuration process; developing the project/portfolio configurator; identification of unifying features for configurator panels with view to their further use in criterial portfolio configuration indicator construction; modelling the flow portfolio characteristics calculating under given restriction in form of step-by-step portfolio financing schedule; suggesting numerical characteristics for projects costs (results) description in S-curves form; developing criterion for portfolio configuring with a given step-by-step schedule for its financing.

The goal and objectives of the research. The research goal is to ground scientific approach to project portfolio formation be development of the method for configuring multi-purpose project portfolio based on flow costs and project results characteristics for a given step-by-step portfolio financing schedule.

To achieve the goal, the following objectives have been stated:

-to develop a system-integrated reflection of activities for the formation of a multi-purpose project portfolio to establish the place of configuration in its structure and design a project/portfolio configurator;

-to identify the connecting features for the configurator panels for their further use when constructing the criterion of the portfolio configuring;

-to develop graphical and mathematical models for calculating the flow characteristics of the portfolio at a given constraint in the form of a step-by-step schedule of the portfolio financing;

-to propose a numerical characteristic of projects costs (results), presented in the form of S-curves;

-to develop a criterion for configuring the portfolio with a given step schedule of its financing;

-to investigate the effectiveness of the proposed provisions for configuring a multi-purpose project portfolio.

Object of a research is processes of the project portfolio formation.

Subject of a research is a process of the project portfolio formation based on configuring technic considering discounted cumulative flows of projects costs and expected results.

Methods used. The methodological foundation for the research is the conceptual provisions of a holistic approach to the consideration of any activity, the ordinalistic approach to the consumer behavior theory and the provisions from the fundamental studies by N. Luhmann on the essence of risk and danger. When developing the method's toolkit, the discounting theory, heuristic methods, multi-criteria rankings and methods of qualitative mathematics were used. The models and methodical provisions to represent project costs and results in the form of *S*-curves were used to visualize and analyze flow characteristics. 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. The systemic model is simultaneously a configurator for the holistic target representation of various projections of the object under consideration, "bypassing the object itself".

In addition, other following methods were used in the research: comparative analysis, graphical modeling, semantic text analysis, graphical modeling, graphical system modeling, context analysis, ranking, mathematical modeling, pairwise comparison, multi-criteria scale method, computer simulations.

Scientific result and findings. The main scientific result is the development of scientifically grounded method to configure project portfolio based on discounted cumulative flows of projects costs and expected results. The novelty of the scientific result of the research is as following:

first developed:

for pairs of configurator panels "cost-feasibility" and "result-attainability" configuring points are defined, in which the unifying features are the flow nature of projects costs and results, S-shaped form of their reflection and environment of creation and using of the project product; this allowed: to introduce norms of projects feasibility and attainability as analogues of the discount rate; to formalize indices of projects feasibility and attainability in the form of functionality; to offer the structure of the criterion indicator of the portfolio configuration that is "attractiveness", which is based on knowledge about the feasibility, attainability and strategic importance of projects;

as a numerical characteristic of the project costs (results), presented in the form of S-curves, the indicator is proposed in the form of a normalized value of the discounted cumulative flow; this allowed to quantify the feasibility and attainability indices of projects with shorter duration and regressive nature of costs;

a criterion to configure a portfolio is developed, which provides maximizing the index of the portfolio attractiveness as the sum of projects feasibility and attainability level in the portfolio; the application of this criterion allows for a given schedule of the portfolio financing, as well as for projects strategic importance and for their inseparable financing in the portfolio to determine the optimal configuration of the portfolio from the number of selected and prioritized projects according to the proposed algorithm;

improved:

structure of the project portfolio formation activity, which differs from the known system-integral representation of its elements in the form of a quartile system model; this allowed to establish the place of the configuring stage in integral relation to other stages (conceptual, preparatory, research) and stages of the portfolio formation and to highlight configuring steps, on this basis to design a six-panel portfolio configurator (costs, results, attainability, feasibility, strategic importance, portfolio financing);

further development has come to

project portfolio packing task, which, unlike the backpack task, takes into account the S-shaped nature of project costs when determining the sequence of their inseparable financing with a given constraint in the form of a step schedule of the portfolio financing; this allowed to offer graphical and mathematical models for cost flows, results, portfolio feasibility and attainability norms based on projects characteristics;

the scientific fact of absence of regularities in configuration of multi-purpose portfolios because of a large number of projects indicators that reflect the peculiarities of their implementation and using of their products.

Practical value. Utilizing of the research findings and recommendations provides to consider the portfolio not as a static set of projects, but as continuously running processes of cost accumulation and results achievement. This allows to select most optimal portfolio that is a combination of projects in a certain sequence of their implementation, that provides maximization of the sum of multiplications of indices of the potential level of projects feasibility and their results attainability within a given flow of portfolio funding. Such mechanism of the portfolio configuring allows to more adequately and accurately determining the potential attractiveness of project-candidates and the portfolio as a whole within its resource constraints. Method is recommended for use in the formation of multi-purpose (complex) portfolios, which combine a wide range of diverse projects (social, commercial, educational, etc.). This is a premise to transfer organizational decisions in the management of project-oriented enterprises. Main applied instrument based on the proposed portfolio configuring method is the computer program "SESPortfolio", developed and registered as a copyright object.

The research findings and recommendations were introduced in practical activities within the educational master program on project management for English speaking students at “KROK” University. Basic findings were introduced to elements of the educational courses “Project oriented management of a firm”, “Project office for innovative development”.

Personal contribution of the researcher. Scientific positions, developments and conclusions of the dissertation work are the result of the author's own research in the field of the project portfolio formation.

Approbation. The main results of the dissertation, conclusions and proposals were presented, discussed and approved at eight international conferences.

Publications. The main provisions of the dissertation are set out in 14 works, of which 5 scientific articles have been published in professional editions of Ukraine, 1 article in Ukrainian edition indexed in Scopus data base, 9 - conference materials. The total volume of publications is 8.24 a.sh., of which personally the author owns 6.4 a.sh.

Structure and scope of work. The dissertation consists of introduction, five chapters, conclusions, list of references and attachments, placed on 279 pages. The text body is presented on 171 pages, it contains 22 tables and 82 figures. The list of references includes 255 positions from 235 sources, and placed on 26 pages, 8 attachments placed on 82 pages.

CHAPTER 1.
MODERN STATUS OF THEORY AND PRACTICE OF PROJECT PORTFOLIO FORMATION

1.1. Projects and portfolio features of large socio-economic entities

This study is implemented from the position of project portfolio management as a tool for the large socio-economic entities (LSEE) development nowadays [1-4]. By LSEE we mean a wide range of multi-scale and diverse enterprises (large firms and corporations), territorial entities (districts, cities, regions, states) with complex socio-economic systems signs. Complexity is determined not only by presence of many relationships that determine interaction (mutual assistance) of social and economic entities at different hierarchy levels, but also by their holistic consideration with a number of different historical, geographical, ethnic, cultural aspects, etc. [5-7]. Let us consider the Niger Delta region as a basic example, based on the study of which the managing projects and portfolios peculiarities LSEE will be revealed.

Uniqueness of this region in exceptional economic importance for Nigeria economy in energy resources - oil and gas extraction terms [8]. This is a large territory (about 70 thousand km2), that is divided into Nine states, with a population of 31 million people belonging to more than 40 ethnic groups and professing different religions [9]. Situation is complicated by the high region population, unemployment and poverty that lead to vandalism and oil theft on a massive scale with consequent damage to the state economy and environmental problems. Understanding the importance of this region and many conflicts presence, government created Niger Delta Development Commission [10] in 2000, and Niger Delta Ministry of Affairs [2008] in 2008.

These institutions have initiated many projects, programs and portfolios. However, as evidenced by documents published on sites [10, 11], more than half of them failed or continue to be implemented with significant deviations. In scientific studies [12-14], this situation is associated with many factors: high corruption, competent managers lack, insufficient study and projects evaluation with a focus on economic, technical and social aspects, etc. In [12, p. 95], conceptual model absence that allows combining various, infact, projects within the framework of a single management emphasized. State funding significant part goes to technical infrastructure projects in energy sector [15,16], while financing for business development, population employment, agriculture, medicine, and information technology introductions mainly provided through grants and World Bank tranches, as well as other organizations (UN programs, Global Fund, etc.) [18,19].

Documents relating analysis to development strategies and development plans for Nigeria as a whole [20-24] and Niger Delta LSEE [25-27] over the past 15-20 years allowed us to conclude that there is a tendency to use portfolio management under that projects are being implemented regarding various LSEE subjects life aspects (economic, political, social, cultural). At the same time, created products are often mutually complementary and affect simultaneously several life aspects [28]. It one of LSEE key features that expressed in multi-aspect rule. It confirmed by publications [29-33]. So, in [29,30] an example considered of managing a large project portfolio over six years (with an annual projects number within 200-300 that can conditionally be grouped into 5 industries) and multi-billion-dollar budget in one of European countries. It is noted that due to goals multidimensionality and flexibility it is possible to achieve portfolio success even with a certain unsuccessful projects number. Certain issues related to the features and difficulties of managing multi-aspect project portfolios were considered in [31–33].

Study of requirements for project portfolio goals, as well as their products and planned results based on sources [19, 23, 24, 26, 34] shows that priority is given to financial support in the first place, those activities that provide benefits (values) for the most part (wider circle) of LSEE subjects on different levels, scales and categories. Its feature is expressed in mass rule, according to project’s product that should be used by most of LSEE subjects.

Multidimensionality and mass rules consequence is complexity rule. According to that, project results evaluation included in portfolio should be carried out according to indicators (criteria) characterizing result simultaneously from several different essence properties position related to various life aspects of LSEE subjects. It should be noted that in this research, quite a lot of attention is paid, both from point of view of studying multicriteria approaches [35–39], and approaches based on holistic, conceptual complex systems vision [40–42].

Implementing diverse projects practice review in LSEE portfolio showed that products receipt (or their intermediate configurations) corresponding to them with results (effects) subsequent manifestation usually occurs with a certain delay after start and can be recorded both during projects implementation and after their completion [43-45]. Given this rule - effects shift (delay) from individual projects, in combination with their implementation sequence in portfolio, one should take into account possible both effects manifestation boundaries during and after its closure. On Niger Delta region example, it can be noted that the most attractive projects are (especially social), where effect manifests itself as early as possible from their implementation start that helps to increase support for those interested and reduce problems being solved impact [22,23].

LSEE project portfolios implementation timing study suggests that the most typical planned project duration is in range from 1 to 3 years, and project portfolios from 5 to 8 years (in relation to Niger Delta) [22,23,34]. For other LSEE, projects and portfolio typical duration may have other meanings that are largely determined by context of their implementation. At the same time, a common feature is manifested in LSEE portfolios limited (periodic) phased financing rule. That is, budget is set for entire portfolio implementation period in step-by-step schedule form, according to that guaranteed financing is issued in parts (tranches) in certain volumes for certain time periods (phases, stages of their use) [46-48]. Such schedule, for example, was considered on example of project portfolio financing of large energy company and metropolis [49.50]. From point of view of funds over time expense controlling, it is advisable to consider minimum period of one month, and maximum allowable one year. It generally corresponds to the data presented in [29, 30, 34] and is consistent with provisions for planning project cycles in portfolio [51,52]. An important rule is also higher priority projects funding continuity. According to that project can be included in portfolio taking into account priority in relation to other projects, as well as subject to its support sufficiency and continuity at guaranteed financing stages. Experience in implementing project portfolio described in [29, 30] shows that in fixed funding amount context, a number of milestones must be used to control projects implementation (at points of decision-making, delivery, payment, etc.). However, as a rule, upon portfolio implementation at certain points in time, up to 65% of projects can lag behind planned milestones. At the same time, it is recommended to determine uncertainty degree for each of projects as a management measure, to manipulate projects that have more flexible cost schedule and, in allocated funding part underutilization case (up to 20%), shift it to the next stage or, if possible, redistribute it to projects of another entity.

Given the significant amounts necessary to portfolio financing and interest in private business projects, it is necessary to identify mutual cooperation rule on public-private partnership basis [20,21].

During LSEE portfolio implementing, maximum involvement rule is important, according to that projects examination, their products and results is carried out at portfolio formation stage (its development conceptual stage, taking into account its implementation peculiarities) with maximum interested parties representatives involvement and project product main users (target audience, beneficiaries). Equally important is control by users and independent experts of project implementation process. From these positions, it is important to coordinate various stakeholders value representations and avoid possible conflicts [53–55].

During research, justification was also found that it is advisable to use S-shaped dependencies to describe evolutionary LSEE various development dynamics [56-58]. In project management theory similar curves are also used as a tool for planning, control and monitoring [59]. Source [60] discusses possibility of applying S - curves properties to manage project portfolios. It allows us to declare another rule - a single approach. It consists in common approaches, tools, principles using to projects planning and evaluation processes, as well as project portfolios in different entities and in different LSEE management levels.

Thus, in information sources analysis a number of projects and project portfolio implementation features of LSEE were identified that are summarized in ten rules (Appendix A). They determine focus of further research on current theory state and project portfolio forming practice, as well as highlighting unsolved scientific problems within this focus framework.

1.2. Current status of LSEE project portfolios hypothesis and practice arrangement

Project portfolio management (hereinafter referred to as portfolios) is today one of the most rapidly developing areas in project management. As indicated by insights, in developed countries, from 50 to 60% of undertaking focused associations oversee extends in portfolio structure [61]. Until this point in time, it has been built up that about 71% of IT organizations with portfolio management use flexible project management methodologies [62], and more than 70% of large companies have project portfolio management offices [63].

In portfolio management, "cornerstone" is their formation. It confirmed by works prevalence (scientific articles) about portfolio formation in total volume of portfolio management publications [64–68]. However, term "portfolio formation" in standards for project management, as well as in books, textbooks, and practical manuals compiled by reputable project managers, is practically not used. It also applies to phase names, project portfolio management life cycle stages of (Appendix B, Table B1), and management processes (Appendix B, Table B2, B3). Circumstance can be clarified by actuality that term "portfolio development" is utilized as a summed-up idea (category). Under development is normally comprehended project decision (selection) procedure from among candidates for given parameters.

Traditionally, formation is considered as a complex, multi-stage process, that is usually divided into separate number, interconnected processes, for example - projects identification, categorization, evaluation, selection, prioritization, balancing and portfolio authorization. In essence, they can have a different theoretical basis, but they allow one to obtain intermediate results necessary for subsequent processes implementation. So, in publication [78] it was shown that in order to solve portfolio management key tasks, a number of theories are used in practice - modern investment portfolios theory, multicriteria utility theory, organizational theory, systems and dynamic processes theory. Author also considers other theories (complexity theory, constraints theory) that can contribute to theoretical project portfolio management foundations development. As an example, in work from organizational PMI project portfolio management context model, procedures for translating strategic goals into portfolio components are highlighted; resources allocation to priority components; portfolio components assessment; identify and track benefits. However, author didn't unveil what explicit techniques and instruments are utilized inside these theories system and on premise of that they ought to be picked.

It was argued in [79] that dynamic research nature in project field, program and portfolio management entails many parallel and diverse research flows, significant part that carried out without converging or generalizing them into working theories. It tends to be clarified by certainty that most productions center around proposed logical methodologies and results acquired usage applied viewpoint introduction. Accordingly, number of works containing subjective methodological and hypothetical avocation for study is inconsequential. Most authors are of assessment that through methodological intermingling, building consistent conditions, consolidating and combination different exact, heuristic and non-deterministic methodologies with traditional hypotheses, strategies and instruments can be created to effectively tackle wide present-day issues extend. Against this background, over past decade, there have appeared works that address need to rethink existing approaches to managing projects portfolio and develop new ones, based on a change in main problems conceptual [80, 81].

There is also a significant amount of research devoted directly to project portfolio management methods consideration [82–87]. They give various ways to deal with gathering and ordering techniques. Authors utilize hypothetical methodologies, formalization strategies, errands types, and portfolio development parameters as criteria traits. Commonly, dispensed gatherings number extents from 3 to 6. Additionally, strategies and models number in these gatherings that legitimately identify with venture portfolio development (ventures prioritization, assessment, choice) fluctuates from 16 to 72. Moreover, authors note that despite methods variety used in practice, “today all researchers agree that none of methods provide an exhaustive and universal answer for choosing portfolio problem, each has certain advantages and disadvantages” [82].

Existing techniques, generally, just in part explain complex combinatorial (multidimensional) ventures portfolio shaping issue. It is because reality during portfolio framing it is important to all the while satisfy a conditions number. Main conditions include: need to solve multi-purpose tasks; accounting for significant qualitative number, quantitative, material and intangible criteria; large alternatives number consideration (sets of projects and their combinations in portfolio); introduction of many restrictions on various factors used in models; taking into account interdependencies and mutual projects influence in portfolio; maintaining a goals balance, resource parameters used and performance indicators in face of uncertainty and risk. Comparable sentiment was communicated in [83, 84], where it was demonstrated that vast majority of the techniques that were created 15–25 years prior has clear reasonable hypothetical base and hence have gotten boundless in portfolio executive’s field. Be that as it may, in present day conditions, they are of little use for tackling multidimensional issues. Generally speaking, such strategies are centered around taking care of individual operational issues, inside specific procedures structure or at specific portfolio board phases. This does not always make it possible to combine them to solve larger complex problems that arise at phases and stages of portfolio life cycle, in particular during its formation. Authors of [85, 86] also state that methods and models based on them should take into account contextual features of their application (specifics, tasks scale, etc.). Features consideration can lead to changes in structure and modifications of methods expression forms. Method essence description plays an important role. Understanding the methodological and theoretical foundations of that method is based allows us to develop its application rules and limitations. In most modern publications about project portfolio management methods, little attention is paid to this aspect. Mostly researchers focus on the method formalization, their software results implementation and analysis. Such research presentation makes it difficult to understand certain methods applicability field. Phenomena and patterns essence underlying them remains unrevealed. It is hard to evaluate results gotten quality that makes it difficult to lead relative investigation and an educated explicit technique decision.

Disadvantages and limitations associated with individual methods use are partially solved using hybrid approaches [82, 87]. This approach involves analytical number combination and empirical methods in solving a single problem logic framework.

However, in this case, problems are manifested that are related to perception complexity and using methods inconvenience, techniques and methods that support them in essence and implementation form. First of all, this is due to the fact that not all decision-makers are sufficiently familiar with the latest developments in above aspects. In addition, there is an interested person’s reluctance not involved in decision-making process to provide weighty information. This is due to insufficient its processing procedures transparency at project initial stages formation.

It was expressed in [88] that a huge piece of multicriteria strategies for portfolio arrangement can't give a satisfactory answer for even a solitary assignment to decide ventures need. Reason is strategies need for effectively contrasting among themselves different undertakings, venture items and their utilization results that are interesting in their tendency and have a various nature. It likewise demonstrates interface nonappearance among key and configuration venture determination levels. In such conditions, they typically utilize naturally created proposals with respect to different strategies coordination (formal and casual) for choosing ventures and shaping elective portfolio choices reason. Norms content similar examination for ventures portfolio overseeing, from time arrangement perspective for their appropriation, made it conceivable to build up facts number.

First fact indicates that most of standards use process models to describe control procedures that are based on a clear sequence of processes [69-75]. Use of unit process element model as a comparison base (Appendix B) allows us to state that the most complete processes description is given in PMI series of standards [72-75]. These standards give proposals with respect to passage sources into forms (past procedures), input group (assets, apparatuses, data changed over into process item), systems depiction for forms execution (explicit calculation of activities), control activities (documentation, guidelines) fundamental for usage procedure of assets and devices (approaches, strategies portrayal), yield position (process item), yield beneficiary (process item resulting forms, consumers). Group of standards [69-71] is progressively centered around forms singular components depiction. In that portrayal yield design is transcendently formalized that occasionally enhanced by a depiction of the information configuration and control activities. That is, they have practically no recommendations regarding specific methods and tools use. Therefore, a dilemma arises between justified choice of one or another standard, suitable management methods definition, or new one’s development that take into account modern problems of project portfolios forming.

Second fact shows that in the latest standards generations, portfolio management paradigm is changing [76,77]. In them, emphasis shifts from use of only process approach and models used within it with clear procedures sequence to more flexible management based on process, system, holistic-holistic symbiosis approaches. So, for example, in [77] fundamental portfolio’s continuous life cycle model consists of four main stages: initiation, planning, implementation, optimization. Stages are disclosed through main tasks at portfolio level and individual components (projects) level. Main difference from other standards is emphasis on continuity and flexibility of life cycle and related management processes and tools. Therefore, only goals that need to be achieved at each stage we describe. Flexibility is understood as ability to perform stages and related processes not sequentially, but through a series of iterations, at any time that may be due to the internal and external factors influence in relation to portfolio. Also, in this standard, special attention is paid to “portfolio value” concept and “portfolio complexity”. Concept. It consistent with general tendencies and trends that are currently being discussed by portfolio management specialists [89, 90]. According to them, managing project portfolios growing complexity in modern conditions leads to the fact that many standards, recommended tools cease to work and be universal. It necessitates existing tools transformation, their adaptation to emerging tasks using new functions and knowledge areas. At the same time, systematic and holistic approach that should primarily be aimed at simplifying management levels and processes and reducing decision-making in increased uncertainty conditions growing [90]. Author of [91] comes to similar conclusions. Author argues that increasing uncertainty factors, management complexity level and the variety of contexts for portfolio implementation in future affect approaches to their formation and management. So, we can see shift from theories and approaches use based on optimization and sub optimization criteria to more flexible methodologies.

Widespread has tools based on cognitive theories, heuristic approaches, large information amounts theories, structuring and reconfiguring complex formations methods.

Information sources review shows that there is already a fairly large number of scientific papers (both dissertational studies, and individual articles, books) related to change in portfolio management paradigm. So, complexity management issues in projects, portfolios and programs based on systematic approach are considered in publications [92–94], holistic (holistic approach) in [95–97], hybrid and flexible methodologies, and tools based on them in [98] -103].

Aforementioned publications general analysis made it possible to single out two key approaches to portfolio formation. It can be conditionally referred to as "evaluative" and "configuring".

Assessment approach depends on venture competitor's determination process. The "best" ventures are that have gotten excellent grades from specialists on chose markers. Determination measure right now imperative job for best tasks choice with "positive" evaluations. Because of chose ventures consequent prioritization, portfolio is adjusted and its outcome (esteem) amplified. In the course of 15 years, this methodology has gotten the most mainstream in venture board. It affirmed by enormous number of distributions where it utilized, just as procedure situated gauges content and functional rules referenced by us before.

Configuration approach essence follows from term "configuration" definition as logical and methodological method for synthesizing diverse subject knowledge, various systemic ideas about the same object (different object projections) [104,105]. During configuring, different system representations, due to their different nature, cannot be directly compared, combined, or transformed. Therefore, no optimality criterion for such technique. Fundamental is correlation by decision maker of different systemic ideas about the same object, bypassing object itself, with respect to configuration purpose. Based on this, in configuration approach framework, each project should be presented in different projections.

In our opinion, to represent diverse subject knowledge corresponding to different projections, it is advisable to use streaming project (and portfolio) representations about costs, expected results, projects strategic importance, etc. Such opinion follows from ability to use S-shaped form for representing various parameters shown in Section 1.1 projects. At its core, S-shaped representation is graphical flow representation. This makes it possible to consider flow as continuously ongoing processes that are measured in units over a certain period of time. For example, to describe costs flow, it is possible to use flow (time-cost) characteristic points parameters where change in costs rise rate occurs. Thus, costs are presented in quantities accumulated form at a certain point in time [106, 107]. Similarly, projects expected result can be presented in flows form. In relation to portfolio, it is necessary to consider costs and results flows that are formed by respective individual projects flows totality included in its structure. Portfolio flows general characteristics depend on project implementation sequence over time that in turn, is determined on at least two factors basis: projects priority (strategic importance) and resources for their implementation adequacy.

Relative investigation of approaches permits us to infer that "configuring" approach is more adaptable than "evaluative" one. According to methodological perspective, it permits you to glance in various route at issues number arrangement in framing ventures distinguished in portfolio [82,85,88]. At the same time, any approach is also certain methods, process, tools combination. Approach implies application an understanding of where, under what conditions and for what purpose they use. This in turn necessitates changes to traditional projects portfolio structure.

Logical works examination recorded in writing list, just as numerous others, shows that today there are no investigations where undertaking of framing multi-reason venture portfolios utilizing arranging approach is considered comprehensively (at hypothetical and methodological, methods, tools degree).

Presenting and using issues of projects accumulated streaming characteristics that can be basis for models and criteria for portfolio configuring, remain poorly studied. At the same time, some elements of configuration approach have already been partially implemented in project portfolio management theory and practice. It helps to solve combinatorial backpack optimization problems [108–111], investment projects and securities portfolios formation [112, 113], life safety projects [114], environmental projects [115], construction projects [116], and systems performance management in project-oriented organizations [117, 118] and others. However, in most of these works, configuration used as a tool for tuning, combining, and not as an integral thinking technique for synthesizing diverse subject knowledge.

The most significant results from shaping tasks portfolio perspective utilizing setup approach components are introduced in [119, 1200]. In [119], it is expressed that portfolio can have numerous inner setups (part sets) that are good with outer limitations (both input and output). In such conditions, there are only a few configurations that ensure its most effective implementation. To form a portfolio, this work proposes an approach that is based on a number of propositions borrowed from scientific areas that study nonequilibrium, variable processes, in particular, statistical thermodynamics. Main criterion for portfolio configuration effectiveness is useful costs value maximization by equivalent unit used resource cost. To formalize rule, dissemination (scattering) rate entropy assets idea and entropy of their utilization in explicit portfolio design. It is argued that entropies sum under consideration for possible combinations should tend to maximum. However, in our opinion, this approach does not take into account change in resources cost of over time (i.e., their flow characteristics) that is an important factor for project portfolios that are implemented for sufficiently long time. Also, its significant drawback in a project economic returns assessment lack. It shortcomings significantly narrow its application scope. Therefore, authors of [119] propose using it for projects and portfolios where expected result, in economic terms, are difficult to predict.

Shortcomings regarding projects economic return assessments are partially offset by [120]. In this work, portfolio formation is carried out on projects configuration basis that ensures overall portfolio profitability maximization while minimizing its risks. Authors pay special attention to portfolio considering as projects interdependent system. At the same time, minimizing costs for individual projects is not prerequisite. To evaluate various portfolio options, we formulate combinatorial problem. Its solution, taking into account cash flow behavior nature of over time, allows us to choose the most acceptable project portfolio structure configuration. Simultaneously, in this work, issues for multi-reason ventures direction were left without thought. It is expected that all ventures have a similar outcome embodiment that can be estimated by benefit. It altogether restrains proposed approach application practically speaking.

Considered papers [119, 120] are interesting by following results. First, they used diverse subject knowledge to configure portfolios (various theories). Notwithstanding, configurator model that as indicated by [105] ought to incorporate boards - projections of various subject information and purposes of their maintenance - cooperation, not described. It makes it difficult to understand nature and change logic, proposed criteria for portfolio configuration. Secondly, criteria based on parameters dependent on stream attributes (asset designation speed after some time; expenses and benefits stream) are criteria pointers premise. Thirdly, portfolio is considered as interconnected projects system, implementation sequence that determines flow parameters behavior. Fourthly, many portfolio configurations presence recognized, choice of the most effective that is determined based on combinatorial problem solution. Despite it, following disadvantages of these works should be noted. They do not have a configurator model and do not address issues related to changes in flows during setting restrictions on both volume and portfolio financing time at certain its implementation stages. It greatly complicates combinatorial problem solution. In addition, multi-purpose project portfolios formation features that provide for obtaining various nature results have not been taken into account.

An option to overcome the last of above difficulties is to evaluate projects and portfolios results not in cost ratios categories, financial benefits calculation, income, but in value categories. Such approach used in [121]. Investigation unmistakable element of this work is proposition to utilize S-molded bends to depict change nature in values after some time, both for singular tasks and portfolio in general. Be that as it may, absence of suggestions with respect to the quantitative worth evaluation’s appraisal, just as rules for developing and dissecting S-bends, are its primary downside. It ought to be noticed that in venture board aggregate bends are getting increasingly across board and not just in classical style aced volume technique [122]. Thus, work [123] shows S-curve advantages as visual diagnostic and control tools, and [124] as a model for displaying cash flows from individual contracts level to portfolio level. Accumulation curves are represented in volume surfaces form [125], in projections on planes [126] that significantly increases their informational level from flow characteristic analysis point of view. Obviously, further developments in this direction are relevant. At the same time, results already obtained give grounds to state possibility of projects and portfolios representing value parameter as accumulated flow characteristics using S-curves [127]. As a result, procedures that were traditionally used to analyze projects and portfolios by cost flows, for example, discounting, can be adjusted and used to analyze value flows. Such statement does not contradict main provisions of [128] according to that discount was initially considered by I. Fisher from evaluating precisely perspective capital goods value.

Thus, during costs and values flow characteristics for projects presenting in S-curves form, problem arises of discounting accumulated values taking into account point of their manifestation in portfolio. Such issue explanation contrasts from customary one, where incomes limiting did by periods [129]. Same issue was halfway considered in [130], where model for remembering a task for portfolio is limited gross proportion benefits (profit) and expenses. Notwithstanding, in this work, procedure for discounting accumulated flows was not used, that is crucial significance.

Development of views on discounting from benefits and costs analysis perspective for programs and projects being implemented in economy public sector, led to social discount rate concept. It was shown in [131] that there are several approaches to determining discount rate values and all of them are based on risk concept. However, from N. Luman's theory standpoint, term "risk" is not applicable at portfolio formation phase [132]. Term "risk" is used only after decision is made on implementation of formed portfolio. So far, during displaying stream attributes, it is prudent to utilize term "peril". Ways to deal with deciding rebate coefficient considering risk metric have not yet been created.

From works analysis [121-132], following conclusions can be drawn. It show comparing possibility divergent projects results based on category "result value" use, but tools for determining "value" are not described enough. Value is considered as a flow characteristic that can be represented as an S-shaped curve. It is proposed to use discounting procedures for value flows, while introducing problem an appropriate discount coefficient and determining its values is indicated. In these publications, traditional approaches and procedures for discounting flows were considered - based on an assessment of difference in income and expenses over time periods (discrete approach).

Unlike well-known approaches, our idea is based on discounting accumulated flows (cumulative approach). It makes possible to reduce (make up) number of parameters characterizing S-curves into a single numerical value that can be used to construct criterion for project portfolio configuring.

In light of hypothesis state survey and task portfolio arrangement practice, it very well may be contended that today, from existing issues viewpoint and recognized patterns, the most encouraging way to deal with portfolio development is design approach. Despite this, it did not get wide distribution because not yet explicated to this activity field. Its application within individual methods framework and models is more intuitive and limited to portfolios with small simple projects number. With an increase in their number and essential expected results diversity, rational portfolio forming complicated by magnitude orders. Also, in the conditions of time-variable portfolio financing flow, it becomes practically impossible to solve without specially developed software. Creation of such software requires scientifically based and explicitly presented configuration method. Formalization of such method today is an urgent scientific and practical task. Its solution feasibility enhanced by practical need to form multi-purpose project portfolios for LSEE development.

Indicated scientific and practical task determines such dissertation research purpose - method development for configuring multi-purpose project portfolio based on flow costs and project results characteristics for a given step-by-step portfolio financing schedule.

To achieve this goal, taking into account information sources of known solutions identified in analysis process, their shortcomings, problematic issues requiring further study, a logical sequence of research tasks is defined:

1. Develop system-holistic view model of forming a multi-purpose project portfolio activity to establish configuration elements place in its structure and design a project / portfolio configurator;

2. Identify unifying features for configurator panels with view to their further use in criterial portfolio configuration indicator construction;

3. Develop graphical and mathematical models for flow portfolio characteristics calculating under given restriction in form of step-by-step portfolio financing schedule;

4. Propose numerical project cost parameters (result) description, presented in S-curves form;

5. Develop criterion for portfolio configuring with a given step-by-step schedule for its financing;

6. Investigate performance (test) of method and its supporting tools for configuring multi-purpose project portfolio.

1.3. Conceptual model of project portfolio formation phase

As was shown above in standards for project portfolio management, emphasis is mainly on main and supporting management processes description, and portfolio life cycle presented as a sequence of cyclically related stages - initialization, planning, execution and optimization. Each of steps revealed through key processes series. At the same time, in practice, in contrast to standards, many publications use phase concept as a portfolio life cycle element [133-139]. Proposed models usually contain from three to five phases, first of that is portfolio “formation phase”. At the same time, researchers note that control processes groups are not phases, but separate processes necessary for achieving main phase results can be distinguished in phases. Based on this, it can be argued that it is possible to compare management processes with portfolio life cycle main phases. However, procedure for such comparison disclosed mainly at logical reasoning level [138]. Terms essence comparing results that are close in their use in practice — phase, milestone, stage, juncture, process presented in [139], allow us to state that such a comparison is possible both at the level of individual stages and of individual processes. Fig. 1.1. a graphical model of the areas of the time axis is presented, for the designation of which the corresponding terms are used. We call them our study terminological system core.

Model analysis shows that distinctive feature of any phase is its direct link to life cycle. Phase can be represented as life cycle part, that in turn consists of logically interconnected parts (works, operations), end of that involves receipt of one or more products (results). Project portfolio management phases can be implemented either sequentially or in parallel.

Milestones are certain events that indicate significant intermediate result achievement or phase change. Under stages we mean certain time periods of phases that differ among themselves in a qualitatively new portfolio management activities state that can considered as stages of phases development. An even shorter period of time reflects term “juncture”, by what we mean a single moment or control process part, ending with an intermediate or final result of process and usually consisting of operations (actions) that are uniform in content. It makes possible to use term “juncture” when describing the most locally dynamic actions occurring during phases and stages implementation, as well as considering connections presence between different junctures both inside and outside of individual phases, stages, processes.

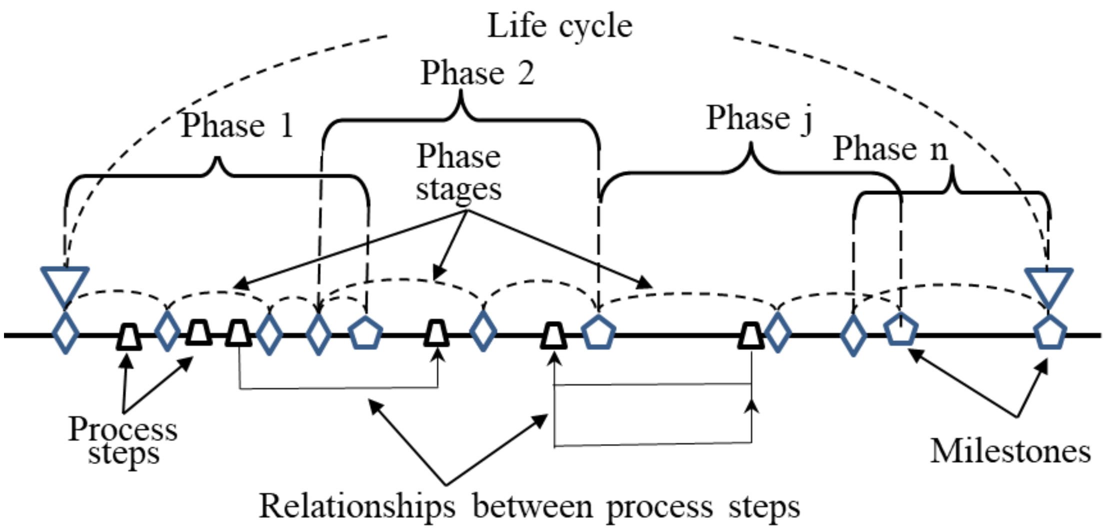


Figure 1.1 - Semantic terms interconnection model that used to describe a group of processes for project portfolio managing

Source: developed by author.

Interrelated tractor terms given above fully comply with approach stated in standard [77], that defines portfolio life cycle essence by such categories as “flexibility” and “continuity”, information and decisions are transmitted both within stages and between them.

Variety of different points of view to content and existing standards for project portfolio management processes structuring description use of diverse terminology, led to need for holistic review of all standards from project portfolio management possible structuring perspective. Approach elements of the thesaurus approach methodology are used in structuring [140,141]. From these positions, main emphasis was placed on terminological apparatus that used in standards. Information sources analysis made it possible to identify four semantic groups of terms that used to describe control processes (Appendix E). First group includes terms that are used in considering methodological issues in project portfolios formation. Second - terms associated with preparing processes for portfolio formation, and in third - with direct formation processes. Terms were selected in separate group, contextually related to obtaining new information that reflects portfolio features being formed, in particular, multi-purpose portfolios formation. Such data must be acquired through explicit research. Based on activity meaning that reflect each group terms, imagine them in corresponding stages form. We use terms for their name - «conceptual», «preparatory», «configuration», «research stage». They are implemented as portfolio formation phase part. As you can see stages names correspond to above selected groups meaning.

Proclamation in standard [77] of the need to consider a portfolio as a complex system from holistic approach perspective confirms appropriateness of using system models to represent project portfolio formation phase. One of such models is four-element system model [142]. It was developed in 2000 at scientific school in what this study was conducted and has positive results in more than 100 system studies that related not only to project, program and portfolio management. In fig. 1.2, such model is informatively filled with components that correspond to four identified project portfolio formation stages.

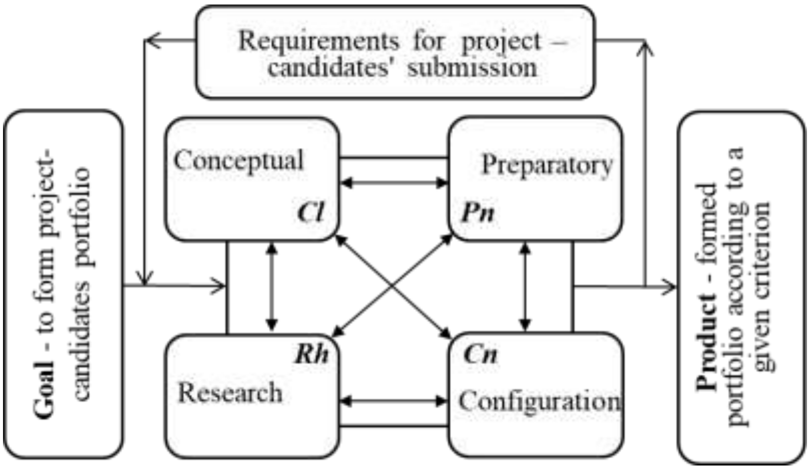


Figure 1.2 - Project portfolio forming phase system model represented by its stages

Source: developed by author based on [142].

Model reflects interaction (interaction relationships) presence between individual stages. Each stage, in turn, can be represented by similar model. It allows to display connections presence between juncture within stages. An important element in system model is feedback between output and input. The latter, in our case, provides an unambiguous requirement arising understanding from portfolio formation criterion determined by its strategic objectives, to all portfolio formation stages - conceptual, preparatory, research and configuration. It’s definitely considering relations between segments that the framework model we have proposed varies from comparative model created in [143].

Portfolio formation stages representation as system components allows to determine their goals, that are determined based on entire system (portfolio formation phase) goals.

So, conceptual component purpose is to develop rules (principles) that set restrictions on methods, procedures and tools choice for portfolio formation. Such restrictions, for example, determine multi-purpose portfolios formation features. Preparatory portfolio formation component purpose is aimed at creating requirements for project-candidates and organizing collection of information about them. Configuration component purpose is to determine projects and sequence list of their implementation from pre-selected project-candidate from portfolio formation criterion perspective. Activities within research component are aimed at timely synthesis and delivery to other missing information (knowledge) system components. Such information reflects project-candidates features and criterion for specific large socio-economic education portfolio formation.

To correlate distinguished stages (system components) meanings, it was structured on “Pyramid 3M” model basis (Fig. 1.3) [144, p.143]. In accordance with this model, at upper (methodological) level M1, restriction rules should be formulated and reflect portfolio formation features, project-candidates grouping, relevant criteria for their inclusion in portfolio, etc. Highlighting this level is important, as practice shows that insufficient attention to methodological principles of any activity, including portfolio management, leads to ineffective solutions in dynamic, rapidly changing modern knowledge economy conditions [12,145,146].

At average “Pyramid 3M” model level M2, methods and procedures for stages implementation, restrictions imposed by level M1 rules should be determined. For each method and selected procedure at lower (methodical) level M3, appropriate tools for their implementation are developed.

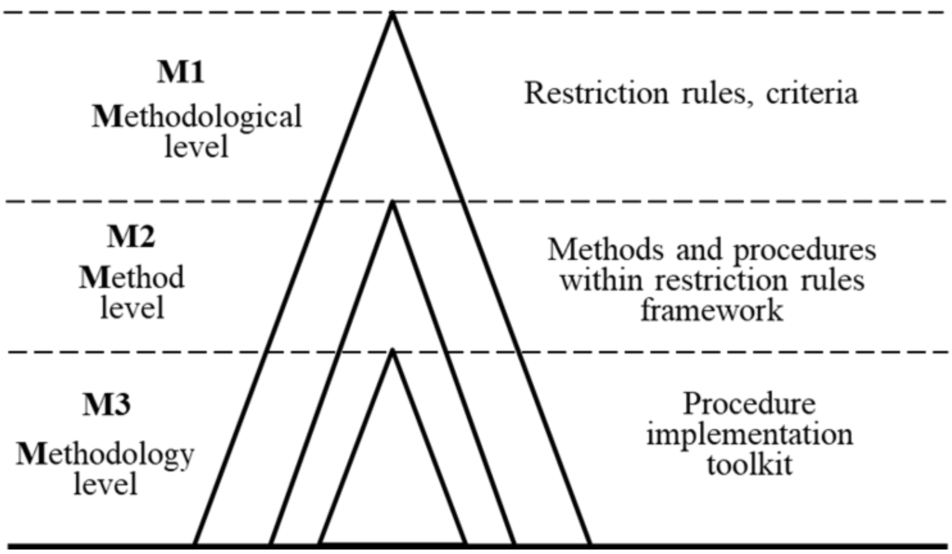


Figure 1.3 - Activity products in "Pyramid 3M" model levels context

Source: developed by author based on [142].

Based on core components meaning of our study terminological system, portfolio formation stages should be presented in junctures sequence form for activities implementation. Apply this rule to project portfolio formation phase system model. Represent each of its components (stage) by corresponding junctures (fig. 1.4). Each stage denoted by flowcharts graphic element that fixed in international standard ISO 5807: 1985. Competent authority last reviewed the Standard in 2019 that confirmed its relevance [147]. System model components junctures made possible to identify zones M1, M2, M3 that contextually correspond to Pyramid 3M model levels (fig. 1.5 – 1.8). Arrows "output" from stage and "input" into juncture were used to display connections between junctures. Arrows recorded information about interconnected junctures in indices form. Index consists of an alphabetic character that denotes corresponding component, and juncture number in component.

Let us consider in more detail junctures of conceptual system model component stage implementation (fig. 1.4). As shown in Section 1.1, portfolio formation is not possible without an LSEE development strategy. Main objective of any portfolio is to ensure safe LSEE existence in long term by increasing its productivity through fixed strategic achievement goals [148]. Issues related with strategy formation are not considered in this paper and are not reflected in models at individual junctures level. It's separate task.

Conceptual juncture initial stage is juncture of projects and portfolios features identifying. Features are determined by particular LSEE specifics and its development strategy. Requirements, rules and restrictions developed taking into account particularities are associated with not only with strategic goals specifics, LSEE management system, but also with conditions under that both individual project portfolios (portfolio components) and portfolio, as a whole will be implemented. If projects and portfolios features have already been identified previously, then transition to the next juncture follows. If not, then decision made on need for research to identify such features. In system model, it reflected in relationships between various components junctures. For example, for stage under consideration, Rh1 – "output" appeal to research component; CL1 –corresponding answer, "input" related to conceptual model component (fig. 1.4, fig.1.5). In this way, two-way connections are formalized, mirroring model segments association.

Understanding projects and portfolios features helps determine criterion for projects in portfolio inclusion. Simultaneously, basic leadership strategy like above-portrayed circumstance is rehashed, but with respect to criterion: justification and criterion selection from known list and previously used ones, or our own criterion development that takes into account particular portfolio specifics and characteristics.

Let's proceed to consider preparatory system component (stage) (fig.1.6). First step in this stage is to develop options for financing schedules for project portfolios. Usually one schedule is formed based on possible funding amount. However, standards focus on need to develop several adaptable alternative financing plans and schedules that contributes to portfolio flexibility. So, for example, several options for schedules can be proposed, with same funding amount but with different start and end dates, as well as funding distribution over time periods that can certainly affect portfolio configuration results. In funding schedules absence, research is needed to develop them.

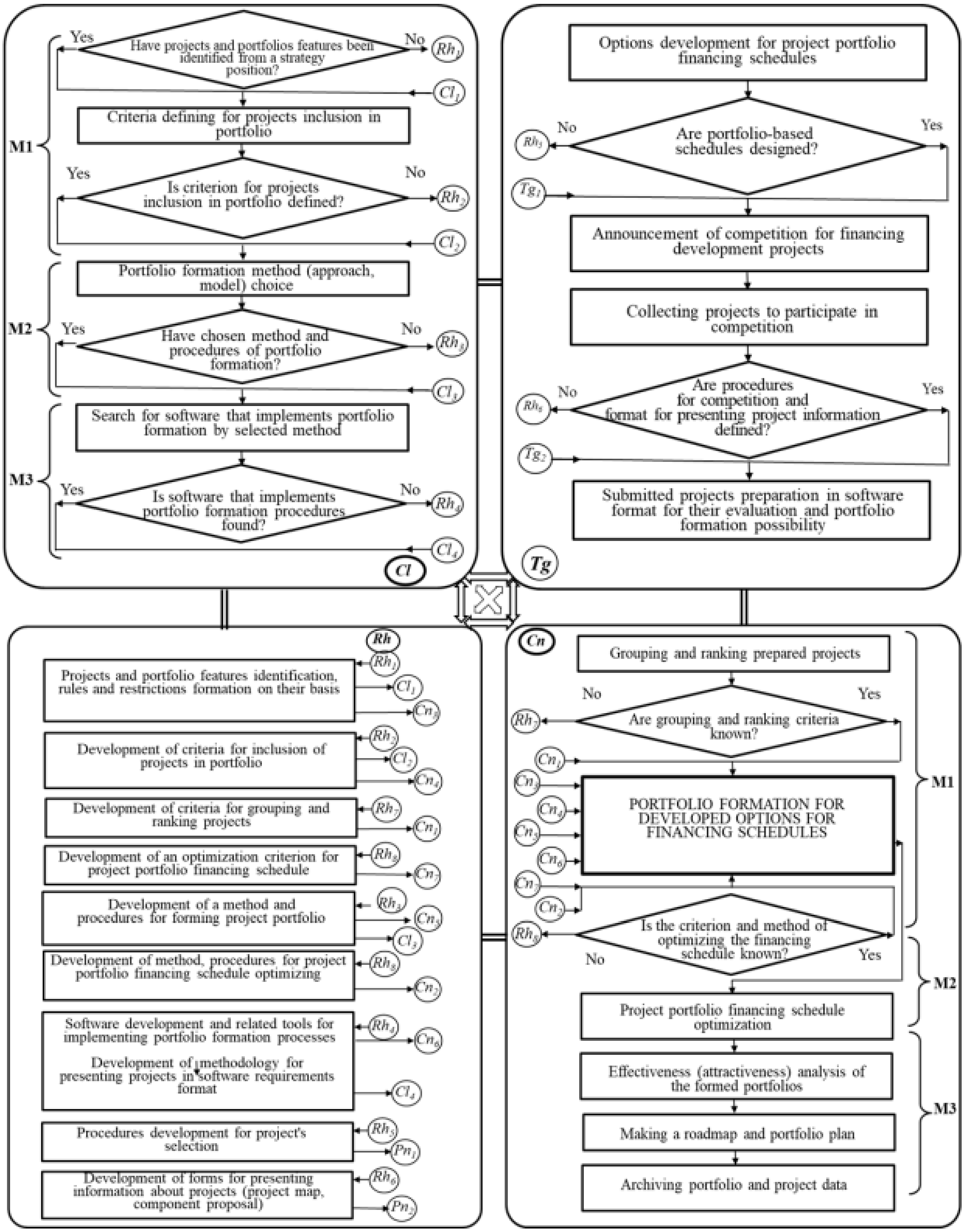


Figure 1.4. Project portfolio formation phase components - stages presented in their implementation stages form

Source: developed by author.

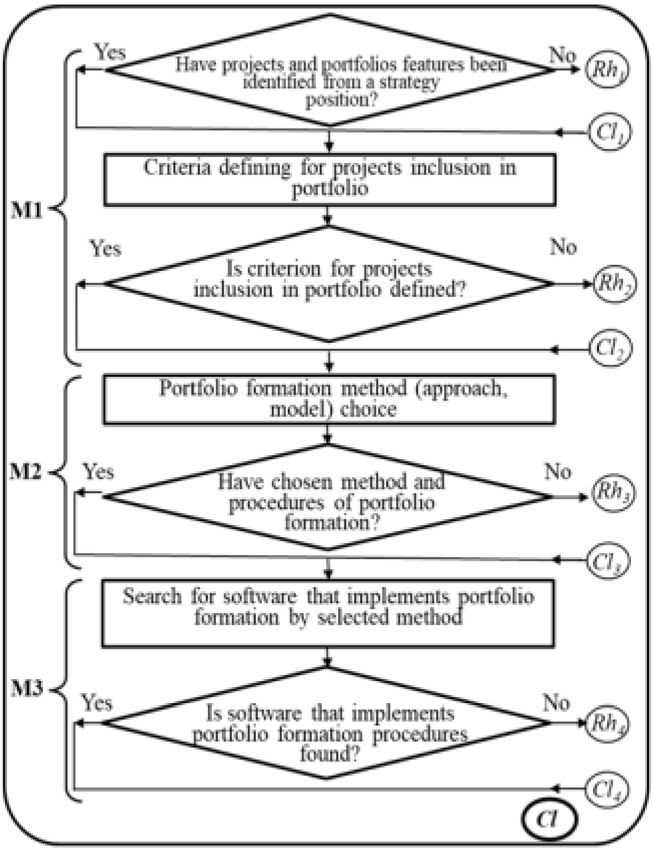


Figure 1.5 - Junctures of conceptual component (stage) implementation in portfolio formation

Source: developed by author.

Next juncture is announcement of competition for financing development projects. Correctly announced competition provides 50% success in achieving strategic goals for achievement of what project portfolio will be form. Main thing at this juncture is timely potential participants about channels notification of information available to them. This information about participation conditions in competition for financing, portfolio forming purposes, project-candidates form and project documentation templates that must be prepared according to certain rules. Templates should contain all sections, completion of what, according to specified clear recommendations, will make it possible to state in full all primary information about project, its importance for specific portfolio, implementation features, etc. Primary information processing allows obtaining secondary information, based on decision that made on whether or not to include project in portfolio, on its place in project financing priority list, etc.

Collecting projects juncture for participation in competition involves initial project-candidates processing identifying primary incorrect information presentation gross errors presence or project data distortion. Initial processing allows preventing projects that are not related to strategy priority objectives that must be ensured, first of all, by project portfolio correct formation.

After collecting pre-tested projects, next juncture is implemented - procedures for competition (selection of projects) determination and information presentation format. If such procedures are absent, it must be developed what is reflected in system model by connections corresponding with research component stages. Projects preparation in format that allows entering all necessary information into project portfolio formation program is an important stage. Main objective of such training is to bring different performance project products indicators to single basis. In most cases, such basis cannot be indicators expressed in monetary terms. So, for example, for social projects, effect showed in humans' number who can use project product.

Next stage is dedicated to portfolio configuration (fig. 1.7). It begins with juncture of grouping and ranking projects. Grouping criteria (key descriptors) are used for it that can determined, selected from known ones, or should be developed as research component part. Typically, grouping criterion is an established strategic goals sequence that reflects their importance for given portfolio. Each goal can be achieved by different projects. Such projects are included in projects group that associated with goal. Ranking criterion, for example, may be temporary priority of achieving a particular strategic goal. If it is desirable to achieve two or more goals at the same time, then these goals should have the same rank.

Next juncture is portfolio configuration. It is consistently implemented for developed financing schedules. Portfolio configuration should be carried out automatically taking into account indicated projects priorities, their feasibility, value, duration, cost and effectiveness. Each miscalculation for each financing schedule forms primary corresponding portfolio plan and corresponding financing schedule.

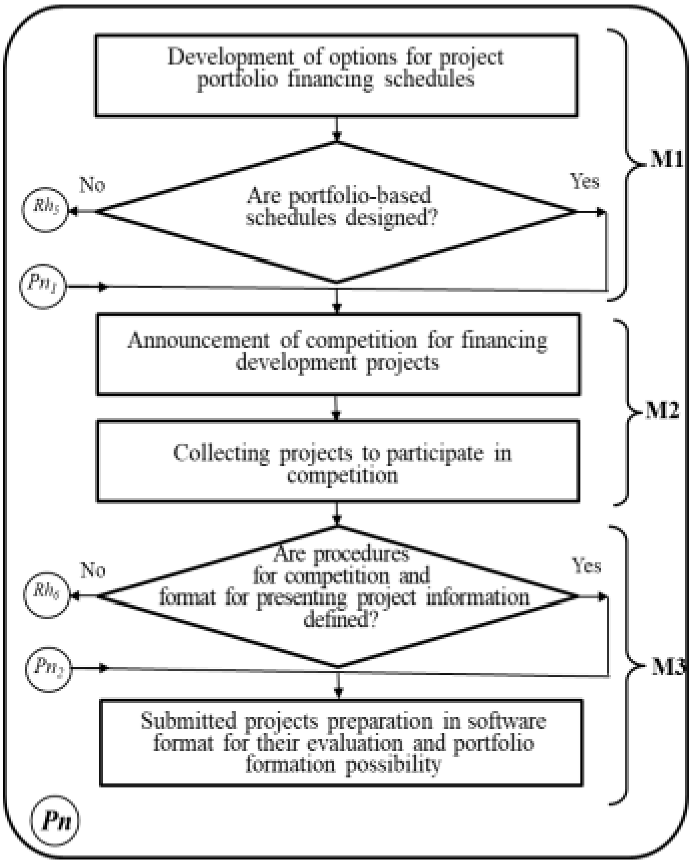


Figure 1.6 - Preparatory component (stage) implementation stages in the portfolio formation

Source: developed by author.

Optimization is next step through what received portfolio financing schedules pass. Optimization needs can cause by significant discrepancies between basic (initial) schedules for financing portfolios (finance amount allocated for certain time periods to achieve strategic goals) and formed (planned) portfolios financing schedules. At the same time, situation may arise when basic financing is not enough to finance certain portfolio components (in general or for certain time periods). In this case, optimization is possible due to rebalancing portfolio, changing priority of its components, and revising connections between them. It led to change in planned portfolio implementation schedule and corresponding financing schedule. Basic schedule is much less often adjusted. However, this option can also consider under certain conditions. Another situation is possible, when basic financing schedule is redundant in relation to planned portfolio financing schedule both as a whole and for individual time periods. In this case, optimization is reduced to finding reserves, financing and adjusting base schedule "overplus". Using software allows quickly recalculate and verify portfolio parameters by replacing base schedule with planned schedule for its financing.

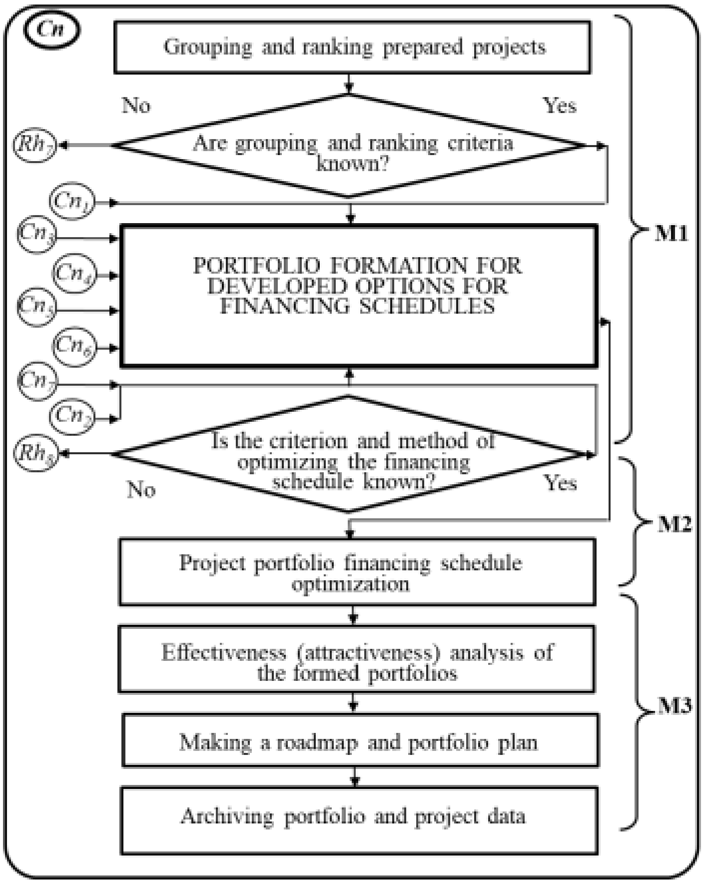


Figure 1.7 - Configuration component implementation stages in portfolio formation

Source: developed by author.

Compares various portfolio options based on an analysis of their effectiveness (attractiveness) at next stage. Designing and calculating such criterion (indicator) is rather non-standard task, requiring appropriate research at conceptual stage, as criteria development part for individual projects portfolio inclusion.

Roadmap and portfolio plan final drafting is determining projects list included in portfolio, order of their implementation, building portfolio financing schedule, total portfolio duration calculating indicators, portfolio performance parameters, etc. are performed in penultimate stage. All of above portfolio parameters are calculated automatically according to finally approved funding schedule, project groups and their ranks.

Projects and portfolios archive creating juncture is portfolio configuration phase completion. Archiving purpose is to form knowledge base accumulated during work with portfolio that can be used to compile new portfolios or to make changes to formed during their review at implementation phase.

As can be seen from the above figures 1.5-1.7 during project portfolio formation, at its stages situations number often arise related to information lack, criteria, methods, procedures, techniques, etc. are necessary to solve tasks. These circumstances necessitated research in indicated areas. Such moments appear almost always, because project and portfolio activities are unique and not repeatable, requiring a creative, creative approach. It determines importance and research component portfolio formation presence relevance in proposed system model (fig. 1.8).

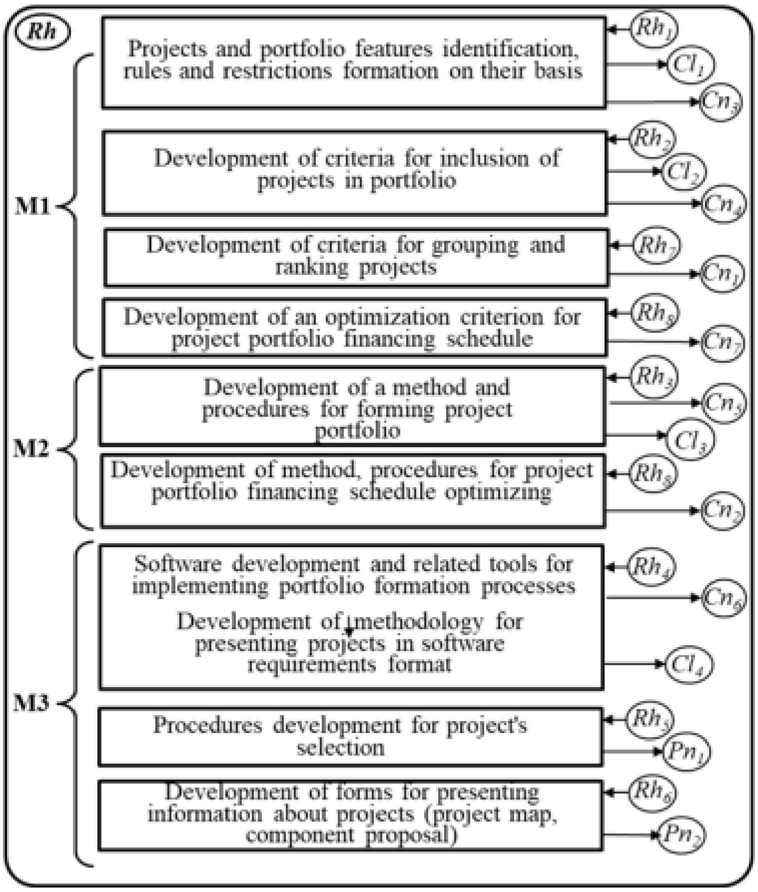


Figure 1.8 - Research component implementation stages in portfolio formation

Source: developed by author.

Knowledge that synthesized in different system model components at M1 level (fig. 1.5-1.8) is concentrated in “Portfolio configuration for developed options for financing schedules that is “Configuration” component core. Despite expressed practical junctures orientation, it related to methodological level. It emphasizes need for a system-holistic implementation using all methodological tools synthesized in all other system model components activities. Therefore, these junctures are key not only for configuration stage, but also for portfolio formation as a whole.

CHAPTER 2
CONFIGURATOR DEVELOPMENT OF PROJECT-CANDIDATES IN PORTFOLIO

2.1. Project-candidate configurator model

As noted in section 1.2 (1), configuration involves synthesizing of new knowledge about projects based on different subject cognitions about this project. At the same time, diverse knowledge differs among them in that the change in the quantity and quality of knowledge in one subject area does not affect change of knowledge in another subject area [150 - 152]. For a more visual representation of this provision, we use the principle of "orthogonal organization of representation-application". This principle, according to G.P.Shchedrovitsky, is one of the fundamental in the methodology of organization, leadership and management [153]. According to this principle, mutually perpendicular planes are used to organize the space of activity and thinking of people. In this space bounded by planes, the integral activity of a particular object is mentally implemented, and that projected onto each of the planes (in the terminology of G.P.Shchedrovitsky onto boards).All projections (sides) of an object's activity are fundamentally different from each other and are essentially different images of its activity, which is implemented in this space. Therefore, the content of each image is autonomous, that allows operating each image separately.

Orthogonality of the planes suggests their mutual intersection. Moreover, there is a mutual "capture" of images (projections) along the line of intersection. Understanding the essence of mutual capture is revealed by G.P.Shchedrovitsky when considering orthogonality. "Orthogonality is the maximum possible distinction when–something "recognizes" another something to some extent and "becomes attached" to it or "captures" it.... Orthogonal planes must-intersect in three-dimensional space (geometric fact). The intersection belongs to both orthogonal - it is both that, and another, and is not that, and not another of them. It could be called both a "turning point" and a "configuration holding point". Orthogonality is not just a distinction or opposition, but it is an opportunity for each side to change, as if to move freely while maintaining their original relationship to each other. This is a very important point. Because it is enough to find a way to build the "orthogonality" relationship-at one point, and one -can apply it at any point, wherever the sides go" [154,155]

In essence, projections are different knowledge about the object of activity, and their combination, justifying and explaining the existence of various knowledge about the object, is called the configurator" [156, p.655].

Based on the objectives set in section 1.4, we determine the necessary and sufficient amount of various (different subject, multi natured, multi subject) knowledge about projects-candidates. To do this, we use the model of components (stages) of the phase of formation of the project portfolio, presented in the form of stages of their implementation (fig. 1.3). The analysis of the model made it possible to identify five independent contexts (aspects, projections) of the projects-candidates vision, which allow obtaining multidimensional (multi subject) information about the projects.

The first two contexts are related to the project costs–and the project strategic importance of the project for LSEE. They are always present in any approach to portfolio formation. However, the presentation of information on costs and strategic importance may differ from each other within each approach. The third context is related to the result that will be obtained due to project product usage. It is increasingly starting to be taken into account when forming a project portfolio. To characterize the result, most often nowadays they use the category of "value". The fourth and fifth contexts focus on the parameters of project reachability and feasibility. These terms do not yet have a clear, coherent definition among portfolio managers. Perhaps this is the main reason for their rarer application in the practice of portfolio formation.

The implementation of the above contexts allows to obtain the necessary and sufficient amount of various (multi subject) knowledge about projects-candidates to solve the portfolio configuration task. We introduce the term "project-candidate configurator" in order to make it possible to represent different knowledge about a project-candidate within the framework of one concept. By the project-candidate configurator we mean the project presentation in the form of diverse knowledge about it, fixed on orthogonally located panels, with the aim of their subsequent assembly and synthesis of new knowledge in the form of an integral indicator of the project, which is used to configure the portfolio.

We used the term “panel” to indicate the location of multi subject knowledge. It is an analogue of the term “board”, which was used by G. P. Shchedrovitsky at the end of the twentieth century. Nowadays, in the era of Industry 4.0, “panel” is a more perceived term due to its use in combination with the term “operating”. Such a phrase as “operating panel” means part of any user interface of any device and gadget.

In fig. 2.1 a graphical model of the project-candidate configurator is presented, which corresponds to the definition proposed above and considers the five selected knowledge panels. As one can see, all panels are located orthogonally or parallel to each other.

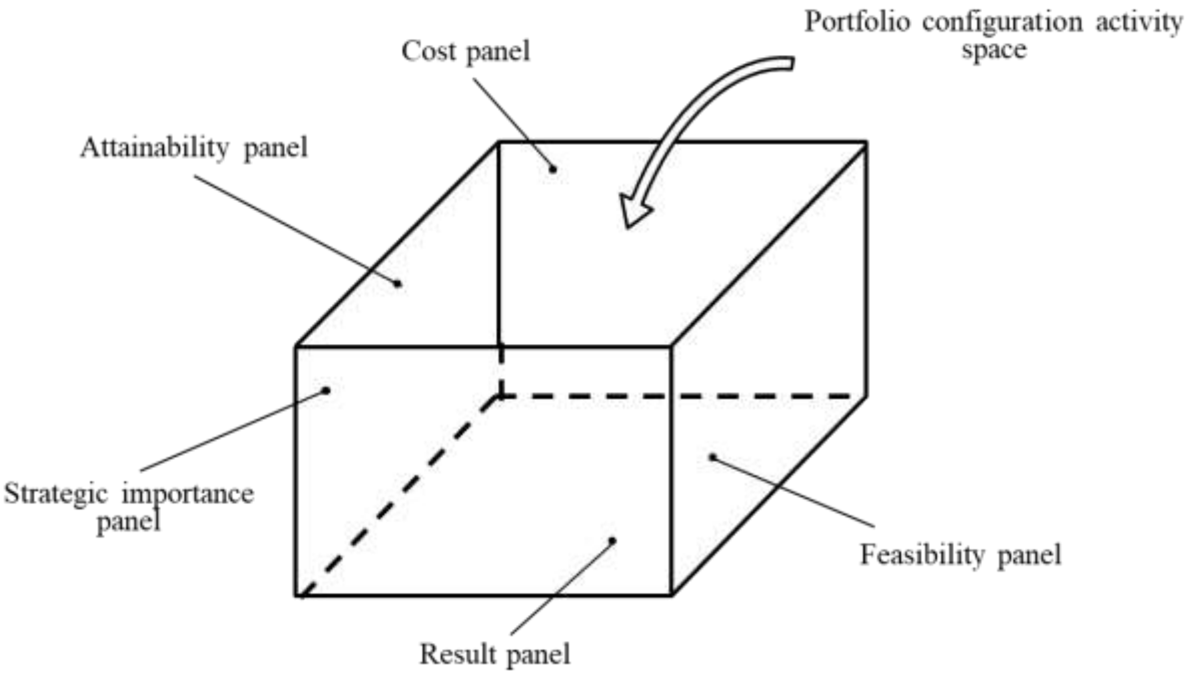


Figure 2.1 - Project-candidate configurator panels

Source: developed by author together with supervisors.

Panels form an activity space. In our case, it is the space to configure project portfolio. Therefore, as a new knowledge that should appear after assembling the diverse knowledge presented on the panels, there is knowledge about the project integral indicator, to be used when configuring the portfolio (fig. 2.2).

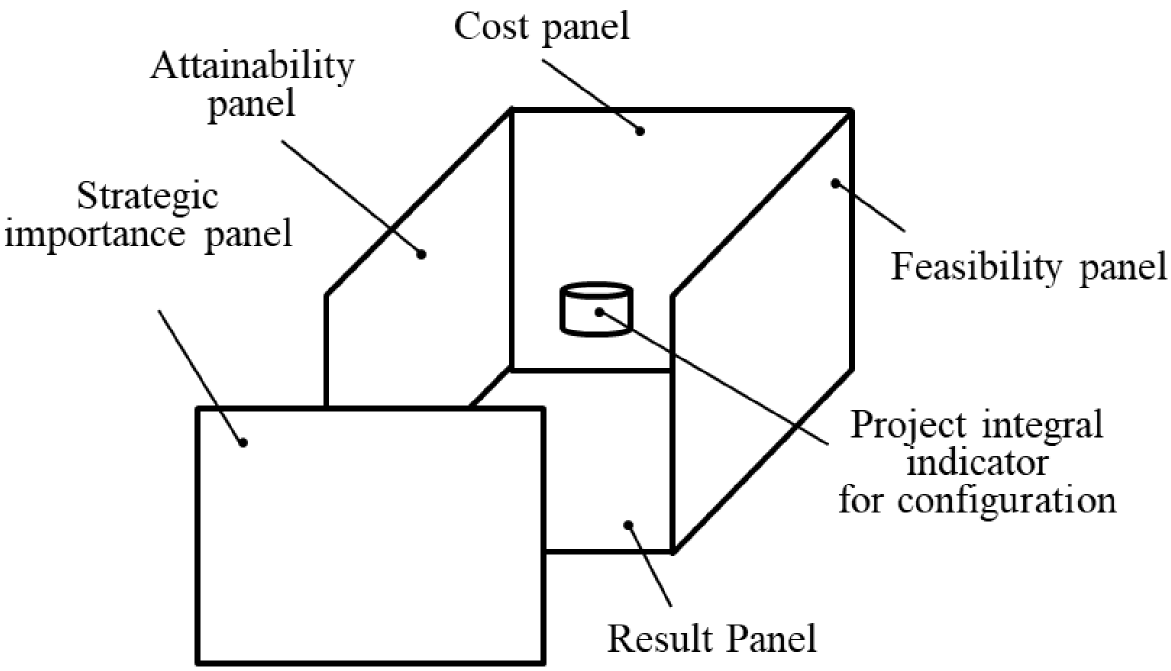


Figure 2.2 - Location of the project-candidate integrated indicator in the space of activities for configuring the project portfolio

Source: developed by author together with supervisors.

In the proposed model, a larger number of orthogonal planes was used compared to the methodology configurator model proposed by G.P. Shchedrovitsky. There are two of them in his configurator model: one is used to display the projection of the ontological picture, and the second is used to display the organizational activity picture [154]. And always there is a line of intersection between two orthogonal planes. The requirement of intersection of all planes with each other is not fulfilled in model we proposed. Range of planes are located parallel to each other (panels of strategic importance and feasibility, cost and reachability). To eliminate this drawback, we draw four diagonals in the space of holistic activity, as shown in fig. 2.3, that intersect at the location A of the project-candidate integral indicator.

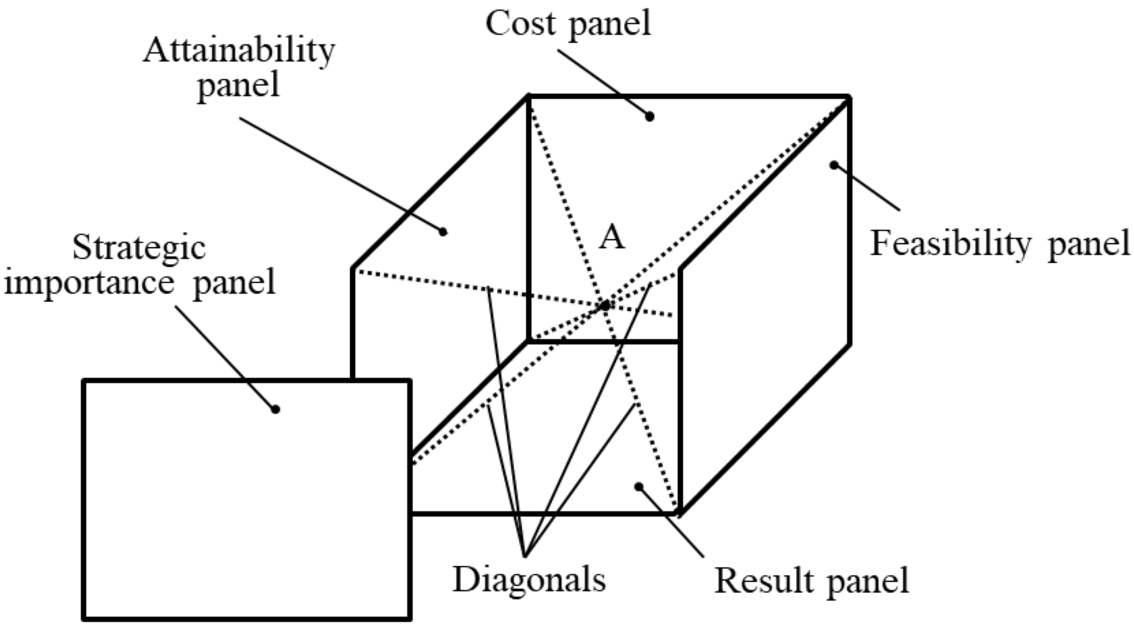


Figure 2.3 - Separation of the project portfolio configuration activity space

Source: developed by author together with supervisors.

Then, we build a tetrahedral pyramid on each panel. The edges of such pyramid pass along the diagonal lines. We separate the resulting pyramids from canter of intersection of the diagonals - the location of the project-candidate integral indicator (fig. 2.4).

We connect the vertices of the pyramids with dash-dotted lines. The intersection point of these lines-performs the same function as the intersection line in the configurator of two plane. Thus, it is the “configuration hold point”. It is at this point that new knowledge about the project-candidate is generated based on knowledge, fixed in the corresponding panels. An integral indicator is the product of generating new knowledge in our research.

To configure the integral indicator, it is necessary to choose ways of representing diverse knowledge in the corresponding panels. The following sections of the research will be devoted to this point.

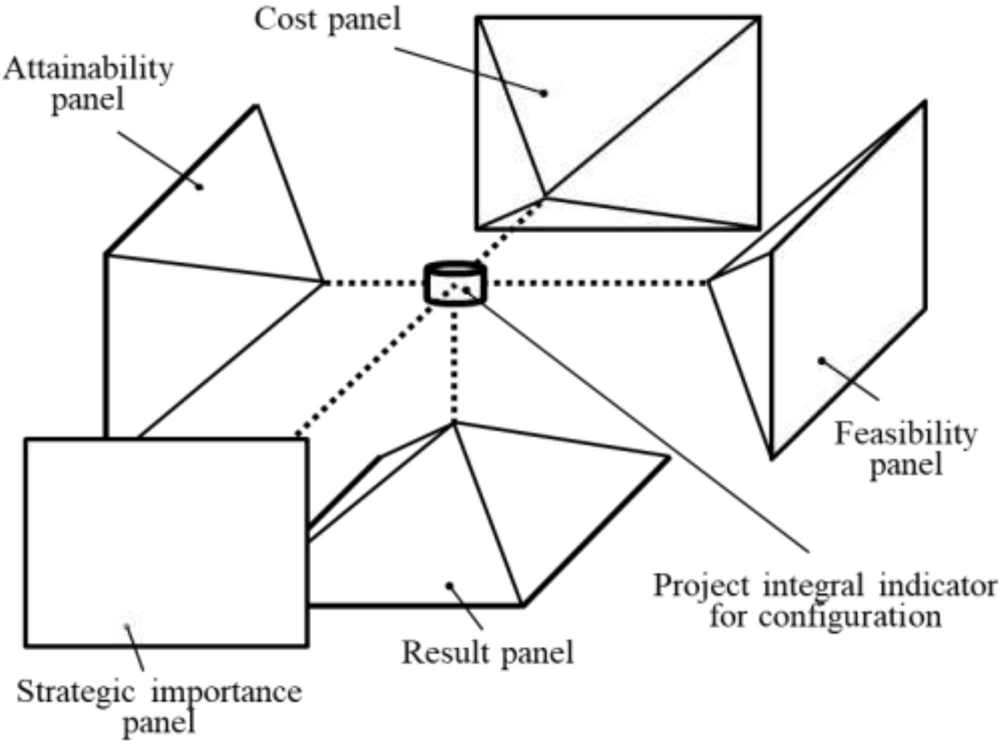


Figure 2.4 - Location of configuration retention point in the activity space, that limited by more than two planes

Source: developed by the author together with supervisors.

2.2. Project-candidate costs and results streaming panels (presenting as flows)

In works dedicated to project and portfolio management, multi-index presentation of indicators is widely used when developing mathematical and graphical models, models of generalized integral indicators. [158-160]. This method has also been successfully used in research conducted at the scientific school where this work was performed [161,162]. Therefore, when describing the knowledge about the costs and results of the project-candidate in the corresponding panels (section 2.1), the method of multi-index presentation of indicators will be used.

It is potentially possible to use four zones with a multi-index representation of the indicator (fig. 2.5). At initial stage of work with configurator, we use three zones A, B, C. List of basic parameters and indices used by us in graphical and analytical models for presenting information and formalizing new knowledge, as well as their semantic meaning, are given in table 2.1.

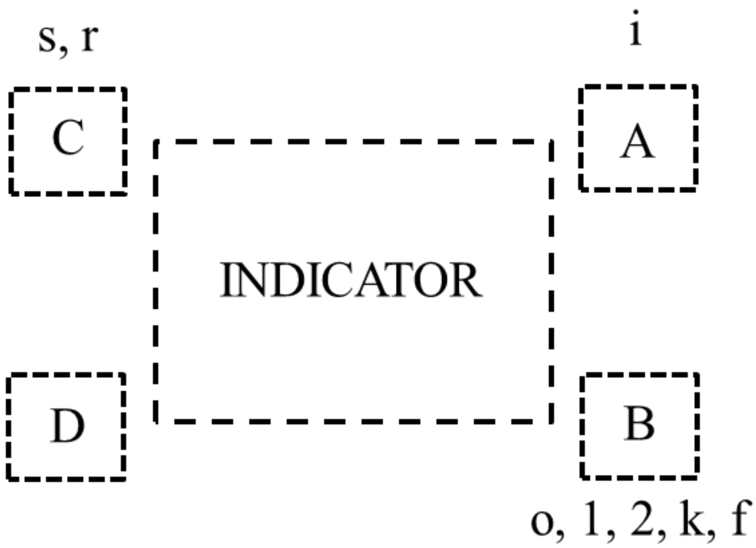


Figure 2.5 - Indices system used for projects and portfolios indicators and parameters

Source: developed by author.

Table 2.1 - Keys for decoding indices and indicators

Index area	Indicator or index designation	Semantic meaning of indices and indicators
Possible indicators	σ, S	Cost indicators
	r, R	Result indicators
	τ	Time indicator in the project (local coordinate system)
	t	Time indicator in the project portfolio (global coordinate system)
	T	Duration indicator
A	i	Number of project-candidate in portfolio
	j	Number of project selected in the portfolio
B	o	Initial moment (start)
		Current moment
	1, 2, k	Critical moments
	f	Final moment (finish)
C	s	Project implementation mark
	r	Mark of the result of using the project product
D	Reserve zone	

In section 1.2, it was shown that S-shaped curves are widely used as a convenient graphical way of representing information in project management. In accordance with the methodological provisions, the PMBOKS curve is defined as “a graph of the dependence on time of the total costs, labor costs, percentage of work completed or other quantitative indicators” [171]. Based on this, one can conclude that the use of S-curves should not be limited to their application only to formalization (visualization) of financial and resource indicators, but can be applied to any quantitative indicators and at any phases and stages of project, program and portfolio management.

At its core, the S-curve is a curve that reflects the accumulated values of a specific project parameter and presented in the form of its dependence on time that is in the form of a flow. We consider flow as continuously performed processes that are measured in units of a parameter over a certain period. Therefore, the S-curve can be considered as a curve that describes a specific flow.

To describe the flow of costs, it is sufficient to use the parameters of the characteristic points of stream (time – cost), where changes in the rate of rise of costs occurs. At least four characteristic points are needed to construct the S-curve. Based on this, one can conclude that the S-curve constructed base on four points contains at least information on eight particular project indicators and can be considered as a "graphical flow indicator" (fig. 2.6).

Portfolio configuration involves analysis and comparison of flow characteristics of project-candidates. To implement these procedures, we use the methods of qualitative mathematics [172-175]. It provides work with graphic models. Main advantage of using such methods is the ability to obtain a holistic vision of the process, trends, patterns, etc. through the use of graphic images and models. Qualitative research involves studying the behavior of various types of curves and other geometric images. It allows you quickly and fairly accurately to propose a solution to the tasks without the use of bulky, and sometimes complex, analytical calculations. Also, in situations where solution of problem cannot be found explicitly, it is possible to determine some of its properties using qualitative methods [176-180].

An example of the application of approaches used in quality mathematics in the refinement of the graphical representation and description of S-shaped curves based on the mastered volume method are works of [181,182].

In our research, S-curves that reflect flow of project costs and the results of using project products are basic graphical indicators of the corresponding flows [183].

Consider the presentation of cost stream of the project-candidate. To obtain a description of S-curve of costs in the local time coordinate system of the project (fig. 2.6), we introduce the following notation using the developed index system (fig. 1, table 1):

i – number of project, $i = 1,2,...,M$, where M – the number of projects considered in the portfolio { *input value* };

${}^s\tau_0^i$ – initial moment (start) of financing of i-project, ${}^s\tau_0^i = 0$ { *input value* };

${}^s\tau_f^i$ – final moment (finish) of financing of i-project { *input value* };

${}^sT^i$ – funding duration of i-project, ${}^sT^i = {}^s\tau_f^i - {}^s\tau_0^i$;

${}^s\tau^i$ – current moment (time) of financing of i-project, ${}^s\tau^i \in \left[{}^s\tau_0^i; {}^s\tau_f^i\right]$;

${}^s\tau_1^i$, ${}^s\tau_2^i$ – critical moments of financing of i-project, that coincide with a change in the pace of financing, ${}^s\tau_1^i < {}^s\tau_2^i$, ${}^s\tau_1^i \in \left[{}^s\tau_0^i; {}^s\tau_f^i\right]$, ${}^s\tau_2^i \in \left[{}^s\tau_0^i; {}^s\tau_f^i\right]$ { *input value*};

${}^sT_1^i$, ${}^sT_2^i$ – funding duration of i-project to the first and second critical moment, respectively, ${}^sT_1^i = {}^s\tau_1^i - {}^s\tau_0^i$, ${}^sT_2^i = {}^s\tau_2^i - {}^s\tau_0^i$;

σ_0^i – initial costs for i-project, costs at the moment ${}^s\tau_0^i$ { *input value* };

S^i – total financing costs of i-project (in monetary units) incurred for all time ${}^sT^i$ to the moment ${}^s\tau_f^i$ { *input value* };

σ_1^i, σ_2^i – financing costs of i-project at critical moments ${}^s\tau_1^i$, ${}^s\tau_2^i$ respectively *{input value}.*

By the term “input value” we mean parameters that act as source information about the project-candidate.

Designations introduced S-curve, that reflects cost of financing i-project at the moment ${}^s\tau^i$ and consists of three linear sections (fig. 2), represented as a piecewise linear function $\sigma^i({}^s\tau^i)$ as follows:

$$\sigma^i({}^s t^i)=\begin{cases}\dfrac{\sigma_1^i-\sigma_0^i}{{}^s\tau_1^i-{}^s\tau_0^i}({}^s\tau^i-{}^s\tau_0^i)+\sigma_0^i, & {}^s\tau_0^i<{}^s\tau^i<{}^s\tau_1^i\\ \dfrac{\sigma_2^i-\sigma_1^i}{{}^s\tau_2^i-{}^s\tau_1^i}({}^s\tau^i-{}^s\tau_1^i)+\sigma_1^i, & {}^s\tau_1^i<{}^s\tau^i<{}^s\tau_2^i\\ \dfrac{S^i-\sigma_2^i}{{}^s\tau_f^i-{}^s\tau_2^i}({}^s\tau^i-{}^s\tau_2^i)+\sigma_2^i, & {}^s\tau_2^i<{}^s\tau^i<{}^s\tau_f^i\end{cases}, \tag{2.1}$$

where, ${}^s\tau_1^i$, ${}^s\tau_2^i$ – intermediate characteristic points where change in the rate of rise of costs occurs.

Similarly, to the description of flow costs, one can also provide a description of stream of expected project results. Wherein should be considered that not all project results, depending on their nature, can be presented in monetary terms. By the result of the project, we understand both - effects of using the project product and created values for consumers and stakeholders that can be expressed in any unit of measure, for example, marks. This approach does not contradict our definition of stream.

Let’s consider the task of constructing an S-curve for the result of project i product. (fig. 2.7). By analogy with the project costs, we introduce the following designations of parameters for the project result:

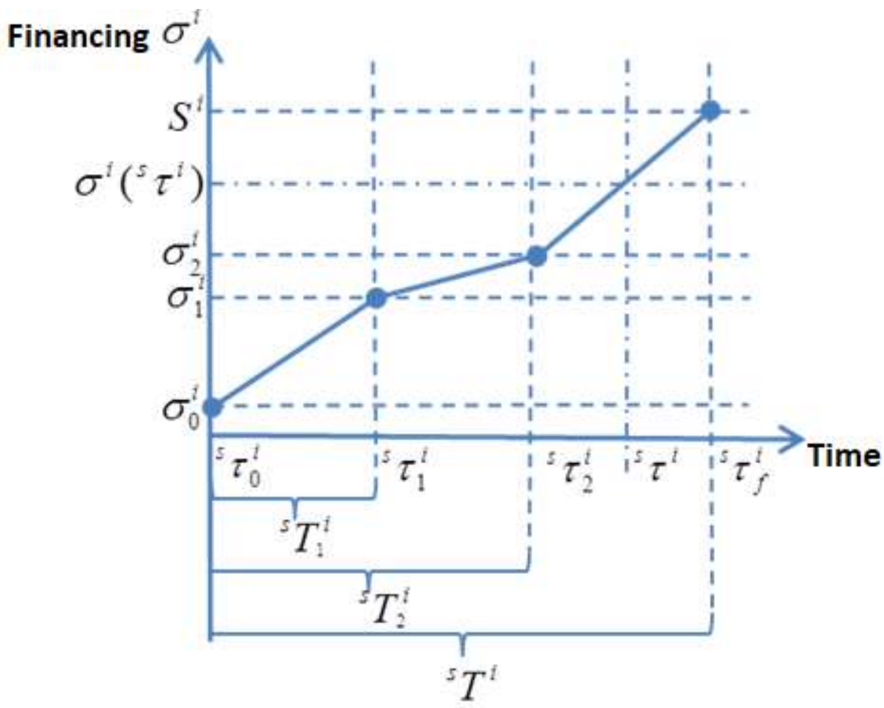


Figure 2.6 - S-curve of project costs (financing)

Source: developed the author.

δ^i – time after which comes the initial moment of obtaining the effect of the product of i - project;

${}^r\tau_0^i$ – initial moment (start) of obtaining the effect of the project i product, ${}^r\tau_0^i = {}^s t_0^i + \delta^i$ {*input value*};

${}^r\tau_f^i$ – final moment (finish) of obtaining the effect of the project i product {*input value*};

${}^rT^i$ – duration of the effect of project i product in days, ${}^rT^i = {}^r\tau_f^i - {}^r\tau_0^i$;

${}^r\tau^i$ – current moment (time) of receiving the effect of the project i product (unit of measure - day), ${}^r\tau^i \in \left[{}^r\tau_0^i; {}^r\tau_f^i\right]$;

${}^r\tau_1^i$, ${}^r\tau_2^i$ – critical moments (change in pace) of effect of the project i product, ${}^r\tau_1^i < {}^r\tau_2^i$, ${}^r\tau_1^i \in \left[{}^r\tau_0^i; {}^r\tau_f^i\right]$, ${}^r\tau_2^i \in \left[{}^r\tau_0^i; {}^r\tau_f^i\right]$ {*input value*};

${}^rT_1^i$, ${}^rT_2^i$ – the duration of the effect of the project i product to the first and second critical moment, respectively, ${}^rT_1^i = {}^r\tau_1^i - {}^r\tau_0^i$, ${}^rT_2^i = {}^r\tau_2^i - {}^r\tau_0^i$;

r_0^i – initial effect of the project i product (in monetary or other units), effect at the time ${}^r\tau_0^i$ { *input value* };

R^i – final effect of the project i product received all the time ${}^rT^i$ to the moment ${}^r\tau_f^i$ { *input value* };

r_1^i, r_2^i – project i product effect at critical moment ${}^r\tau_1^i$, ${}^r\tau_2^i$ respectively { *input value* }.

Based on the notation, S-curve consists of three linear sections (fig. 3), that reflects effect of the project i product at the moment ${}^r\tau^i$, denote by a piecewise linear function $r^i({}^r\tau^i)$ and imagine in the following form:

$$r^i({}^r\tau^i) = \begin{cases} \dfrac{r_1^i - r_0^i}{{}^r\tau_1^i - {}^r\tau_0^i}({}^r\tau^i - {}^r\tau_0^i) + r_0^i, & {}^r\tau_0^i < {}^r\tau^i < {}^r\tau_1^i \\ \dfrac{r_2^i - r_1^i}{{}^r\tau_2^i - {}^r\tau_1^i}({}^r\tau^i - {}^r\tau_1^i) + r_1^i, & {}^r\tau_1^i < {}^r\tau^i < {}^r\tau_2^i \quad r^i, \\ \dfrac{R^i - r_2^i}{{}^r\tau_f^i - {}^r\tau_2^i}({}^r\tau^i - {}^r\tau_2^i) + r_2^i, & {}^r\tau_2^i < {}^r\tau^i < {}^r\tau_f^i \end{cases} \tag{2.2}$$

where ${}^{r}\tau_1^i$, ${}^{r}\tau_2^i$ – intermediate characteristic points where change in effect occurs rise rate.

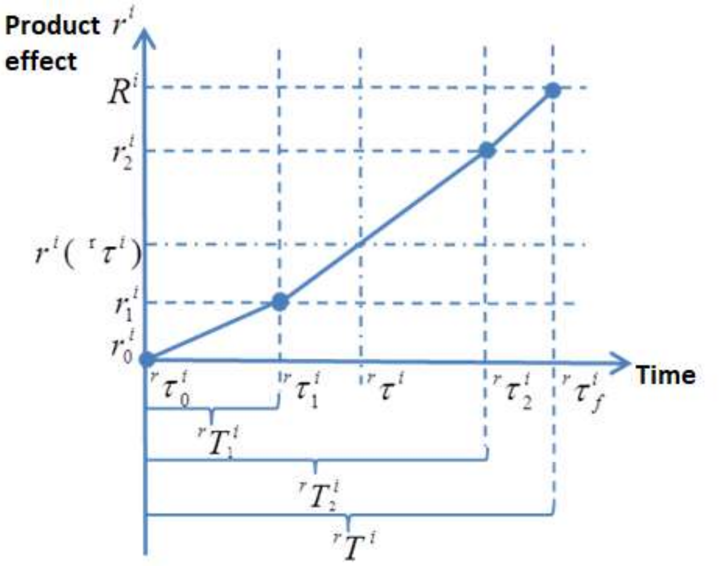


Figure 2.7 - S-curve of the result (effect value) from i project product

Source: developed by author.

Table 2.2 summarizes all designations of indicators that are used to describe an individual i project

Table 2.2 - Indicator designations of i project

Temporary characteristics of project				Project costs (financing): time	Project costs (financing): value	Result (value) from the project product: time	Result (value) from the project product: value
Moments of time	Input	initial		${}^{s}\tau_0^i$	σ_0^i	${}^{r}\tau_0^i$	r_0^i
		critical moments	1	${}^{s}\tau_1^i$	σ_1^i	${}^{r}\tau_1^i$	r_1^i
			2	${}^{s}\tau_2^i$	σ_2^i	${}^{r}\tau_2^i$	r_2^i
		final		${}^{s}\tau_f^i$	S^i	${}^{r}\tau_f^i$	R^i
	current			${}^{s}\tau^i$	$\sigma^i({}^{s}\tau^i)$	${}^{r}\tau^i$	$r^i({}^{r}\tau^i)$
Duration	to the critical moment		1	${}^{s}T_1^i$	–	${}^{r}T_1^i$	–
			2	${}^{s}T_2^i$	–	${}^{r}T_2^i$	–
	whole project			${}^{s}T^i$	–	${}^{r}T^i$	–

Thus, S-curves using as graphical indicator of the flow allows us to formalize the knowledge in panels that give an idea of the nature of the change in stream of costs and results for each project applicant. It should be noted that the costs of all projects are presented in monetary units, and the results from the use of project products in different units. This fact, from the perspective of configuring project portfolio, causes difficulty. Therefore, an additional task of transforming project results into a single measurement system arises. Its solution requires finding universal method of transformation.

2.3. Panels to present project-candidates feasibility and result attainability

As shown in Section 2.1, maximum possible difference in knowledge reflected on orthogonally located configurator panels can be considered holistically due to the presence of "configurator holding points". Finding such points simultaneously for all panels at the same time is quite a challenge. Therefore, it is logical to solve it step by step. Let us consider initially pairwise orthogonal panels that have a common unifying feature. In fig. 2.8 two pairs of such panels are presented.

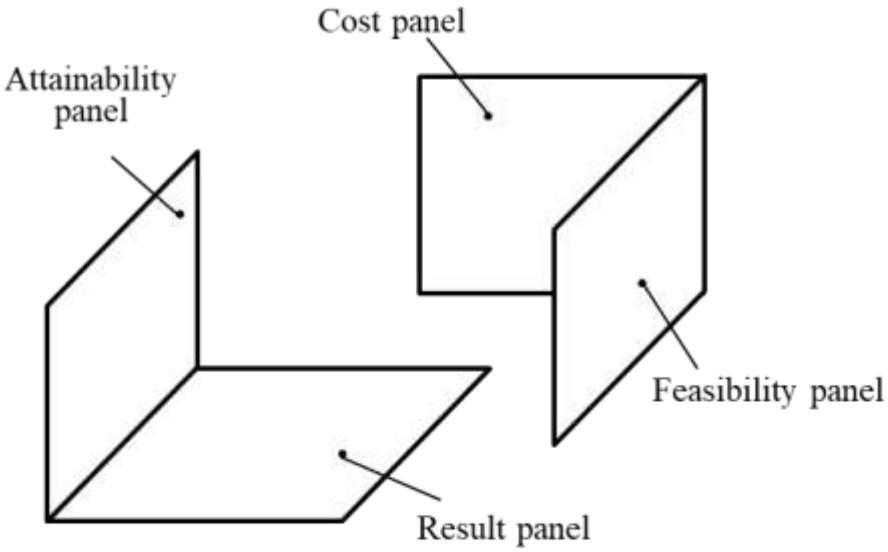


Figure 2.8 - Pairwise representation of configurator orthogonal planes

Source: developed by author.

Unifying feature between two pairs is the project product. And unifying feature within the first pair between cost and feasibility panels is internal environment of activities for obtaining project product. And for the result and reachability panels, such a sign is the external operating environment of the resulting project product.

Identified defining signs make it possible to define concepts of "feasibility" and "attainability" in the context of project activities:

- feasibility, this is a characteristic of project, that reflects extent of sufficiency of the innovative, competency and technical and technological potential of the internal environment of project to obtain planned product within the planned resource-time schedule;

- attainability of the result, this is a characteristic of project, that reflects extent of realism: relevance of project product; prediction growth of result (effect) in the process of its usage; the perception of the product by potential consumers and the consistency of opinions between different groups of consumers regarding value demand for project product.

An analysis of above definitions shows that these characteristics contain components that depend on time. For feasibility, it is innovative, competence and technological potential of the internal environment of project during the planned resource-time schedule of costs. And for the achievement of the result - maintaining the relevance of project product throughout the entire period of its operation; increase in the result (effect) in the process of its use; perception of the product by potential consumers and availability of co-ordination of opinions between different groups of consumers regarding the value demand of project product throughout entire period of its use. Therefore, the feasibility and attainability of the result, as well as the costs and the result, are also stream characteristics. In addition, they are also multicomponent.

Introduced concepts of “feasibility” and “attainability” correlate with categories “assessment of project feasibility” and “analysis of attainability of result” that are widely used in the field of project analysis and project financing.[176 - 178] So, for example, in [179], the feasibility of the project and the attainability of its results are assessed in eight aspects, and in [180] using 11 criteria, for each of that an indicator characterizing the extent of sufficiency is formed. Extent of attainability is determined by calculation as the ratio of the amount of available resources (finance, time, information, etc.) to the necessary. Main difference of our approach is that “feasibility” and “attainability” are considered as flow characteristics.

Next step is finding the holding points of the configurator panels, shown in pairs in fig. 2.8. Common to these pairs is a way of presenting information about costs and results from using the project product in the form of S-curves. And information about the characteristics of the feasibility and attainability of project result is multicomponent and involves a search for its presentation in minimized form. Similar coagulation requires S-curves. In project management, discount procedure is used to represent the cash flow of a project in a single number. However, this procedure can also be used to discount any flow parameter (indicator). In a generalized form, the discount formula has next form:

$$DCF = \sum_{p=0}^{n} \frac{CF_p}{(1+v)^p} \qquad (2.3)$$

where, CF_p – stream parameter value in *p* period of time,

v – discount rate,

n - number of time periods during what parameter flow *CF* appears.

Comparative analysis of discount formula and information presented on the panels of configurator, that are shown in fig. 2.8 allows to draw the following conclusion. In essence, S-curves contain information about the flow of costs and results from the use of the project product, which is reflected in formula (1) by the parameter *CF*. A multicomponent information in a convoluted form on the feasibility and attainability of the project result is reflected in formula (1) with the discount rate *r*. Therefore, the discount formula in our case is the retention point of the configurator. Due to its usage, it is possible to obtain new synthesized knowledge about the project in the form of a single DCF number.

For deeper disclosure of the characteristics of feasibility and attainability of the result, we consider in more detail such a parameter as the “discount rate”. To understand the essence of this parameter, it is necessary to refer to the origins of its appearance. In the economic and financial communities of professionals, it is believed that I. Fisher was one of the first scientists who used the discount procedure in economic calculations and revealed its essence [128]. He considered discounting as a basic principle to assess the value of capital goods. [181]. We emphasize value assessments. It is very important. I. Fisher focused on objective indicators of income, but on subjective income, that is associated with the ability of the good to bring pleasure, that is, value to its recipient. And the benefits are measured in grams of food, in units of clothes, in square meters of housing. Since it is unreasonable to add the listed benefits, I. Fisher faced with a problem that exists for configuring project portfolio with essentially different results. Discount rate appeared when considering the difference between the benefits that a person can use instantly and the benefits of long-term use.

Nowadays discount rate associated with the benefits is called the social discount rate [182]. It is considered from the standpoint of benefits and costs to get benefits. [183,184]. Used panels of costs and results are similar in meaning to the costs and benefits associated with boons. It should be noted that costs and benefits are calculated values that are obtained under incomplete and inaccurate information at the stage of modeling process of obtaining and operating benefits of long-term use. When configuring a project portfolio, another task is solved. And meaning of discount rate in our case differs from its classical interpretation. Therefore, to reflect this difference, we propose to introduce term “project feasibility rate” instead of the term “discount rate” ${}^{\sigma}d^{i}$ and “result attainability rate” ${}^{r}d^{i}$.

These norms are determined by certain factors (components), that are reflected above in the definitions of feasibility and attainability of result. Based on definitions, rate of feasibility should be determined by indicators of estimated state of internal environment of project, and result attainability rate - by the state of external environment of consumption of project product. The less norm, the more potential opportunities for successful implementation of the project and extent of realism to achieve the result from operation project product. If we take discount rate as an analogue as the rate of return of investments, then proposed norms are associatively similar to investment risks. Accordingly, by analogy, it is possible to use approaches to determining values that we have introduced norms, as well as for values of the discount rate.

As one knows, discount rate is variable, depending on number of factors $i = f(i_1, \dots i_n)$. In practice, several methods are used to determine discount rate, each of that has its own advantages, disadvantages and is used to solve economic problems that are essentially different [184,185].

Analysis of the most common models and methods for calculating discount rates showed that, fundamentally, from the point of view of mathematical notation, they can be divided into four types:

- additive models (accumulation of the discount rate by the cumulative method, i.e. by summing the components of the formula);
- multiplicative models (product of constituent components);
- multiple (ratio of constituent components);
- mixed (as combinations of the previously mentioned models) including functional dependence of the components

The simplest for perception and understanding are additive type models. Method that uses operation of summing numerical values of estimates of components is the most purposeful at the initial stage of configuration method development in calculating the values of norms.

To determine the possible values of norms, by analogy with discount rate, we will analyze results of their calculation based on additive models (CAPM, Gordon, WACC) and practical examples of their application [185-187]. Analysis showed that discount rates in the range of 0.25-0.5 are more common. In this case, main share of rate is risk premium. Maximum value in various models can reach 0.2-0.47. Theoretically, the discount rate can take values from 0 to 1.

Further, we use certain ranges of changes in discount rate as indicative during computer experiments.

If we continue to draw an analogy between the discount rate and the norms, it should be borne in mind that for long-term projects (and especially programs and portfolios), when calculating their financial attractiveness, the concept of a variable (dynamic, variable, floating) discount rate is often used [188]. By essence, it reflects conditions of implementation changing over time (by periods) (change in values of its constituent components) that affect the assessment of flow characteristics (cash flows, capital structure, etc.). As stated in [190] it is enough to know (predict) the dynamics of the rate change and the duration of its relative stability over the periods of the project, to take this fact into account in the calculations. At the same time, work [191] focuses on fact that “an important issue when discounting cash flows is the calculation of the discount factor, that has additional difficulties at floating rate. Discount factor is a coefficient showing how much the flows to a given date will decrease, taking into account the time factor and project risks. Moreover, for each separate period, this coefficient is calculated independently of previous or subsequent periods. And the final coefficient should be calculated by the accumulated total, i.e. take into account the values of discount factors of previous periods [192, p 72-73]. These features make it possible to assert that the norms of feasibility and reachability, by analogy with the discount rate, can change over time. This fact confirms the correctness of our consideration of the norms of feasibility and attainability as flow characteristics. At the same time, a weak theoretical study of this issue does not allow the use of any ready-made tools for describing changes in norms in dynamics. Therefore, at this stage of our research, we assume that they are constant in time and can be represented by a single number.

Research did not set the task of developing a method for calculating norms. Therefore, we dwell on the most important point in our opinion that is essential to consider in the further development of method to calculate standards for projects in Nigeria. This concerns the consistency of opinions between different groups of consumers regarding the value relevance of the project product. Determining the numerical values of the project result attainability norm should certainly base on consistency of assessments of importance extent of the project product for the main groups of stakeholders. In [193], an approach is proposed that allows one to take this assumption into account. Results of testing the mentioned approach, using the example of projects to introduce high-tech equipment to improve safety and protection of oil pipelines in Nigeria, have shown that evaluating the effectiveness of projects and the value of results obtained with help of involved groups of experts are not always adequate. This statement, supported by many researchers, is based on the fact that experts always give contextual rather than holistic assessments and conclusions. Reason for this is that in many cases experts do not participate in current situation but play the role of outside observers. Therefore, for natural reasons, they see the situation from certain subjective positions, that is, contextually. In order to get a holistic assessment of the situation, it is recommended to involve participants from among the real stakeholders participating in its discussion and potential consumers as experts. On the example of projects examined in [193], such participants were government officials (reflecting the interests of the majority of the country's population), students (who assess the situation from the point of view of the future) and businessmen (part of the population most sensitive to project implementation). In order to select from indicated three groups representatives of which gave agreed opinions on the value of the project product, special questions were drawn up on various aspects of value. Moreover, the questions were initially formulated in such a way that they initially provided for a correlation between the statements proposed in them. Number of such questions should be equal to three. This approach corresponds to the methodology of the triad of reflection of reality through the triad of components of “rational - emotional - intuitional”. We emphasize that the above stakeholder groups are also consistent with this triad. Group of civil servants corresponds to the “correlation” component, the group of students corresponds to the “emotions” component, the group of businessmen corresponds to the “intuitive” component.

Following fuzzy scale was used to evaluate each of the statements: completely agree; more agree than disagree; 50/50; disagree more than agree; totally disagree. Number of respondents in each of three groups was almost the same.

An analysis of the responses received (table 2.3) shows that on the first question, “Using the latest technologies in monitoring oil pipelines increases their safety” (refers to the “correlation” category), 100% of respondents in all three groups rated “completely agree”. Estimates of remaining statements were not so uniform. As you can see, second statement was rated 100% by a group of businessmen and civil servants as “50/50”. Only 43% of students joined this assessment, while the remaining 57% rated it as “totally agreeable”. Even less consensus is found in evaluations of the third statement (called the “intuitive” component of integrity). 100% of businessmen rated this as “completely agree”, 88% of students and 50% of civil servants agreed with this. The remaining 12% of students rated it as “more agree than disagree”, and 50% of businessmen rated it as “50/50”. At the same time, none of the three groups of respondents used the rating “disagree more than agree” or “completely disagree”. This indirectly indicates correctness of statements.

Table 2.3 - Estimates received from groups of respondents

Fuzzy scale	Businessmen			Civil servants			Students		
	Ratio	Emotio	Intuitio	Ratio	Emotio	Intuitio	Ratio	Emotio	*Intuitio*
completely agree	100	0	100	100	0	50	100	57	88
more agree	0	0	0	0	0	0	0	0	12
50/50	0	100	0	0	100	50	0	43	0
more disagree	0	0	0	0	0	0	0	0	0
completely disagree	0	0	0	0	0	0	0	0	0

To determine whether there is a relationship between the estimates for each of three statements for each of group of respondents, we used the independence criterion $\chi 2$. This criterion is most often used in testing hypotheses in the social sciences. It belongs to the category of nonparametric, that is, “free from distribution”, since it does not require any assumptions about the form of distribution of sample statistics. The criterion provides the formulation of the null hypothesis H_0. If null hypothesis is true (that is, not rejected), then variables in statement are independent. If the null hypothesis is rejected, then the hypothesis H_1 is valid. Hypothesis H_1 means that the variables are considered dependent. In our case, we consider groups of respondents and their statements as variables. Calculations (table 2.4) showed that responses of respondents from groups of government representatives and students were independent (hypothesis H_0 not rejected), despite the fact that we formulated the statements in such a way that their estimates should be dependent. This indicates the inconsistency of opinions in this expert group. On the contrary, in group of business representatives, for most of its privateers, opinions were agreed, and their assessments - answers to questions, can be taken into account as expert opinions. Proposed approach can be used to coordinate opinions of experts on assessing the components of the feasibility of projects and attainability of their results, which contribute to the more adequate assessment of numerical relevant norms values.

Table 2.4 - An analysis of the relationship between respondent ratings using χ2, with degrees of freedom n=8 and significance level α = 0,05

Respondents groups	$\chi2_{exp}$	$\chi2_{theor}$	Conclusion: H_0
Businessmen	40	15,507 for the number of degrees of freedom equal 8	rejected
Civil servants	12.73		not rejected
Students	11,63		not rejected

Thus, clarification of the essence of the proposed standards for project feasibility ${}^{\sigma}d^{i}$ and result attainability ${}^{r}d^{i}$ in addition, a description of possible approaches, assumptions, and recommendations related to the determination of their numerical values allows us to record new synthesized knowledge at the retention points of the configurator in the form of the following functions

$${}^{\sigma}V^{i} = F(\sum_{p=0}^{n} \frac{CF(\sigma)_p}{(1+ {}^{\sigma}d^{i})^{p}}), \quad (2.4)$$

$${}^{r}V^{i} = F(\sum_{g=0}^{n} \frac{CF(r)_g}{(1+ {}^{r}d^{i})^{g}}), \quad (2.5)$$

where ${}^{\sigma}V^{i}$ – feasibility indicator of the *i* project, depending on the project implementation processes, the potential of the components of the internal environment of the project;

${}^{r}V^{i}$ – indicator of attainability of the result of the *i*-project, depending on the demand for the project product and the conditions for its operation;

$CF(\sigma)_p$ – value of the flow parameter that describes the costs of the project in the *p* period of its creation;

$CF(r)_g$ – value of stream parameter that describes result of project in the *g*-period of its operation.

Specific types of functions cannot be precisely defined now. For this, it is necessary to conduct additional research to identify the nature of stream parameters

$CF(\sigma)_p$и $CF(r)_g$. In addition, it is necessary to determine the method of bringing the parameters of the result of various essences of various candidate projects $CF(r)_g$ to a single basis. However, insertion of feasibility indicators ${}^{\sigma}V^i$ and attainability ${}^{r}V^i$ should be considered as the first step in the formation of the essence of the integral indicator of the applicant project, which will be used to build the criteria for configuring the portfolio of projects. Fig. 2.9 defines their place in zone of the future integral indicator as points of pairwise retention of the panels of configurator costs and feasibility, result and attainability.

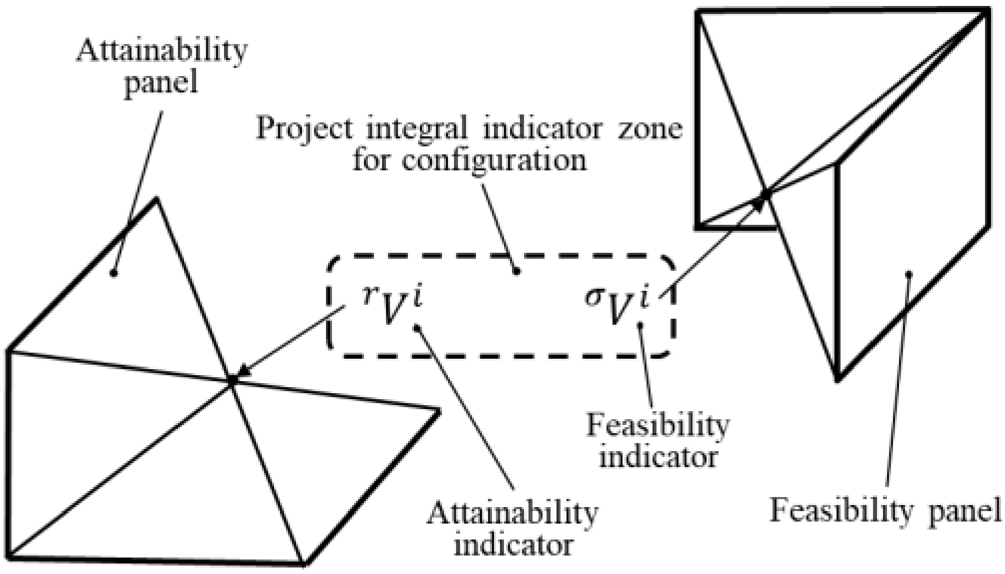


Figure 2.9. Presentation of feasibility and reachability indicators in project for configuration integral indicator zone

Source: developed by author.

2.4.Roadmap template for gathering information panels of project-candidate configurator

As we indicated in section 2.1, configurator is a set of diverse knowledge that justifies and explains features of the project as an object of activity. And this diversity of knowledge is recorded in the form of information on the corresponding panels using methods of high-quality mathematics. Each panel has its own specific reporting. Therefore, within the framework of research component of system model for the formation project portfolio (fig. 1.4), includes step of developing forms of information about applicants, projects, that must comply with meaningful selected component in the conceptual approaches and methods, and also used in the portfolio configuration (section 1.3).

As a tool for gathering information about the project-candidate in the context of the project configurator panels we propose to use roadmap method. Concept of "map" (road, information, interactive, plan map, etc.) is widely used in practice and in project portfolio management theory [194-199]. Main feature of this document is its small size, wherein through imaging elements (graphs, diagrams, tables), the most important information is recorded in a compressed form.

Typically, project maps are developed by management team for stakeholders, sponsors in order to reduce their time when reading voluminous documentation, sharing the general vision of the project, formalizing goals, expected results, characteristics of main participants, key stages of implementation, identifying alleged threats, risks [200-202]. Maps are also used in managerial process as simplified graphical models that allow team to focus on the main results, ensure establishment and evaluation of dependencies during the project [203-205]. Documents of similar format can be developed not only for project, but also for its product. In this case, focus is shifted not to the specifics of project implementation, but to the specifics of creating project product, its operation, relevance, determining the value of achieved effect [206-208].

Given the specifics of maps using, in our case, as a tool to collect information at the stage of forming project portfolio, templates for project-candidate maps should be developed directly by portfolio management council - the body that makes the decision to declare a tender to form a new portfolio, that selects projects for further participation in process of forming portfolio. Template information content should be carried out by representatives of the project-candidate management teams. This approach ensures correct reflection in the map template of initial conditions of the competition, requirements that are due to the peculiarities of projects in the conditions of formed portfolio. In addition, this template allows to implement the collection of information in a single format and will ensure its comparability for various projects. This will facilitate and make more objective selection process and evaluation of projects we introduced the parameters of their feasibility and achievable results. These features of construction and use of project-candidate maps allow us to argue that the concept of “Project Map”, based on its purpose, structure and format for presenting information, differs from the concept of “Component proposal” widely used to introduce or change portfolio components [209].

Based on analysis of structures and contents of project maps [194, 196, 210], a template for project-candidate map to the portfolio is proposed consisting of three blocks: project-candidate identification, description of its feasibility and description of results attainability (Appendix D). As the name of the first block implies, it is intended to accompany any information about the project at all stages of the process of forming a project portfolio. Names of second and third blocks completely coincide with the name of indicators that we introduced while finding the holding points of the configurator (section 2.3). Let us reveal the content of these blocks in more detail.

Project-candidate identification block contains project name; organization name responsible for the implementation of the applicant project, contacts of the representative; project purpose and an indication of its relationship with strategic objectives of portfolio. It should be noted that goal of project should be presented in the form of a productive and effective description and in accordance with project multi-aspect rule (section 1.2). It should reflect the impact of project on several different aspects of the subjects of LSEE activity. Block for describing the feasibility of the project-candidate contains tabular data for 4-6 key points and a graph in the form of a cumulative S-curve, reflecting the requested amount of funding for the project candidate, in coordinates: time-cost. Time is set in months, that is a consequence of the limited-stage financing rule (section 1.2). This block also contains questions that relate to the performer’s vision of the state of the internal environment of project on three components: innovative, competency and technical and technological (in accordance with the semantic content of project feasibility indicator). By its logic, first component is innovative, that answers the questions: what kind of innovation will be created as a result of project, what is the degree to which this innovation has been developed, what level of novelty, what competitive advantages will be obtained compared to peers. Second component - competency, answers the question: who will implement the project. To do this, data on the level of education and work experience of the leader and members of the project team are indicated in the map of the applicant project. Third component - technical and technological, gives an answer to the question: with what help (what technologies) and in what conditions the project will be implemented. Accordingly, it contains information about the key technologies used to create the project product, the novelty of the technologies used for contractors, the number of organizations of contractors involved in the project, the availability of necessary permits, as well as internal factors of the project that contribute to or impede its successful implementation. Several types of questions are used to collect information. (Appendix D). Type one: the question contains from 3 to 5 proposed answers (closed-ended question) from which only one should be selected. Assessment of answer depends on the proximity of the chosen option to the ideal one, reflecting the preference of portfolio management advice. Type two: question does not contain any answer options (open-ended question), it is necessary to give only one answer in quantitative terms. Assessment of answer is determined on the basis of comparison with a certain norm determined by the portfolio management advice. Third type: question with several open-ended answers, for what it is necessary to indicate their significance. Response is evaluated based on a comparison of the proximity of the vision of the significance of the answer option by the project executors and the portfolio management advice. Fourth type: open-ended question with an unregulated form of answer. Assessment of answer is determined on basis of comparative analysis of information received from other project-candidates. Based on such estimates, the value of the project unrealizability norm is calculated: ${}^{\sigma}d^{i}$.

Block of describing the project-candidate result attainability contains data on the moment of appearance of the result in relation to the project start and a description of the expected effect of usage of project product. Description of project result should be carried out by the integral indicator of effect characterizing the result from the position of several parameters of different nature related to various aspects of the life of the subjects of LSEE. Effect (result) from using project product is presented in the form of an accumulation curve reflecting the dynamics of accumulation and the maximum value of effect in time-effect coordinates (the effect is described in units of its essence) and in a tabular form indicating 4-6 key points used to build S-curve. This block also contains questions that reflect project executor's vision state of environment of consumption of the project product in three components, based on the semantic content of the indicator of attainability of the result (section 2.3). So, to assess the relevance of the project product, it is necessary to identify the problem solved by the project, its severity, justify the degree of need for the project at the moment, indicate the specific user of the project product, the main recipients of benefits from the project results. Forecast of the increase in the result (effect) is estimated based on the argumentation of how and due to which the dynamics of the change in the indicator shown on the S-curve is provided, as well as the justification of the values of the key points in which the change in the nature of the cumulative curve increases. Determination of the main social groups (their number, location), which are consumers of the project product, allows further research on the level of perception of the product by potential consumers and the consistency of opinions between different consumer groups regarding the value of the project product, according to a technique specially developed by us [193]. Value perception of a project product is based on the concept of value. Value refers to all measurable benefits, utility - as the sum of all tangible and intangible elements [209]. Definition of value derived from the functions of products and services should be conducted from the perspective of all stakeholders [209, ch. 2.1]. Thus, values are determined by assessing the benefits and usefulness of the project results, which can have a different form of manifestation (tangible, intangible), in the form of effect (s) from the use of the project product functions. Based on the foregoing, the determination of the values of the norm of unattainability of the result from the use of the project product ${}^{r}d^{i}$ based on information obtained from answers to questions from project implementers, experts, users of the project product and other interested parties.

It should be noted that in our proposed example of a candidate project's map template, the number of questions to determine the values of various parameters and characteristics of the project feasibility indicator and result attainability ranged from 8 to 14. As practice shows, when assessing the feasibility of projects and the feasibility of their results attainability, the number of such questions may be 2-3 times greater, which is determined by the need to obtain more complete and accurate information. An example is the structure of the information map of the project of the applicant used to select projects under federal (state) targeted programs [210], that contains in the section "Characteristics of the expected project result" and in the section "Justification of the project feasibility, the degree of security and study" on 21 issues.

CHAPTER 3

MODELS AND METHODS TO PREPARE PROJECT-CANDIDATES FOR PORTFOLIO CONFIGURING PROCESS

3.1. Model for project-candidates categorization and prioritization

According to the model of project configurator (fig. 2.1), fifth panel that we have not previously considered is “Panel of strategic importance”. In terms of meaning, knowledge reflected on this panel is generated by project portfolio management council at the first stage of “Configuration” of system model component for forming project portfolio (fig. 1.4). This stage is intended for grouping and ranking project- candidates, that correlates with provisions set forth in the standards for project portfolio management [211-212]. In terms of the mentioned standards, this stage provides for categorization of potential portfolio components after the identification process.

An analysis of the conceptual apparatus related to the processes of categorization and identification shows the presence of contextually different definitions and using of similar terms in meaning to refer to the same process. Therefore, to find acceptable and inconsistent interpretations of these terms, there is a need to delve into the conceptual apparatus and determine basic terms and their definitions that we will use in the future.

Further, in the text, terms “project” and “component” we use as synonyms. Therefore, phrases “project-candidate” and “potential portfolio component” are also synonyms.

By portfolio component, we mean its individual element that is a program, project or another activity [211]. By categorization, we mean grouping of components into homogeneous groups that have common strategic goals and criteria for evaluation. Components can have various sources, causes, and places of initiation of origin. Strategic goals and strategic plans are basis of categorization. Implementation of categorization process components allows portfolio management board to balance investments and risks between all categories and, accordingly, strategic goals.

Key descriptors as well as categorization criteria should be defined for categorization. By descriptors we mean a set of characteristics used in categorizing and documenting a portfolio component for further decision making [212]. Many project managements studies [213-215] focus on the fact that categorization of projects can allow their simultaneous correlation to several categories. This fact we use as a hallmark for definition of "categorization" in comparison with the definition of "classification". For term "classification", condition for the mutual exclusion of classes is one of its main distinguishing features.

In [215] it was proposed to use three models during the categorization process: hierarchical (single-criterion, with a strict separation of projects into separate categories), parallel and combined (multicriteria, allowing the distribution of projects into several categories). However, in the context of project portfolio forming, in the standards [216, p.28, 217, p.56] there is a clear indication that each of the projects-candidates we assigned to only one of the proposed categories. From these positions, two classes of methods we use for categorization. First class includes methods that are based on comparing the indicator of the projects-candidates with a certain established norm (criterion), that is used as a grouping attribute. Second class - methods based on experts' opinions. Methods of second class we use when it is impossible to distinguish grouping characteristics. In this case, procedures and approaches to processing the information received use for expert survey.

Further research we carried out based on the assumption that all members of project portfolio management board are experts. They have sufficient experience to consciously and reasonably make decisions related to the implementation of the categorization process.

To increase effectiveness of council work at the stage of categorization, we propose to use the minimax ranking method [218]. This is the simplest and universal decision support tool. Its effectiveness in various fields of activity confirmed by the positive results set forth in [219-221]. Method allows one to take into account the opinion of experts regarding the degree of objectives conformity of the projects-candidates and their intended results, strategic objectives of portfolio, taking into account their priority for LSEE.

Essence of method is in the step-by-step determination of the least attractive factor (indicator, subject, etc.) from available set (with assignment of the lowest rank value), then the most attractive (with assignment of the lowest rank value) and so on with alternating steps to complete convergence - distribution of the original set in a number of factors ranked by priority.

Let’s consider the features of method application on a specific example of projects-candidates categorization. Firstly, experts need to familiarize themselves with the source documents that contain information about vision, mission, and strategic plan for the development of LSEE. Based on this information, strategic objectives of project portfolio are determined. They are basis for developing strategic portfolio plan and fixed in it. Portfolio focused on achieving one or more strategic goals. In order for the goals to be manageable and achievable, their maximum number should not exceed 7±2 (Miller's number) [222]. If there are more goals, we recommended to combine them into groups [212]. Portfolio strategic plan, in addition to the goals, should contain information on the expected benefits of portfolio, performance indicators, key risks, assumptions, limitations. In addition, it describes a model according to what approaches and tools for prioritization defined, that provides unified basis for making decisions regarding the structuring of portfolio components [212, p.3.3, 3.6]. Changes in strategy necessitate revision and adjustment of both goals and model of prioritization that affects portfolio structure. Goals of portfolio potential components indicating their relationship with portfolio strategic objectives are given in the map of the projects-candidates (section 2.4).

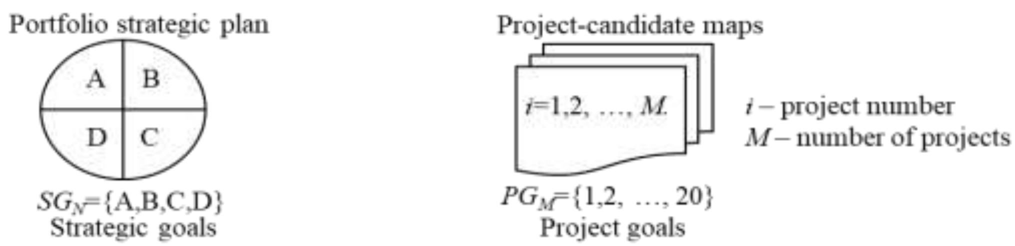


Figure 3.1. Source documents for the projects-candidates categorizing

Source: developed by author.

As an example, fig. 3.1 above considers situation in that four strategic goals (A, B, C, D) are identified within the portfolio, and twenty cards of projects-candidates are submitted for inclusion in the portfolio (M = 20).

To use minimax ranking method for specific example, one needs to determine the number of ranks and their significance. It is recommended to use number of ranks equal to number of strategic goals (RP_{SG}={1,2, …, *N*}, where N = 4 is the number of strategic goals of portfolio). We assume that RP_{SG}=1 has maximum priority, and RP_{SG}=4 minimum priority. Ranking process begins by identifying the least priority strategic goal within the portfolio. This is because in most cases, based on psychological characteristics of decision-making; it is easier for experts to identify the least important, less significant goal, in comparison with the process of determining the highest priority. Further, according to the ranking rules, the most important is determined from the remaining goals. Then again, the least important for the remaining variants of the considered goals, etc.

Described procedure presented in the form of systematic actions (fig. 3.2) for study case.

Goal prioritization procedure	Priority ranks (RP_{SG}); 1-*max*, 4-*min*			
	1	2	3	4
1st step. Least priority strategic goal ranking (*min A,B,C,D)*				A
2nd step. Strategic priority goal ranking (*max B,C,D)*	B			
3rd step. Least priority strategic goal ranking(*min C,D)*			C	
4th step. Strategic priority goal ranking (*max D)*		D		

Figure 3.2. Procedure for determining the priority of goals using the minimax ranking method

Source: developed by author.

Thus, the priority of goals can be represented as: B> D> C> A.

Categorization (grouping) of projects-candidates is based on the correlation of goals of projects-candidates and portfolio strategic goals (fig. 3.3). At the same time, it is necessary to proceed from condition that each of projects can support the achievement of only one of the portfolio designated strategic goals. In practice, situations may arise when goals stated in the maps of projects-candidates not related to the portfolio goals. This entails exclusion of such projects from categorization process and further consideration within this portfolio. In addition, one should consider that if within the framework of any portfolio strategic goal, according to the results of categorization, there are no supporting projects, and then it will be necessary to carry out their additional recruitment or to exclude this goal from the formed portfolio. If, in the direction of achieving one of the portfolio strategic goals, a large number of candidate projects are concentrated, it is advisable to carry out their additional grouping. As a grouping attribute, it is necessary to use the degree of priority of the project for the purpose in question. Grouping is also carried out using the minimax ranking method.

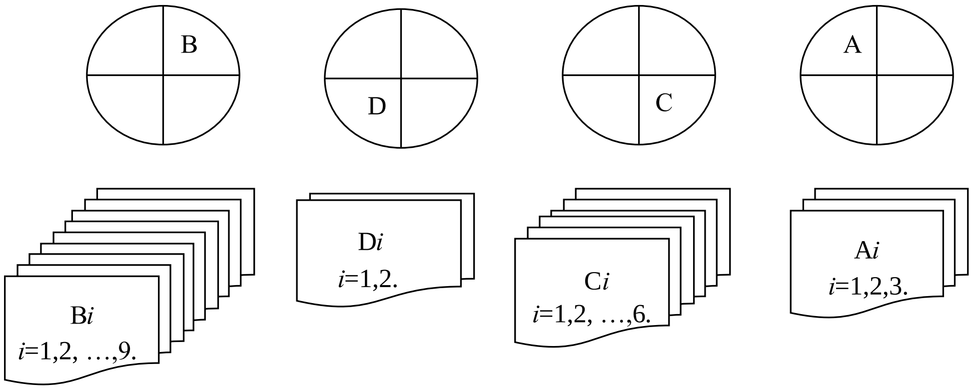


Figure 3.3. Categorization of projects according to the portfolio strategic objectives

Source: developed by author.

According to conditional example (fig. 3.3), we can state that nine out of twenty projects-candidates were assigned to the category of the highest priority strategic goal “B”, two - to goal “D”, six - to “C”, and three - to “A”. It is advisable to carry out an additional grouping of projects to take into account the degree of their priority within goals “B” and “C”, where their greatest concentration is observed. However, it should be noted that the sufficiency of the availability of projects within each of the strategic goals is determined not by their quantity, but based on the level of the total result that is obtained after their implementation [223,224]. At the same time, difficulties may arise regarding the comparison and summation of different results of projects. Section 3.2 in detail reveals this issue. Fig. 3.4, as an example, displays procedure for determining projects priority by their additional detailed grouping within the framework of strategic objective “B”. As a result, is an ordered series of projects from the highest priority RBi=1 to least priority RBi=9. For details, we divide this series into two commensurate subgroups: a subgroup of projects with higher priority GR_{max} and subgroup of projects with lower priority GR_{min}.

Project prioritization procedure	Project priority ranks R_{Bi}; 1-*max*, 9-*min*								
	1	2	3	4	5	6	7	8	9
1st step. Project ranking B_i (i=1,2, …,9) having the lowest priority									B_4
2nd step. Project ranking B_i (i=1,2, …,9)/B_4 having the highest priority	B_2								
3rd step. Project ranking B_i (i=1,2, …,9)/B_4,B_2 having the lowest priority								B_3	
4th step. ………….		B_7							
5th step. ………….							B_1		
6th step. ………….			B_8						
7th step. ………….						B_9			
8th step. ………….				B_6					
9th step. Project ranking B_i (i=5) having the lowest priority					B_5				

Subgroup of higher priority projects (ranks 1–5) | Subgroup of lower priority projects (ranks 6–9)

Figure 3.4. An additional detailing grouping by priority of the projects-candidates for strategic objective “B”

Source: developed by author.

Division is based on the values of R ranks. With an even number of projects and their corresponding rank values, in each of the subgroups there will be an equal value of projects $GR_{max}=GR_{min}=(max R/2)$. For example, in the framework of goal “C” we get two subgroups of 3 projects in each ($C_{GRmax}=C_{GRmin}$=6/2=3). With an odd number of projects, as in the example considered above, in the framework of goal

"B" we get B_{GRmax}=((*max*R-1)/2)+1=((9-1)/2)+1=5, B_{GRmin}=((*max*R-1) /2)=((9-1)/2)=4.

Applying the above procedures for implementing minimax ranking method with subsequent detailed grouping, we obtain, according to the example we are considering, final distribution projects-candidate's groups by priority in the portfolio (fig. 3.5).

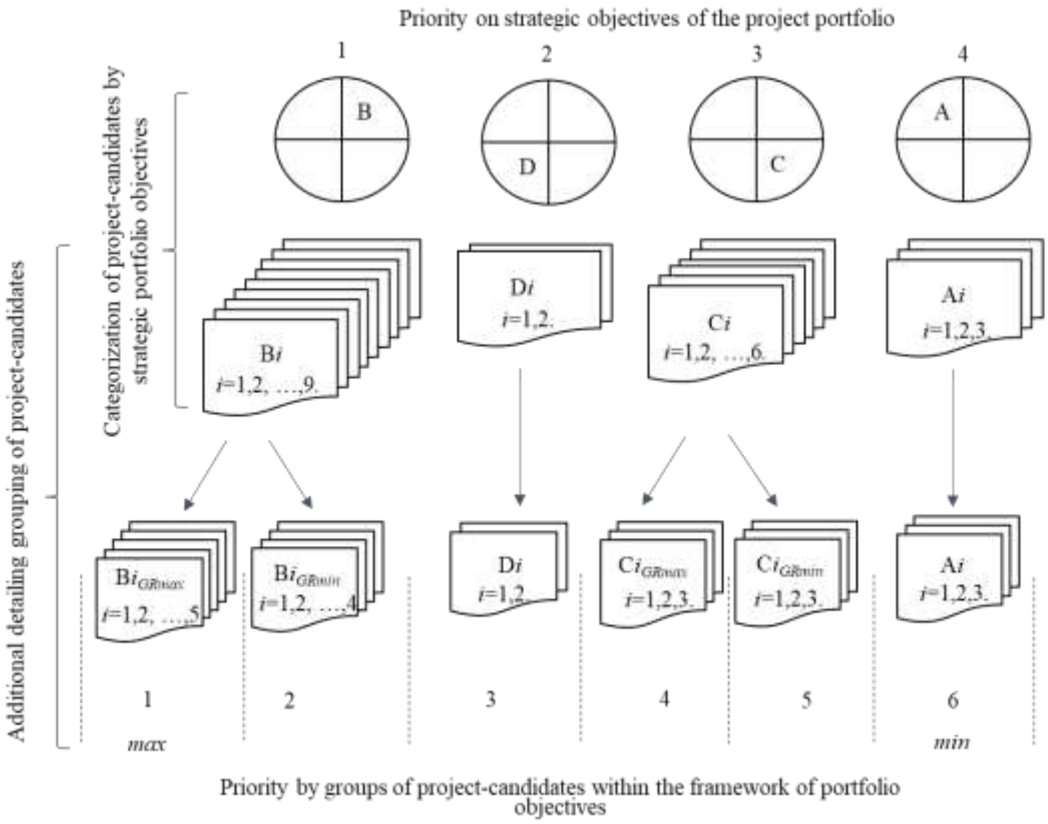


Figure 3.5. Final distribution of project priority groups of projects in the portfolio

Source: developed by author.

At its core, information presented in fig. 3.5, is the formalized knowledge of the fifth panel of the project configurator "Panel of strategic importance". Unlike other panels, it carries information about all projects-candidates, including information about the specific project under consideration. At its core, this information is synthesized new knowledge about the project that could not have appeared without considering all projects together. For specific project, we introduce by analogy with the indicators of project feasibility ${}^{\sigma}V^{i}$ and an indicator of the attainability of project result ${}^{r}V^{i}$ indicator of the strategic importance of project ${}^{s}V^{i}$(fig. 3.6).

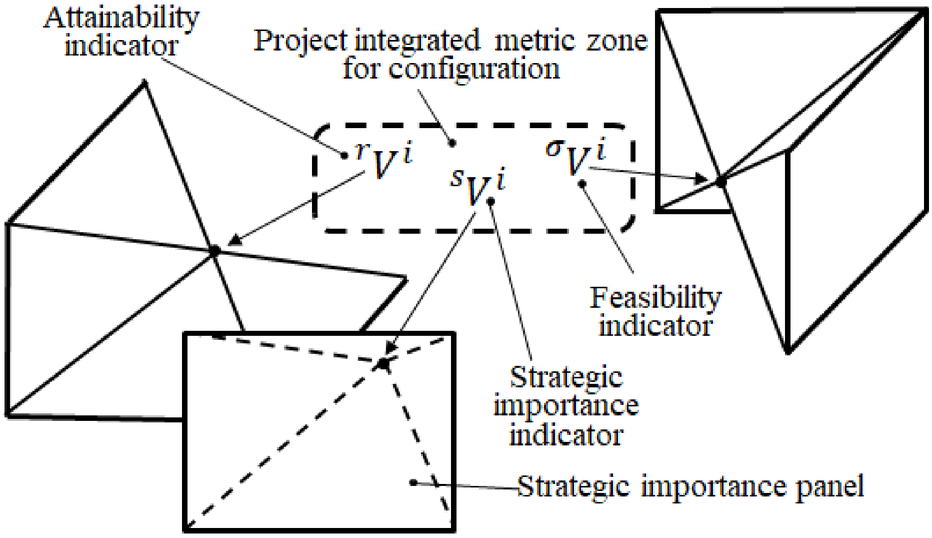


Figure 3.6. Presentation of the indicator of strategic importance of project in project integrated indicator zone for configuration

Source: developed by author.

This indicator, together with feasibility and reachability indicators expand information on the essence of the integral indicator of the project-candidate, that will be used to build the project portfolio configuring criterion. Figure 3.6 defines its place in zone of future integral indicator.

3.2. Method of transforming divergent results of projects into a point estimates metric

In section 2.2, it was noted that, in contrast to the costs that presented in monetary units for all projects, results from use of project products have different units. Reason for this is the presence of various in essence strategic goals of LSEE. They are measured by different values that are achieved by different products of projects within the portfolio structure.

Therefore, from configuring a multi-purpose portfolio of projects, question remains open how to compare projects with a different in nature from the position of value approach. Comparison procedure and value assessment should be carried out by project portfolio management board. Council should have tools that will allow project results presented in the map of each project in the form of an S-curve effect to correlate with each other from the position of value that project create to achieve the integral value of project portfolio.

To solve this problem, we propose method for transforming the divergent results of projects into metric of point estimates. Method based on the method of multicriteria scales (MMS) [225,226]. Main idea of MMS is an expert assessment of values of any indicator of any system at certain reference points that correspond to the transition of the system from the region of one possible state to another. Each reference point is associated with a certain grade in the metric of grade. Relationship construction between value of indicator (comparable with the assessment of its condition) and grades allows you to convey patterns of change in its state. Comparison dependencies built for indicators of different nature allows them to compare on a single scale of grades metric. This method has demonstrated its versatility and reliability in solving a wide range tasks related to the expert assessment of LSEE of different complexity and scope [221,227-229].

Let’s reveal the basic provisions of MMS. Method is based on the state characteristics matrix of any LSEE as a system [226], where five areas of its states are distinguished. Each area corresponds to specific system development character (fig. 3.7). Given development, characters dare invariant for any systems differing in essence. Indicated areas are divided among themselves by six reference points of grades, that determined by corresponding value of system indicator.

Grades at reference points	Value of the system indicator	System status area	Nature of the system development process
1	boundary	unacceptable	breakup
2	threshold		
		critical	absent
3	normative		
		permissible	origin
4	rational		
		rational	stable
5	optimal		
		perspective	dynamic
6	boundary		

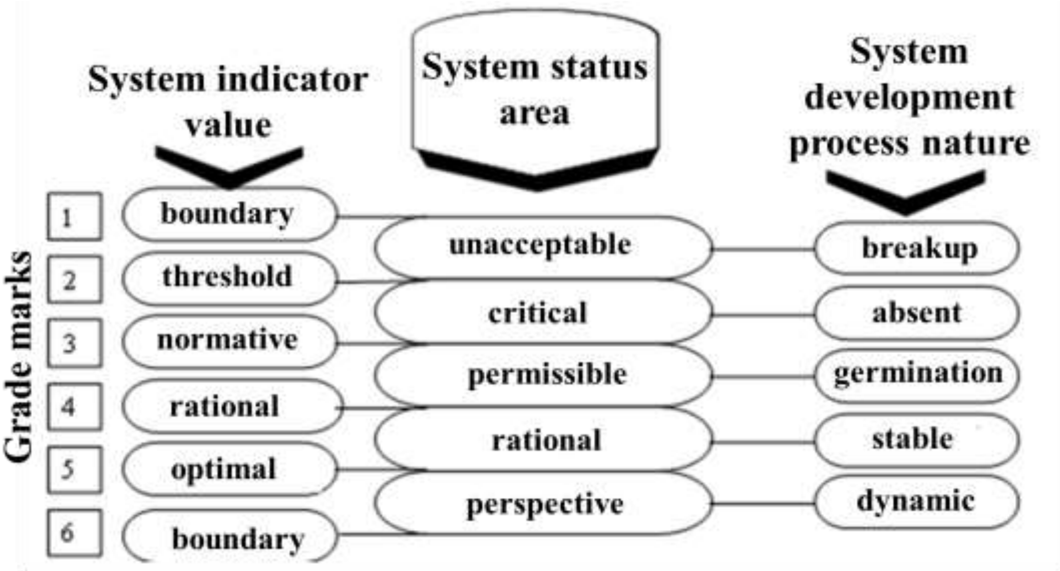


Figure 3.7. Matrix of invariant characteristics of the development process of any system in the metric of grades

Source: According to [226]

In study [221] it is shown that, the point values of indicators at the reference points represent a six-point criterion scale of grades that is understandable to experts from any field of activity. This is facilitated by formulations of value judgments that are most often used to characterize identical states of systems according to indicators that are essentially different (table 3.1).

We added one more grade to the MMS - “0”. Need for such addition is because we use described method for the indicator of accumulated effect in the form of an S-curve, that begins with a zero value.

Table 3.1 - Most frequently used expert evaluative judgments for characterizing the state of systems corresponding to specific point grades in the metric of grade estimates

Grade point	Expert value judgment	Indicator value designation	
		linguistic	mathematical
0	Imperceptibly	Not shown, zero	t_z
1	Disgusting	Lower boundary, minimum	$t_{\min}$
2	Unsatisfactory	Threshold	t_t
3	Satisfactorily	Normative	t_n
4	Good	Rational	t_r
5	Excellent	Optimal	t_o
6	Wonderful	Upper boundary, maximum	$t_{\max}$

Six-point (in our case seven-point) scale used in the MMS is one of the most commonly used expert scales in which five to nine grades are used. Therefore, such a scale has a sufficient level of informativeness (detail) and meets the restrictions associated with the psychological characteristics of a person storing information in random access memory (Miller's number 7 ± 2).

Meaning of linguistic notation essence used in the MMS for the value of the estimated indicator. Limit minimum and lower and upper boundary values determine the possible area of indicator change. Their values depend on the nature of system beyond that system cannot physically exist. Threshold is understood as the indicator limit value, deviation from that towards lower boundary indicates the emergence of trends in the destruction of the system, and, ultimately, its collapse, disappearance of the system. Under normative we mean such value of indicator, change that in the direction of the threshold indicates the absence of any development, and towards the rational about the beginning, the origin of development processes. Rational and optimal values determine the area of sustainable development of the system. Moreover, between optimal and upper boundary values there is a region of dynamic development what indicates that system has a pace of development outpacing the pace of most similar systems development.

As follows from above explanations, distinguished values of indicator are essentially criteria values, a comparison with actual indicator values gives an idea about nature of processes development taking place in the system. Therefore, further, to describe effect of using the project product, we use the term “criteria value of indicator”.

Coordinate system “criterion value of the indicator-score” with areas that defined by the boundaries of grades is presented in fig. 3.8. Within the framework of this coordinate system, evaluation curves are constructed and used to translate values of indicator presented in certain units of measurement into a point estimate. Region of states defined by zones with limited grades can be represented as a term set of a specific linguistic variable. In fig. 3.9 such a linguistic variable is “Nature of system development process”, terms of that are {collapse, no development, development is emerging, sustainable development, dynamic development}.

As part of graphical representation, MMS mentioned in fig. 3.1. moreover, in table 3.1 terms and designations used for expert evaluation of indicators, and characterizing the development of any system (fig. 3.9).

Essence of variable region states linguistic that are determined by grades is determined by the context in what indicator is used. So, for example, concentrating on the assessment of result, it is “Achieved level of result”, and in the context of effect assessment - “Effect level”. Corresponding term sets are shown in fig. 3.10.-3.11.

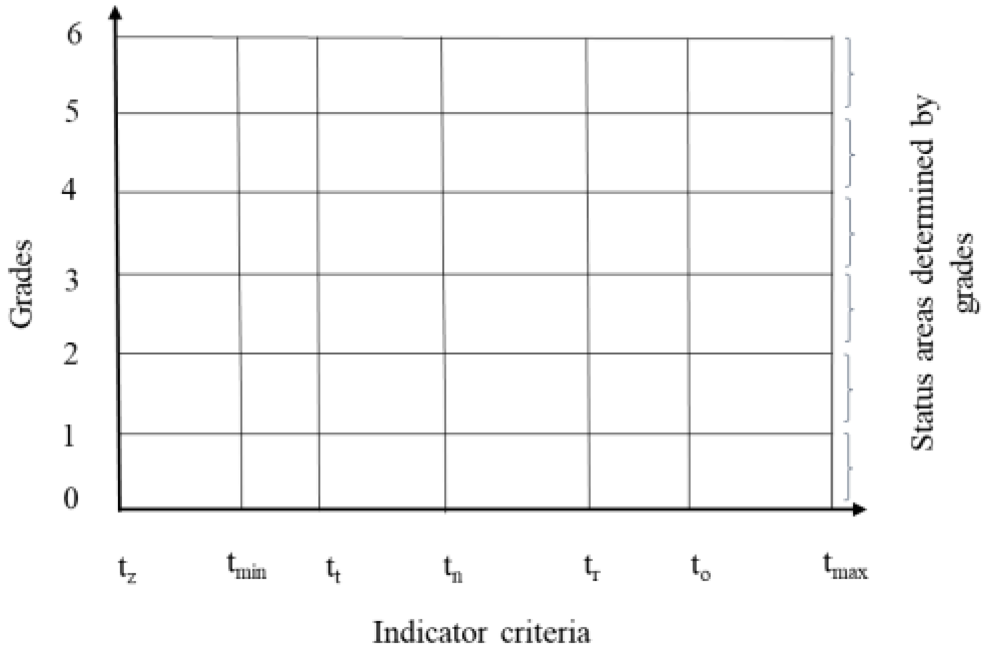


Figure 3.8. Coordinate system for constructing curve of translating an indicator into point of grade metric

Source: developed by author.

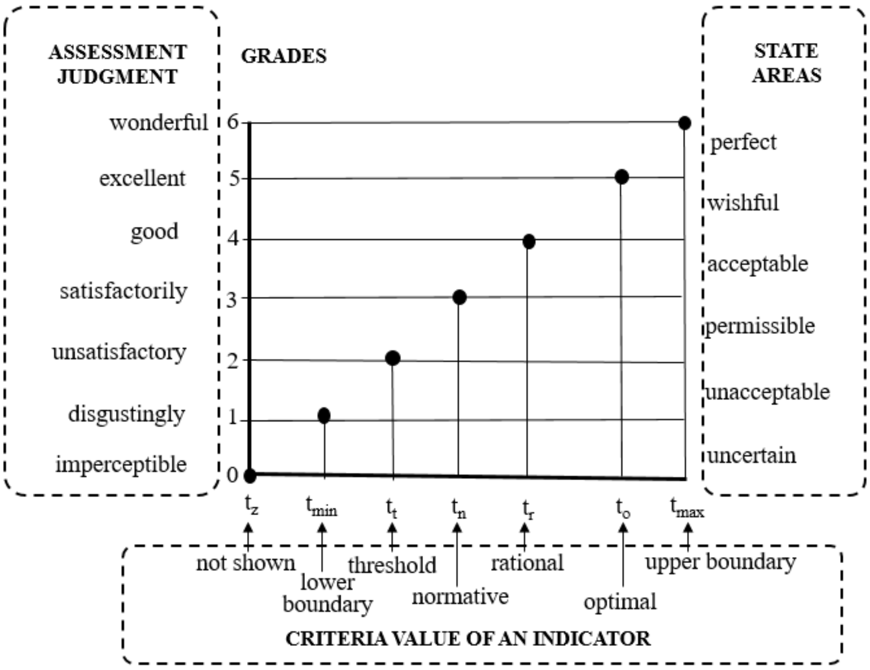


Figure 3.9. Graphic interpretation of MMS basic terms

Source: developed by author.

If there is a need for probabilistic assessment (by analogy with the method of analyzing a probabilistic outcome [230]), then one of the variants of the terms may be the linguistic estimates shown in fig. 3.12.

Members of project portfolio management council begin to use the method of constructing estimation curves to translate project effect indicators into point estimates by determining the lower and upper boundaries of the effect indicator t_{min}, t_{max}. They correspond to grades 1 and 6. In most cases, determination of boundary values is based on information obtained from external sources, and they are considered as objective facts. This allows to more objectively assessing the attractiveness of projects for a particular portfolio.

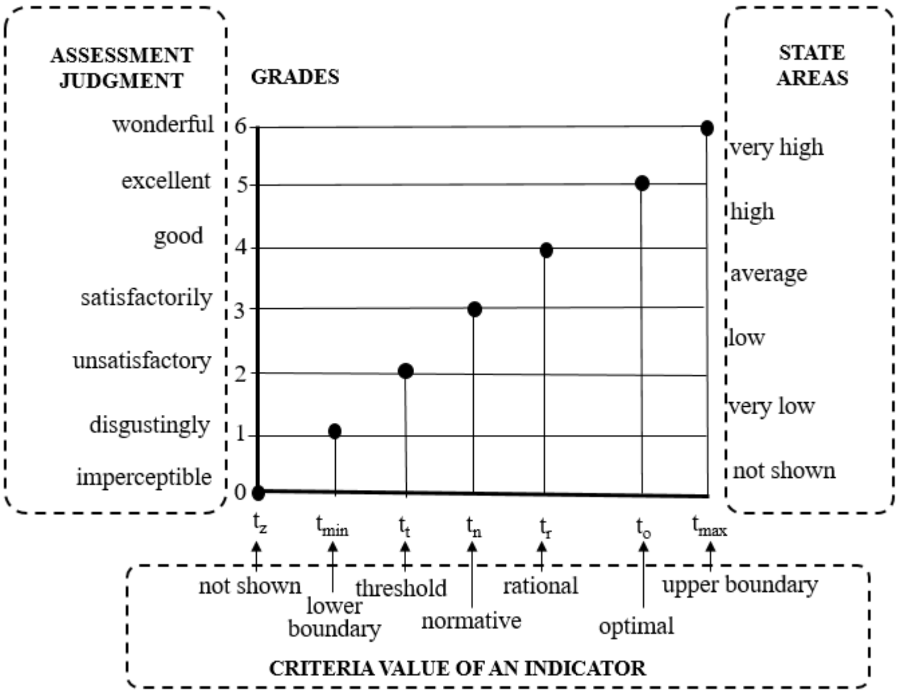


Figure 3.10. An example of state term sets domain for the criteria knowledge of indicators characterizing the achieved result level

Source: developed by author.

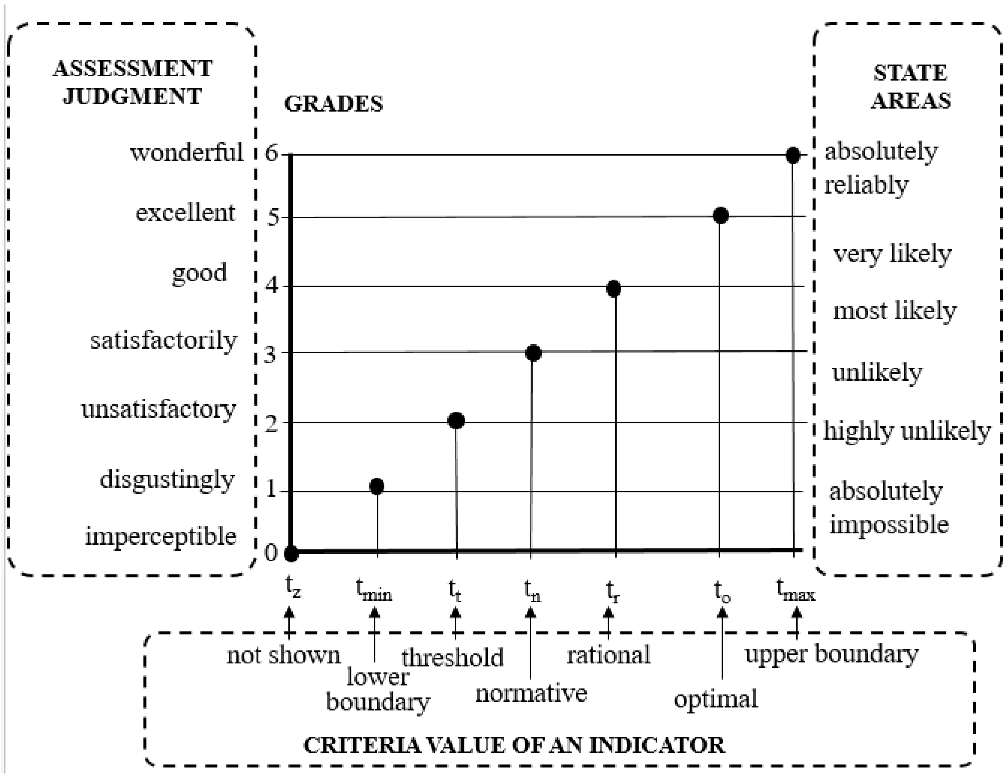


Figure 3.11. An example of state term sets domain for the criteria values of indicators characterizing the achieved effect level

Source: developed by author.

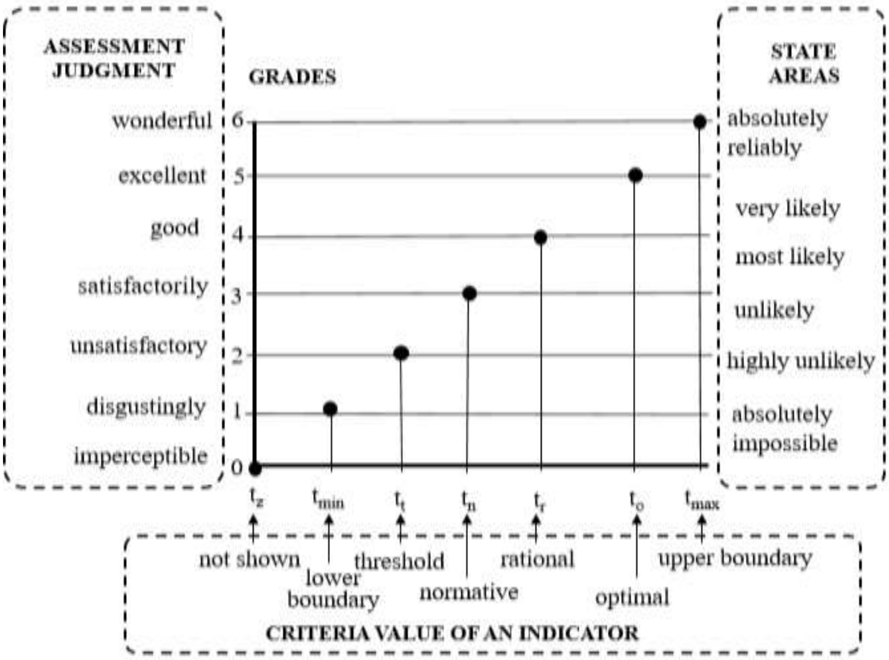


Figure 3.12. An example of state term sets domain for the criteria -based knowledge of indicators characterizing probabilistic estimates

Source: developed by author.

Indicator values t_t, t_n, t_r, t_o, that correspond to points 2, 3, 4, 5 is determined on the basis of knowledge, experience and subjective judgments of council members. An example showing various options for the subjective choice of criteria-based indicator values is presented in fig. 3.13.

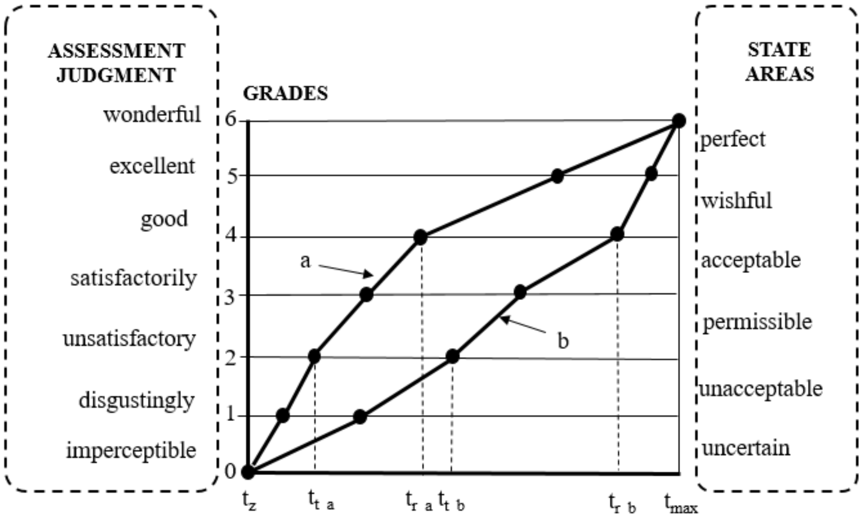


Figure 3.13. An example of evaluation curves constructed for different variants of criteria values of indicators

Source: developed by author.

In practice, it is not always possible to get a consistent opinion about all the criteria values of indicators (t_t, t_n, t_r, t_o). In this case, only those indicator values are set for that consensus is found. In addition, based on them, an estimated curve is built. It should be emphasized that estimated curves for each indicator, which will be used in the formation of project portfolio, are built before the start of the announcement of the competition of projects for participation in their portfolio. This information is confidential and is disclosed only after receiving all the documentation for all project - candidates.

We use linear interpolation formula to get a mark K_f for specific indicator value t_f of particular project:

$$K_f = K_1 + \frac{K_2 - K_1}{t_2 - t_1}\left(t_f - t_1\right), \qquad (3.1)$$

where t_1, t_2 - known criteria indicator values between that are indicator actual value t_f

K_1 and K_2 - grades that are corresponding to known criteria values of indicators t_1, t_2

Case shown in fig. 3.14 we consider as an example.

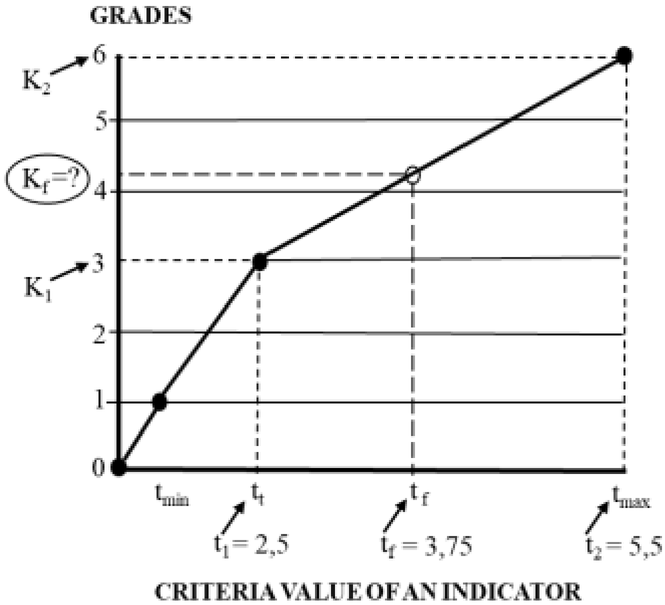


Figure 3.14. An example of grade mark determining for indicator actual value

Source: developed by author.

As one can see, estimated curve is built on the basis of three indicator criteria values that are given in units of this indicator (unit): lower boundary t_{min} =1,5 units, normative t_t =2,5 units and upper boundary t_{max} =5,5 units. They correspond to 1, 3, and 6 points. Actual value of project indicator for that is necessary to determine a point score is equal to t_f =3, 75 units.

Using the formula (3.1) we get:

$$K_f = 3 + \frac{6-3}{5,5-2,5}(3,75-2,5) = 4,25 \text{ grades} \qquad (3.2)$$

Basic provisions of the MMS set forth above allow S-shaped curves conversion that reflecting process of increasing diversity of effects defined in units of project -

candidates into effect grades. Data explaining the process of such a conversion are given in tables 3.2-3.2 and charts in table 3.4.

Table 3.2 - Indicator effect criteria set by the project portfolio management board

Designation	Effect, units	Mark, grade
Project 1 with an effect metric that relates to the first entity		
t_z	0	0
t_{min}	0	1
t_t	15	2
t_n	35	3
t_r	50	4
t_o	65	5
t_{max}	100	6
Project 2 with an effect indicator that relates to the second entity		
t_z	0	0
t_{min}	100	1
t_t	150	2
t_n	280	3
t_r	420	4
t_o	550	5
t_{max}	600	6

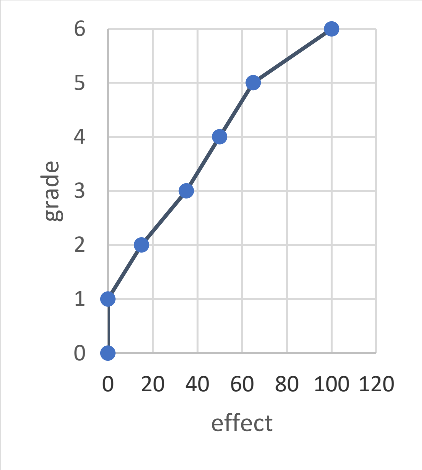
Table 3.3 - Projects effect indicators transfer with different entities into grade points

Effect accumulated values from project product use			Grade value calculation of effect indicator					
Period of time	Time (month)	Effect (unit)	t_1	t_2	t_f	K_1	K_2	K_f
			Effect, unit			Effect, grade		
Project 1 with an effect metric that relates to the first entity								
0	0	0	0	15	0	0	1	0
1	10	20	15	35	20	2	3	2,25
2	30	30	15	35	30	2	3	2,75
3	35	35	35	35	35	3	3	3
4	50	45	35	50	45	3	4	3,67
5	55	47	50	65	47	4	5	3,8
Project 2 with an effect indicator that relates to the second entity								
0	0	0	0	100	0	0	1	0
1	30	120	100	150	120	2	3	2,4
2	40	250	150	280	250	2	3	2,77
3	50	400	280	420	400	3	4	3,86
4	60	500	420	550	500	4	5	4,62
5	70	560	550	600	560	5	6	5,2

Graphical criterion values representation of indicators set by portfolio management board for two projects with different effects in essence given in table

3xx - image variants A and E. Accumulated effect values from using of project products we can see in image variants C, F.

Table 3.4 - Graphic depiction of conversion process

<table>
<tr><td colspan="3">For project №1</td></tr>
<tr>
<td>
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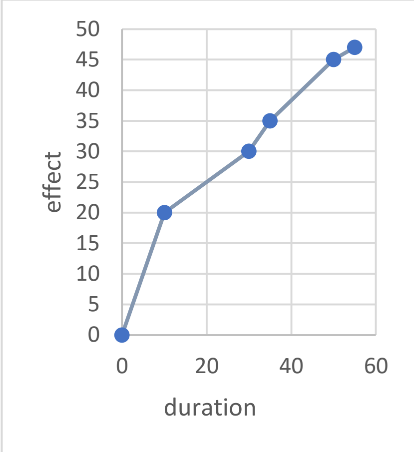
<td>
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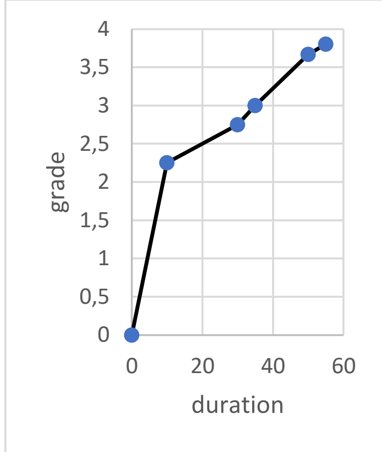
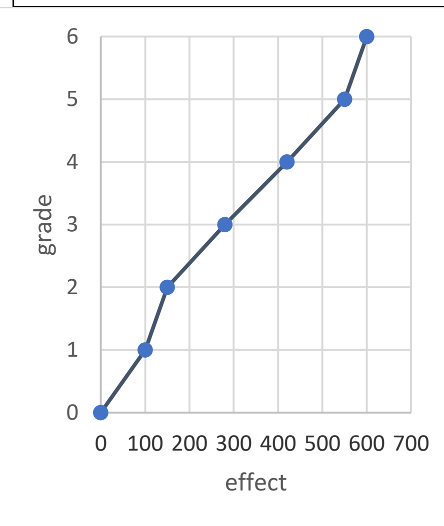
<td>
</td>
</tr>
<tr><td>A)</td><td>B)</td><td>C)</td></tr>
<tr><td colspan="3">For project №2</td></tr>
<tr>
<td>
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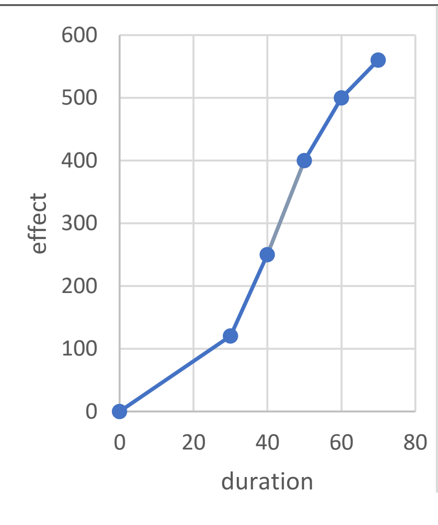
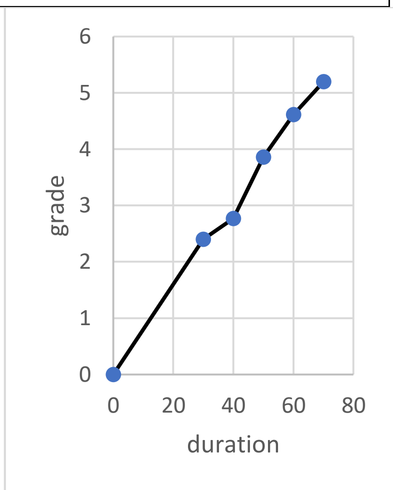
<td>
</td>
<td>
</td>
</tr>
<tr><td>D)</td><td>E)</td><td>F)</td></tr>
</table>

Thus, effect conversion that are essentially different into grade values (in the range from 1 to 6 grades) allows you to build S-shaped curves of effects in a single format, compare them and determine flow values, effect characteristics when achievement coefficient calculating of result and attractiveness as separate projects, and portfolio as a whole.

For the convenience of comparing and analyzing various effects of projects that are essentially different, one can use nomograms that are a graphical representation of several variables function and allow using simple geometric operations to study functional dependencies without calculations. Therefore, nomogram for comparing project effects that considered in table 3.3 is presented in fig. 3.15. In given example, two indicators, essentially different, are located at different scale intervals of their change (R_1 value is approximately 75% of the maximum value and R_2–50%). At the same time, both of these indicators, taking into account the vision of portfolio management council and have the same point value - 3 grades [231]. In addition, one can find that in absolute terms criterion value estimated by the portfolio management board at 3 grades corresponds to the effect for the first project of 35 units, and for the second project - about 290 units. Similar comparison we can make for other grade values too. From monogram, we can see that the maximum value of the second project-accumulated effect has more attractive marks - 5.2 grades, than the first project - 3.8 grades.

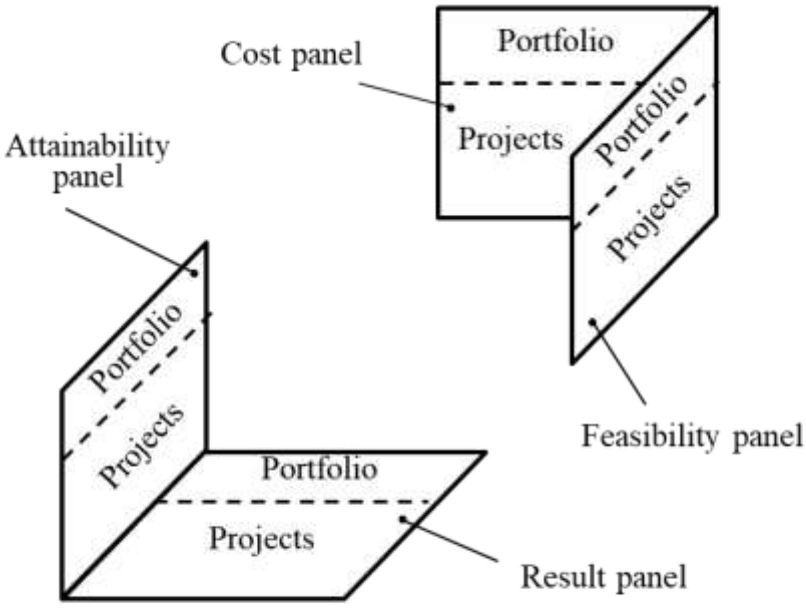
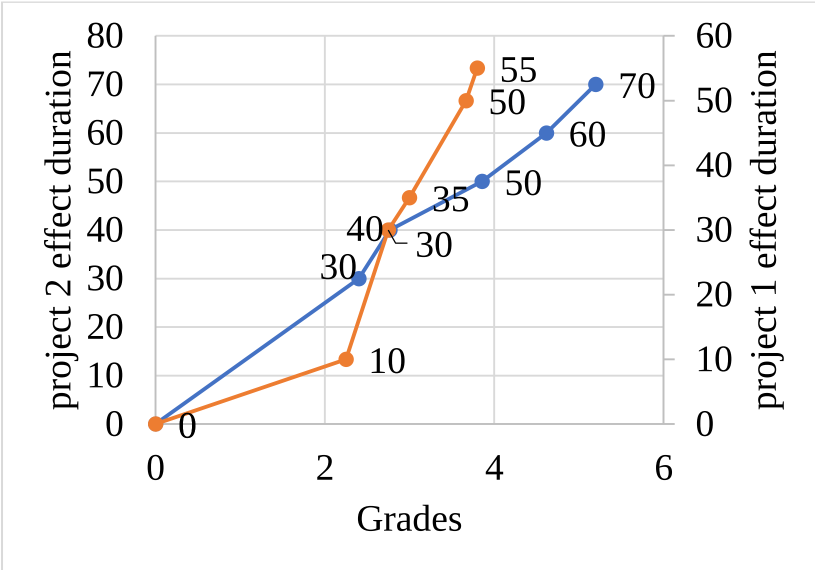


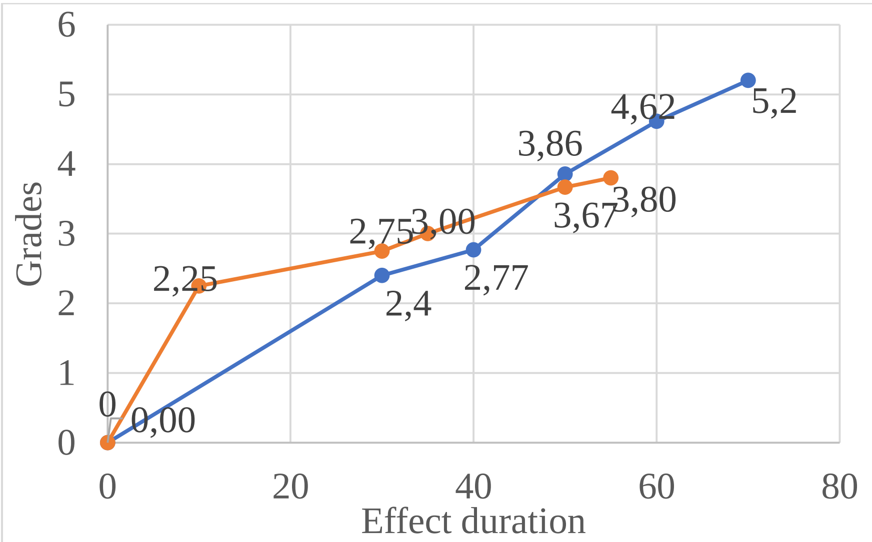
Figure 3.15. Nomogram for comparing project effects with different entities using point marks

Source: developed by author.

Change nature consideration in the effect magnitude over time (fig. 3.16 A, B) allows us to draw a number of useful conclusions regarding the rate of their rise, time it takes to reach the same grade marks, maximum values, etc.



A)



B)

Figure 3.16. Nomogram (A) and graph (B) reflecting the projects duration dependence and change nature in their effects, expressed in a single point system of evaluation

Source: developed by author.

So, for example, from table 3.4 analysis, it can be seen that different change nature in the effect criteria specified by project portfolio management advice, as well as different effects duration - given by the initiators of the project-candidates, affects the change nature in the converted effect curves over time fig. 3.16A, 3.16 B. At the same time, graphs and monograms make it possible to see, as well as compare the parameters for the increase in effects from projects, estimated in grades over time (subject to their simultaneous manifestation). Therefore, equality of different project effects point grades we observe for the first project at 30 months, and for the second at 40 months of their manifestation (fig. 3.16A). Manifestation lower limit of effect from the first project come earlier (10th month - a value of 2.25 grades) than from the second (30th month - a value of 2.4 grades), and has more attractive meanings values up to 45 months (see fig.3.16B).

Such a graphical analysis may be useful in balancing the project portfolio, especially when certain projects do not reach the maximum possible effect values or deviations observe in schedule for their implementation and effect.

Thus, summarizing above information, we can recommend following sequence of procedures for the results transformation (effects) of projects with different essence into a single scale of the grade point metric, allowing their comparison:

1) project grouping according to the effect essence (result);

2) definition for each area entity of its existence, primarily boundary indicator values $t_{\min}$, $t_{\max}$, t_e;

3) construction for each effect indicator of multicriteria scale and an evaluation curve based on determination by the portfolio management board of values t_t, t_n, t_r, t_o;

4) transformation for each project effect with accumulated curve of the result presented in the project-candidate map to corresponding scale in the range of grades from 0 to 6 points, taking into account its essence;

5) project result comparison with different effect nature (result) with use nomograms built on the basis of presented cumulative effect curves in the grade scale;

Proposed method for transforming divergent project results into grade marks metric involves making changes to the feasibility indicator essence. Its original entry form

$$ {}^{r}V^{i} = F(\sum_{g=0}^{n} \frac{CF(r)_g}{(1+ {}^{r}d^{i})^{g}}), \qquad (3.3)$$

transforms into a new form

$$[{}^{r}V^{i}]_t = F(\sum_{g=0}^{n} \frac{[CF(r)_g]_t}{(1+ {}^{r}d^{i})^{g}}), \qquad (3.4)$$

where $[{}^{r}V^{i}]_t$ - attainability result indicator of i project calculated by grades metric marks $[CF(r)_g]_t$ project results;

Corresponding changes and integrated indicator of project for configuration zone are must made (fig. 3.6).

3.3. Method to discount project cumulative flows of costs and results

In section 2.3, with introduction indicators of feasibility ${}^{\sigma}V^{i}$ and attainability ${}^{r}V^{i}$, it was indicated a need for additional studies to identify flow parameters nature $\mathrm{C}F(\sigma)_p$ и $\mathrm{C}F(r)_g$ that are in use in calculating these indicators. Leys consider $\mathrm{C}F(\sigma)_p$ parameter associated with flow characterization of project financing. To do this, we consider three basic projects that have the same amount of funding but differ in types of cash flows (table 3.5, columns 2, 3, 4). First and third projects are distinguished by the duration of flow - number of financing periods (six and eleven, respectively). In addition, first and second have different flow values parameter in the same financing periods, i.e. differ in financing nature.

Table 3.5 - Cash flows of basic projects

Period p	Cash flow $({}_0\sigma)_p$.			Accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
1	*2*	*3*	*4*	*5*	*6*	*7*
0	100	20	69	100	20	69
1	80	40	56	180	60	125
2	60	50	45	240	110	170
3	40	60	37	280	170	207
4	20	70	30	300	240	237
5	20	80	24	320	320	261
6			19			279
7			14			294
8			11			305
9			9			314
10			7			320
Amount	**320**	**320**	**320**	1420	920	2580

First and third projects have the same financing nature. Cash flow components value $({}_0\sigma)_p$ decreases with increasing funding period p. Moreover, for the second project, on the contrary, the greater the financing period p is, the greater the financing $({}_0\sigma)_p$ falls on this period.

In table. 3.5 (columns 5,6,7) also shows component values of accumulated cash flows $(\sigma)_p$, that are calculated according to the following rule. For zero period, accumulated flow value is equal to the zero period financing, i.e.

$$(\sigma)_0 = ({}_0\sigma)_0. .. \qquad (3.5)$$

For the first period, value is equal to the accumulated zero-period flow sum and first period financing

$$(\sigma)_1 = (\sigma)_0 + ({}_0\sigma)_1 \qquad (3.6)$$

For the second period - accumulated cash flow sum of the first period and second period financing.

$$(\sigma)_2 = (\sigma)_1 + ({}_0\sigma)_2 .. \qquad (3.7)$$

That is accumulated flow in any period under consideration is equal to the accumulated flow sum in previous period and financing provided for by the financing schedule for under consideration period

$$(\sigma)_p = (\sigma)_{p-1} + ({}_0\sigma)_p .. \qquad (3.8)$$

It is easy to notice that graphically accumulated flow is displayed by the S-curve.

In the bottom line of table. 3.5 sums of cash flow indicator values (columns 1, 2, 3) and indicators of accumulated cash flows (columns 4, 5, 6) are given. As follows from analysis of this line with the same amount of project financing (columns 1, 2, 3), sums of accumulated cash flow values differ significantly between projects (columns 4, 5, 6). At the same time, project 2 has the smallest accumulated amount of cash flow value (920 conventional units), in that financing values for periods increase with increasing period number (column 5). From a comparison of first and third projects, that have opposite financing nature, an increase in the duration of financing leads to an increase in the sum of accumulated cash flows (columns 4, 6). Therefore, for the first project it is equal to 1420 conventional units, and for the third 2580 conventional units.

Analyzing table 3.5, it is generally seen that as a parameter $CF(\sigma)_p$, that is associated with the flow characteristic of project financing, theoretically, both cash flow and accumulated cash flow can be used. Parameter $CF(\sigma)_p$ participates in discount procedure in calculating the feasibility indicator ${}^{\sigma}V^{i}$ as a new synthesized knowledge at the configurator retention point. Therefore, it is logical to investigate value change nature ${}^{\sigma}V^{i}$ at various discount rates. Values ${}^{\sigma}V^{i}$ numerically equal to discounted flows sums.

Discounting process for discount rate of 1, 2, 3, and 4% displayed in table 1-5 of Appendix E . Calculation results are summarized in table 3.6.

Table 3.6 - Discounting flows at different discount rates

№	Amount	project 1	project 2	project 3
Discount rate 1%				
1	cash flow	315	320	319
2	discount cash flow *ADCF*	310	310	310
3	accumulated cash flow	1415	920	2574
4	discounted accumulated cash flow *ADACF*	1373	887	2425
Discount rate 2%				
5	cash flow	310	320	318
6	discount cash flow *ADCF*	301	301	301
7	accumulated cash flow	1385	920	2571
8	discounted accumulated cash flow *ADACF*	1305	856	2286
Discount rate 3%				
9	cash flow	307	321	319
10	discount cash flow *ADCF*	293	293	293
11	accumulated cash flow	1372	926	2574
12	discounted accumulated cash flow *ADACF*	1255	832	2162
Discount rate 4%				
13	cash flow	300	320	317
14	discount cash flow *ADCF*	283	283	283
15	accumulated cash flow	1348	920	2533
16	discounted accumulated cash flow *ADACF*	1200	798	2011
Discount rate 4 %				
17	cash flow	320	320	320
18	discount cash flow *ADCF*	301	284	287
19	accumulated cash flow	1420	920	2580
20	discounted accumulated cash flow *ADACF*	1263	799	2050

As one can see, with the same amount value of discounted cash flow *ADCF* for selected discount rate (lines 2, 6, 10, 14 of table 3.6) of discounted accumulated cash flow amount *ADCF* for projects, it was necessary to slightly change structure of their cash flows (table 1-5 of the Appendix E). This led to slight change for project cash flows (lines 1, 5, 9, 13 of table 3.6). Subject to the equality of cash flows amount of between projects (line 17 of table 3.6), amount values of discounted cash flow is slightly differ (line 18 of table 3.6).

For more visual representation of revealed dependencies, we summarize necessary information for this in table 3.7. As table shows, discounted cash flow value *ADCF* does not reflect features of project financing (lines 1, 3, 5, 7 of table 3.7). This characteristic does not take into account flow change nature (increasing or decreasing), rate of flow change (rate of increase or decrease flow), and flow duration. Unlike *ADCF* discounted value of flow rising *ADACF* changes its value adequately to the change in the above flow characteristics (lines 2, 4, 6, 8 of table 3.7).

Table 3.7 - Project cash flow characteristics

№	**Discount rate, %**	**Amounts**	**project 1**	**project 2**	**project 3**
1	1	*ADCF*	315	310	311
2		*ADACF*	1378	887	2431
3	2	*ADCF*	310	301	303
4		*ADACF*	1336	856	2294
5	3	*ADCF*	306	292	295
6		*ADACF*	1300	827	2167
7	4	*ADCF*	301	284	287
8		*ADACF*	1263	799	2050

Therefore, calculations gave a reason to make following conclusion. Discounting accumulated cash flow can be used as a make-up operation where obtained parameter value reflects change nature in cash flow and project financing duration. It is impossible to get a parameter with such properties in the traditional cash flow discounting [232].

Considering that the output obtained applies to any type of flow, discount procedure for the accumulated project result can also use for flow presentation.

At first glance, numerical value obtained from discounting the accumulated flow does not have a specific economic or other meaning, in contrast to the calculation, for example, of the net present value (NPV). However, during forming portfolio by configuration, two requirements imposed on the integrated indicator - reflecting differences between projects and possibility of quantitative comparison between them. Using the discounted procedure for the accumulated value of any stream parameter allows these requirements to meet.

In real project management practice, actual forms of “time-cost” and “time-result” curves are significantly different from S-curves. However, this does not affect discounting and comparison procedures between projects. Therefore, term “S-curves” can use as name of curves reflecting “time – parameter” dependence.

Above judgments and conclusions, allow us to clarify formulas for writing functions of new synthesized knowledge at the configurator retention points that are given in section 2.3. For feasibility indicator, formula converted to the following form

$$ {}^{\sigma}V^{i} = F\left(\sum_{p=0}^{n} \frac{CF(\sigma)_p}{\left(1+{}^{\sigma}d^{i}\ \right)^{p}}\right) = F\left(\sum_{p=0}^{n} \frac{(\sigma)_p}{\left(1+{}^{\sigma}d^{i}\ \right)^{p}}\right). \qquad (3.9) $$

And for attainability indicator taking with transformation into grade metric (section 3.2), it has this form

$$ [\ {}^{r}V^{i}]_t = F\left(\sum_{g=0}^{n} \frac{[CF(r)_g]_t}{\left(1+\ {}^{r}d^{i}\ \right)^{g}}\right) = F\left(\sum_{g=0}^{n} \frac{[(r)_p]_t}{\left(1+\ {}^{r}d^{i}\ \right)^{g}}\right), \qquad (3.10) $$

where, $[(r)_p]_t$ - accumulated flow components of project results transformed into a score metric [233].

CHAPTER 4

MODELS OF COSTS, RESULTS AND PORTFOLIO FINANCING IN PROJECT-CANDIDATES FLOW PRESENTATION

4.1. Conceptual model of project packaging on the portfolio-financing panel

Sections 2 and 3 show study results that allowed not only formalizing knowledge on all five configurator panels of project-candidates, but also synthesizing knowledge at the retention configurator points. Each panel may contain same knowledge of several project-candidates. However, for the possibility of the simultaneous use of such knowledge, an additional unifying factor is required. In addition, such a factor is future project portfolio financing schedule. Therefore, to move on to solving portfolio configuration tasks, it is necessary to add sixth portfolio financing panel to portfolio - candidate configurator (fig. 4.1). Conditionally, financing schedule in integral indicator zone of project for configuration represented by symbol $_{T}^{S}S$.

Introduction of new panel raises need to consider two issues. First concerns definition of the most frequently used forms of portfolio financing schedules that define boundaries of periods and allocated funding volumes. Second is rules and processes formalization for packing S-shaped cost schedules (requested funding) for project-candidates within specified portfolio financing schedules.

Analysis of information sources carried out in section 1.1. and 1.2 shows that program and portfolio financing have a significant implementation period of three years or more is carried out in part tranches form. Such portfolio-financing scheme can present in systematic schedule form (fig. 4.2). This chart, in fact, sets discrete time and financial constraints that reflect features of particular portfolio financing. Schedule form determines both number of project-candidates that portfolio could potentially include, and possible combinations of their financing sequences.

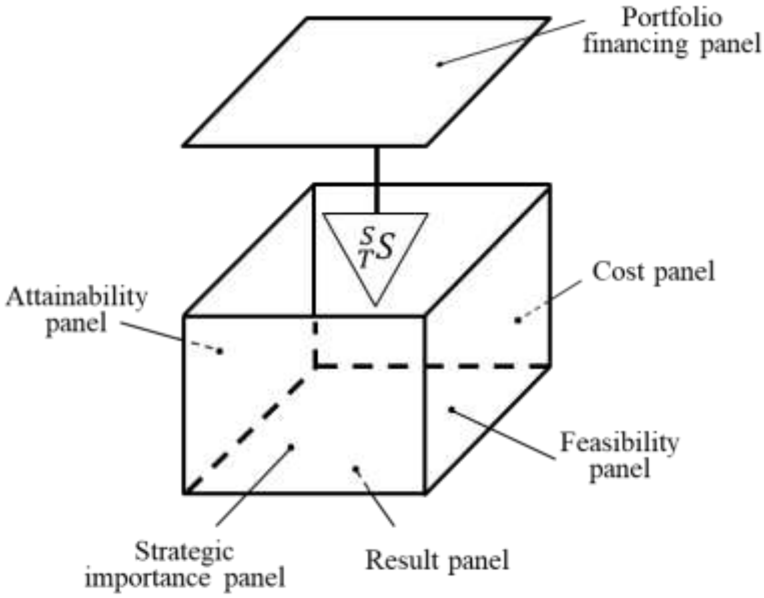


Figure 4.1 - Project-candidates configurator that supplemented by a portfolio-financing panel

Source: developed by author together with supervisors.

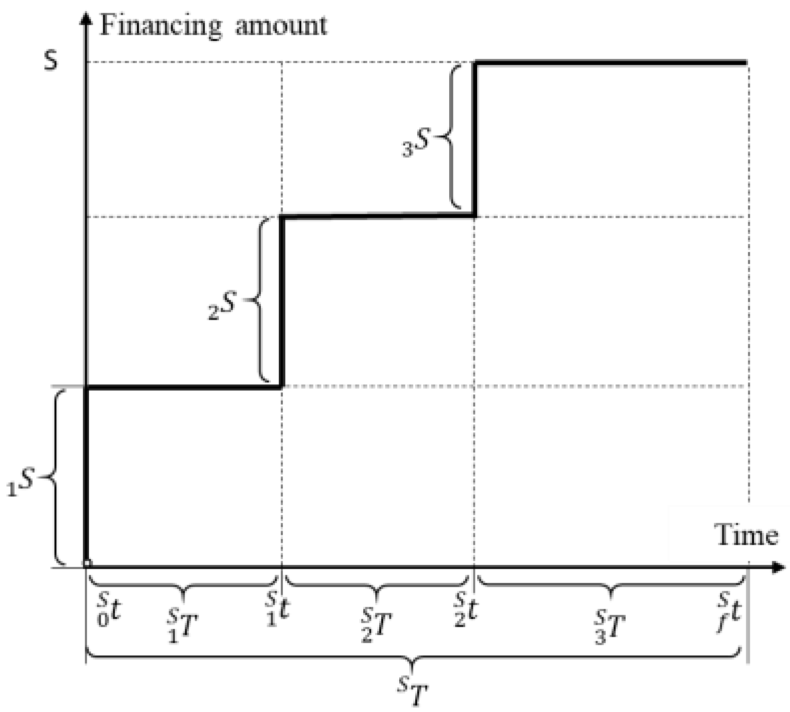


Figure 4.2 - Schedule field for financing project portfolio

Source: developed by author.

As can be seen from fig. 4.2 financing is set in the form of certain amounts of funds that allocated for periods. Such scheme greatly simplifies the budget preparation as a whole for portfolio at the planning stage and adjusting it possibility during actual implementation in comparison with other known approaches. However, today no studies that would give recommendations that regarding construction of such financing schedules. For project portfolio management council practical activities recommendations on the rational number of financing tranches (steps) depending on the amount of funds allocated to the portfolio or portfolio duration are valuable. Program and portfolio financing practice with duration of 3 to 8 years shows that funding amount regardless, number of tranches for the entire portfolio implementation period ranges from 3 to 6 (see section 1.1). It is quite logical since allows you to do an intermediate project implementation analysis and results achieved at each step - financing stages. Moreover, financing amount for first stage should be at least 20% -25% of the total financing volume allocated to portfolio. Given fact we reveal on basis financing schedules consideration for actually implemented project portfolios for LSEE development (for example, Nigeria) (see section 1.1. justification of the rule of limited (periodic) phased portfolio financing). From theoretical point of view, this corresponds to well-known Pareto 20/80 principle. We assume that such financing conditions ensure portfolio successful start even if there are deviations in the actual individual projects costs. It should be noted that the most priority projects in achieving strategic goals terms usually start realization at first stage. Therefore, successful start of such projects largely determines entire portfolio success. First stage financing duration recommend selecting within 15-20% of entire portfolio duration. Funding amount in subsequent stages may gradually decrease, and stages duration may increase. This is due to the fact that according to statistics in most projects (from 50 to 70%) deviations from the plan for their implementation are observed primarily in terms of time parameters [234-236]. At each stage, it is advisable to provide for funding reserves of up to 10% of the amount of necessary funds planned for this stage. In event that unexploited funds remain, they should automatically proceed to the next financing stage only by portfolio management decision council. For example, if there is a balance up to 15% of the undeveloped allocated funds amount for reason not depending on the project management team, then it can be transferred to the next same project financing stage by council decision.

One of the main tasks of configuring a portfolio, given a step-by-step schedule for its financing, is the efficient use of funds (resources) at each stage, subject to the maximum achievement of strategic goals by implementing the largest project number. Such problem statement is similar to “backpack problem,” that is, combinatorial optimization problem [237-240]. In this case, schedule "filling" should be carried out taking into account the priority of projects and the continuity of their implementation.

Consider project financing continuity ensuring task with given funding schedule in general form [8]. We assume that portfolio projects are sorted by the selected criterion ($j = 1$ - the most significant project, $j = M$ - the least significant project by selected criterion). Such a criterion may be: priority; financing duration amount; result (effect), etc. Information about projects priority contained in configurator on the “Panel of Strategic Importance”. Assume that portfolio financing has a discrete-time constraint in three-stage financing form. Portfolio financing is provided by the allocation of funds in three different parts at certain points in time ${}_{0}^{s}t$, ${}_{1}^{s}t$, ${}_{2}^{s}t$ {input value}. Moreover, portfolio financing start coincides with first project financing start in portfolio ${}_{0}^{s}t = {}^{s}\tau_{0}^{1} = 0$. In ideal case, financing use completion moment should coincide with last project financing completion moment in portfolio ${}_{f}^{s}t = {}^{s}\tau_{f}^{N}$. However, in practice this condition is difficult to implement. Same situation observed in individual portfolio financing phases. Therefore, underutilized funds can always remain at stages, and at the last stage, underutilized time. We emphasize that we consider project portfolio configuring tasks. Therefore, term “underutilized funds” means that they remained unallocated during portfolio configuring at particular stage and can be used in the next stage.

We introduce additional notations that relates to portfolio financing panel (fig. 4.2):

${}^{s}T$ - project portfolio financing duration {input value}.

${}^{s}_{1}T$ – time interval between first and second financing receipt, ${}^{s}_{1}T={}^{s}_{1}t-{}^{s}_{0}t$;

${}^{s}_{2}T$ – time interval between second and third financing receipt, ${}^{s}_{2}T={}^{s}_{2}t-{}^{s}_{1}t$;

${}^{s}_{3}T$ – time interval between third financing receipt and portfolio financing final moment (finish), ${}^{s}_{3}T={}^{s}_{2}t-{}^{s}_{f}t$;

${}^{s}T^{i}$ - i-th project-candidate financing duration.

S - total portfolio costs that are already allocated to projects over a period of time ${}^{s}T$.

${}_{1}S$ - first tranche financing volume of project portfolio at the initial time (start) ${}^{s}_{0}t$; {input value}

${}_{2}S$ - second tranche financing volume of project portfolio at time ${}^{s}_{1}t$; {input value}

${}_{3}S$ - third tranche financing volume project portfolio at time ${}^{s}_{2}t$.{input value}

It is easy to see that:

${}^{s}_{1}T+{}^{s}_{2}T+{}^{s}_{3}T={}^{s}T$, and ${}_{1}S+{}_{2}S+{}_{3}S = S$.

Consider a model for priority determining and distribution of project financing in portfolio. We believe that criterion for portfolio configuring is known and first tranche volume is sufficient to start financing at least one project. We use methods of qualitative mathematics to build model. Where each project that represent an S-curve is placed in a rectangle. Rectangle base is equal to project financing duration, and height is financing amount required. Further work with rectangular representation of projects facilitates an understanding of portfolio-candidates "packaging" model for portfolio financing schedule field.

According to the key for decoding indices and indicators (table. 2.1) index j we denote number of project - candidate selected in portfolio, that had i number in project – candidates list. Then selected project duration denote T^j. Selected project numbers j correlate with importance ranks of these projects. Then, by definition, first selected project number in portfolio $j := 1$. Denote first financing stage $h := 0$. Subsequent numbers of selected projects and funding stages are increased by one. Packing procedure described below is applicable for any project number and any stage of financing.

May we have first “attractiveness” with financing duration ${}^sT^j = {}^sT^1$ longer duration of portfolio financing first phase ${}^s_1T$. Represent project in rectangle form with dimensions $S^1 \times {}^sT^1$ inside that is S-curve, taken from project map (fig. 4.3). Because if project longer than first phase financing duration, we determine intersection point A of S-curve and time of first phase financing completion ${}^s_1t$ (fig. 4.3).

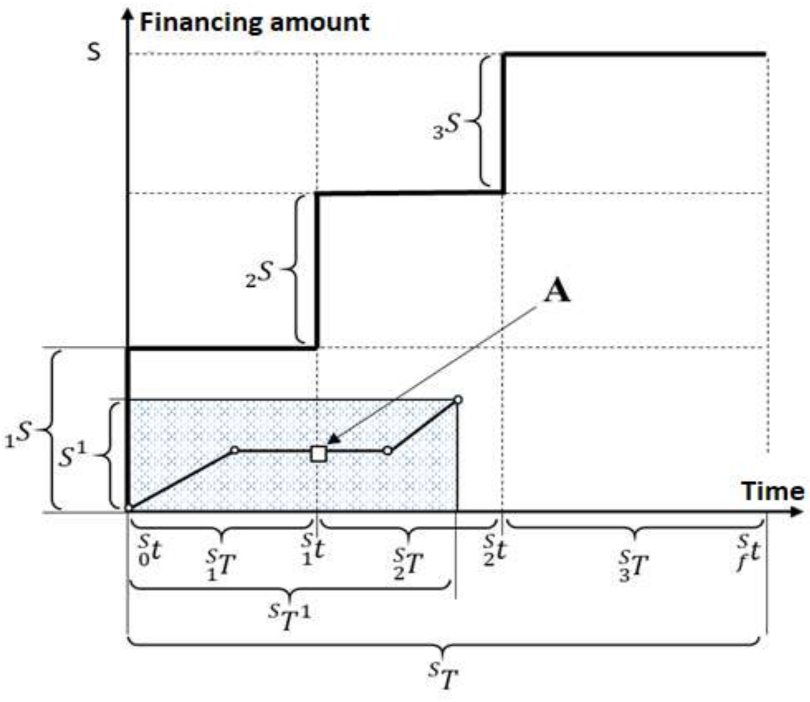


Figure 4.3 - First project placing in portfolio financing first phase

Source: developed by author.

Regarding this point, we replace previously constructed rectangle with two, sizes of that are equal respectively ${}_1S^1 \times {}^s_1T^1$ and ${}_2S^1 \times {}^s_2T^1$ (fig. 4.4).

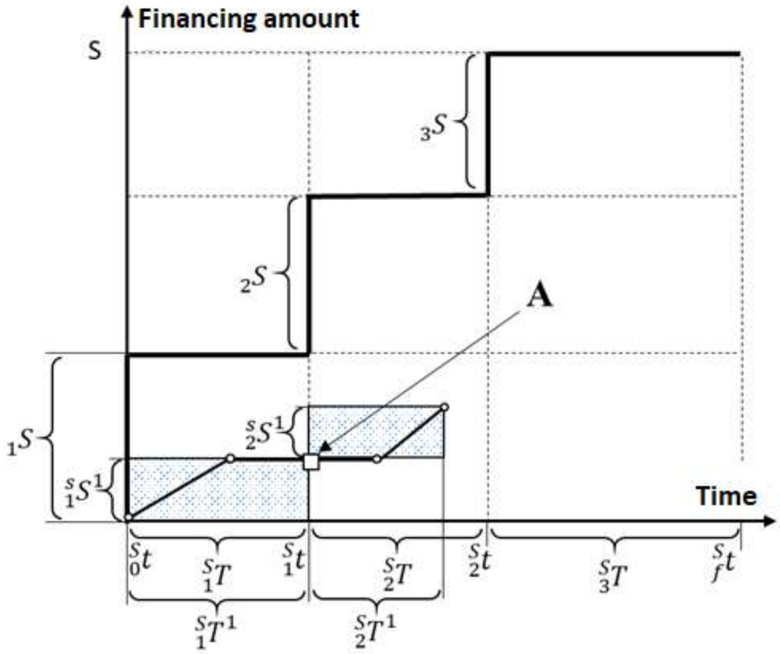


Figure 4.4 - First project dividing into parts by portfolio financing phases

Source: developed by author.

First rectangle defines financing that from first tranche is intended for first project implementation. And the second part, by analogy, corresponds to the financing that is intended for the same project, only from second tranche. Therefore, starting point for second part financing of first project must be combined with starting point for portfolio financing through second tranche (fig. 4.5). On this first project provision consideration in portfolio is completed.

In first financing phase, after first project packaging, unallocated funds remained ${}_{1}^{ND}S$ (fig. 4.5). Therefore, from project - candidates list, we take next "attractiveness" project and present it similarly to the first in rectangle form with an S-curve located inside.

Then we place rectangle above the first part of first project, combining its start with portfolio start (fig. 4.6). (For visual convenience of graphic information perception, already packaged projects of S-curve we temporarily delete). Duration of this project ${}^{S}T^{2}$, longer than first phase duration ${}_{1}^{S}T$. Therefore, by analogy with first project, we find intersection point B of S-curve with end of first phase financing ${}^{S}_{1}t$ (fig. 4.6). Around this point, build two rectangles with dimensions ${}_{1}S^{2} \times {}^{S}_{1}T^{2}$ and ${}_{2}S^{2} \times {}^{S}_{2}T^{2}$ (fig.4.7).

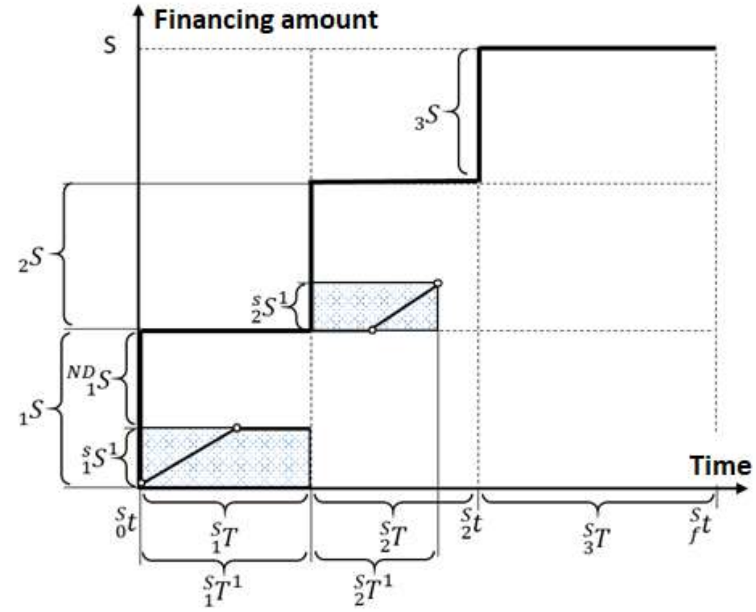


Figure 4.5 - Second part transfer of first project to the beginning of its financing in second portfolio phase

Source: developed by author.

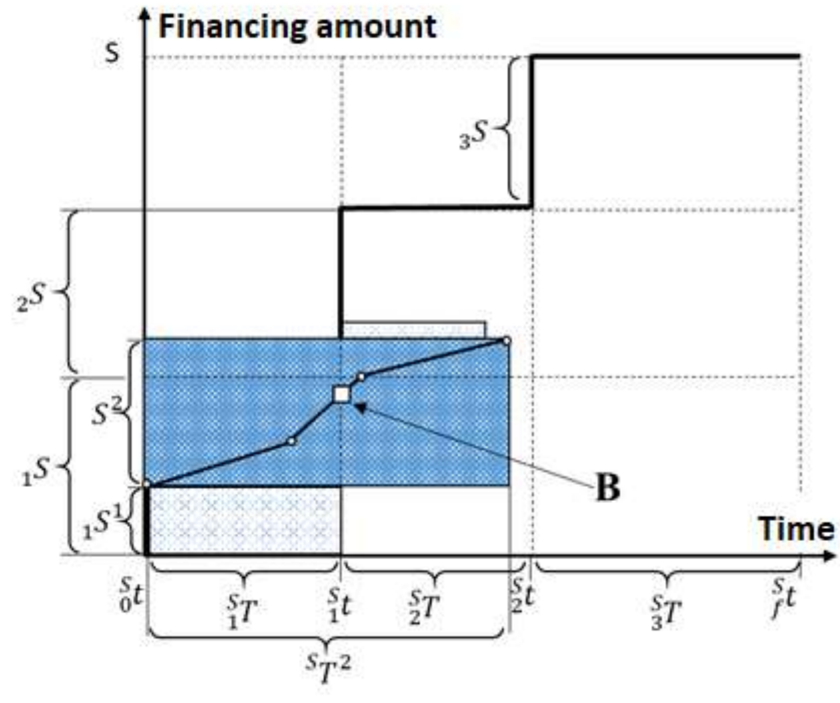


Figure 4.6 - Second project placement in the first portfolio financing phase

Source: developed by author.

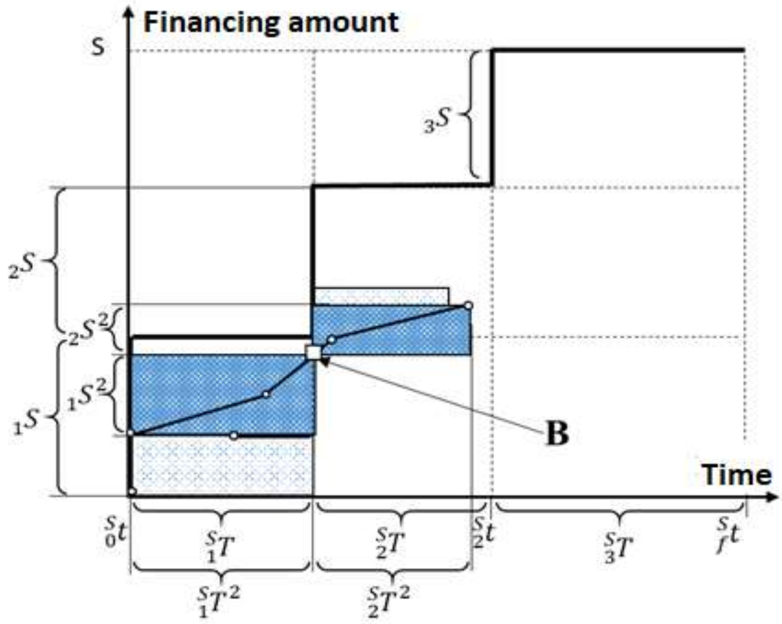


Figure 4.7. Second project division into parts by portfolio financing phases

Source: developed by author.

Second part is moved vertically upwards and placed above the first project rectangle (fig. 4.8). Now work with second project is completed.

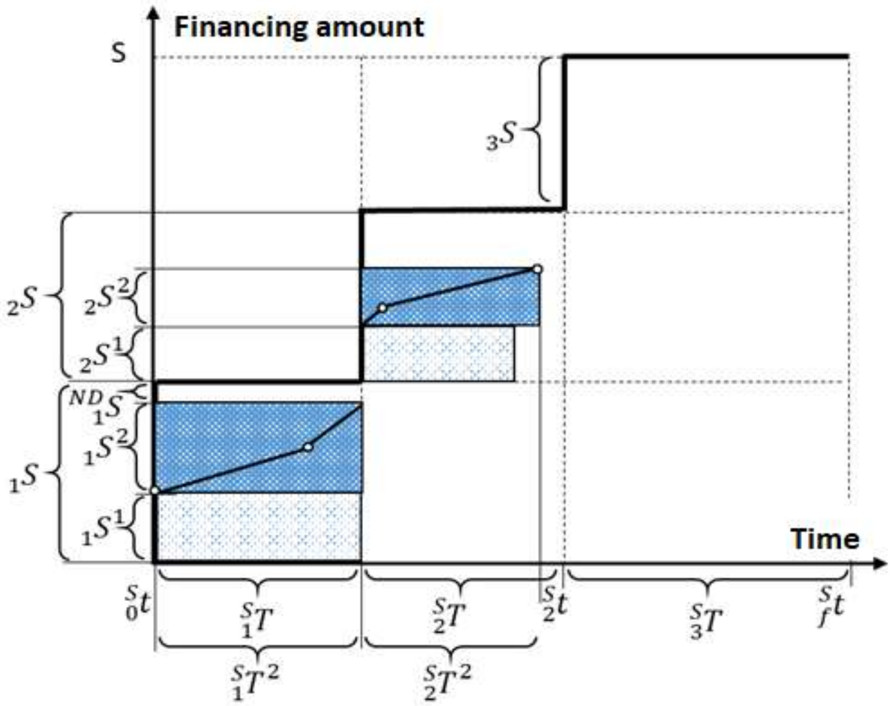


Figure 4.8. Second part transfer of second project to the beginning of its financing in second portfolio phase

Source: developed by author.

After packing two projects in first phase, there were still unallocated funds $^{ND}_{1}S$ (fig. 4.8). Therefore, we select next priority project, prepare it as the previous ones, and place it on the first financing phase (fig. 4.9). As we can see, S-curve previously intersects at point *C* with straight line that limits the first phase financing. Those, for given financing schedule, in contrast to previous projects, limiting factor for third project is not financing phase duration, but its financing volume.

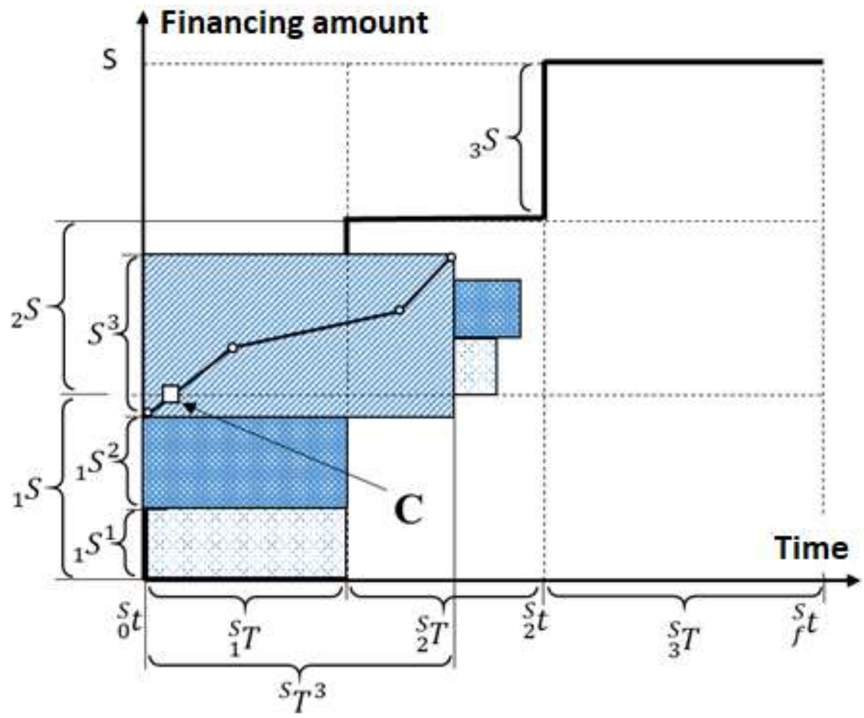


Figure 4.9 - Third project placement in the first portfolio financing phase

Source: developed by author.

Therefore, we do not mix constructed rectangles (fig. 4.10) upwards, as we did for the first and second projects, but to the right until point C coincides with start point for second portfolio phase financing (fig. 4.11). Then we move second rectangle vertically upwards and set it over second project rectangle (fig. 4.12). As we can see, in this position S-curve intersects with line that limits second tranche volume at point *D*. Therefore, relative to this point, we build two new rectangles (fig. 4.13) and move them together until point *D* coincides with start point for third phase financing. (fig. 4.14). Such displacement caused temporary break in third project S-curve. And this violates packaging project logic. Therefore, third project cannot be financed in first phase. For this reason, unallocated funds remain in first phase ${}^{ND}_{1}S$ (fig. 4.15).

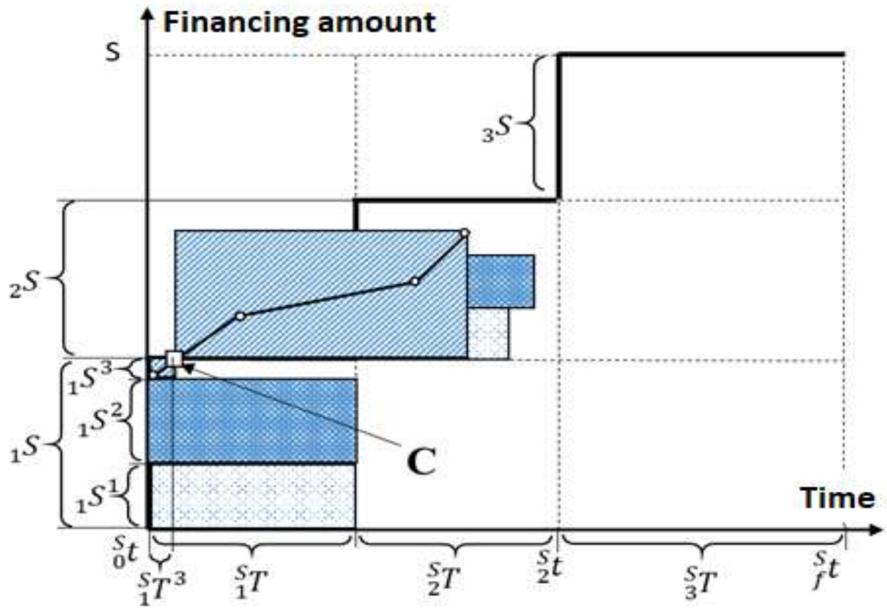


Figure 4.10. Third project dividing into parts by portfolio financing phases

Source: developed by author.

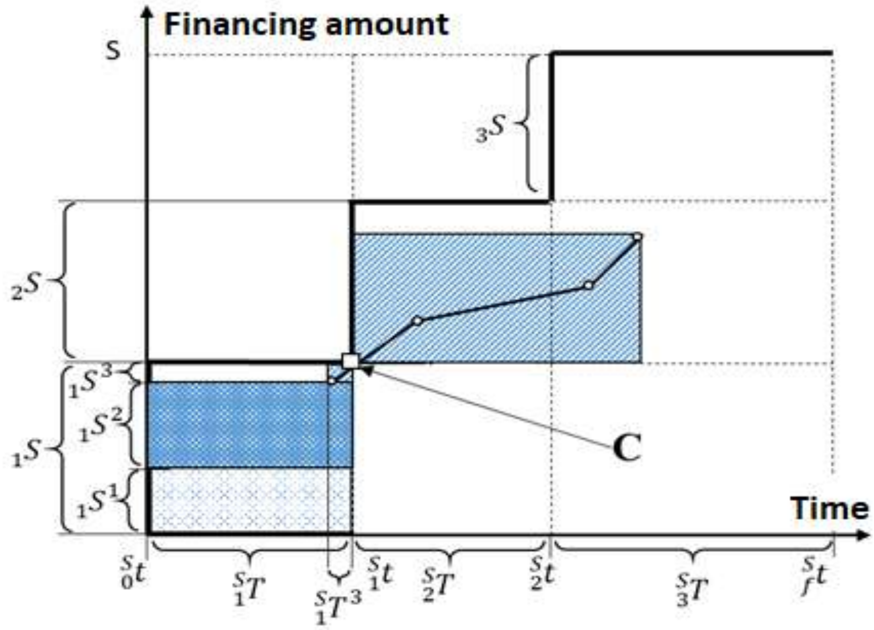


Figure 4.11 - Third project shift to combining point of its separation into parts with beginning of second portfolio financing phase

Source: developed by author.

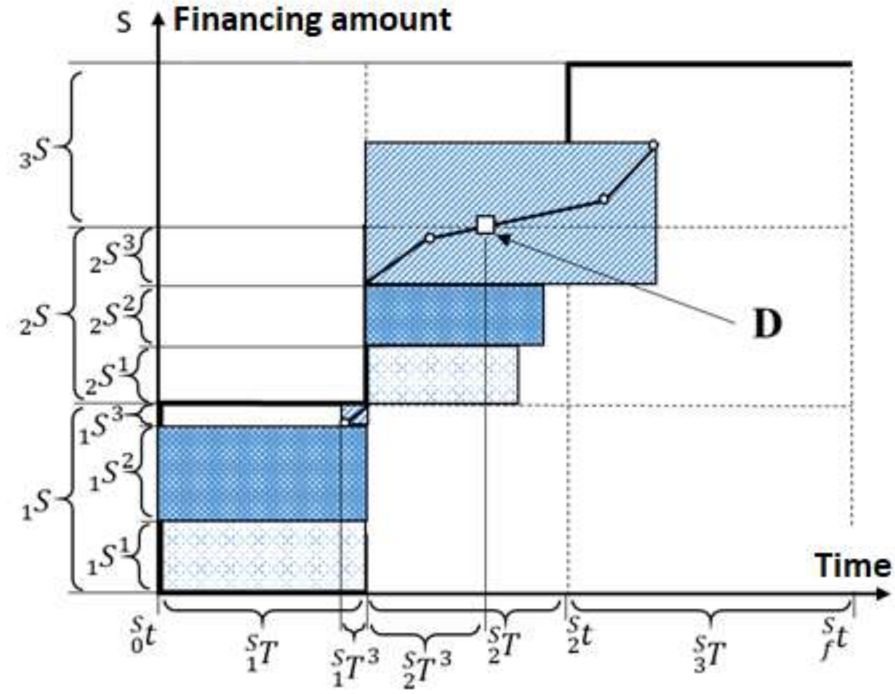


Figure 4.12 - Second part transfer of third project to the beginning of its financing in second portfolio phase

Source: developed by author.

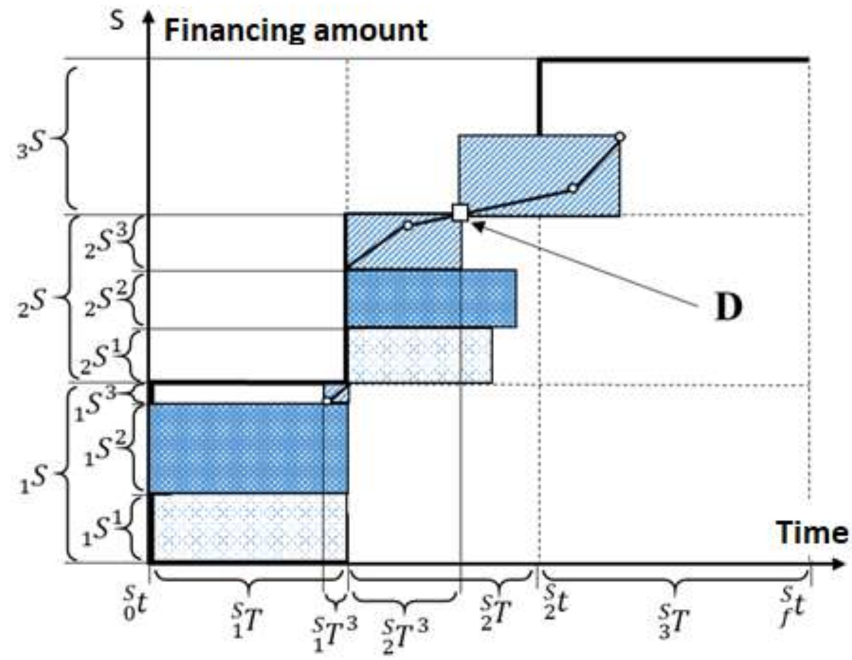


Figure 4.13 - Second part division of third project into two parts by portfolio financing phases

Source: developed by author.

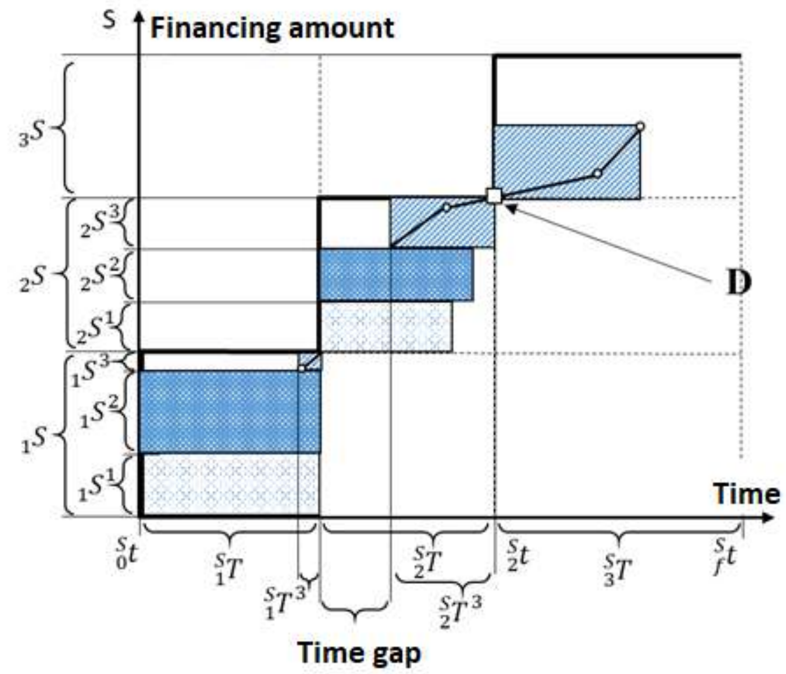


Figure 4.14 - Second part shift of third project to combine point of its separation into parts with third portfolio financing start phase.

Source: developed by author.

According to previously described rules, unallocated amount goes to the second financing stage. Therefore, second parts of first and second projects are shifted vertically downward by $^{ND}_{1}S$. (fig.4.15). After this, third project combine with financing start of second phase and locate above them. As a result of this arrangement, point E of third project S-curve intersection with line appears that limits second tranche volume (fig. 4.15). Two rectangles are constructed around this point (fig. 4.16) that jointly moved to the right point where third tranche financing begins (fig. 4.17). It completes third project packaging.

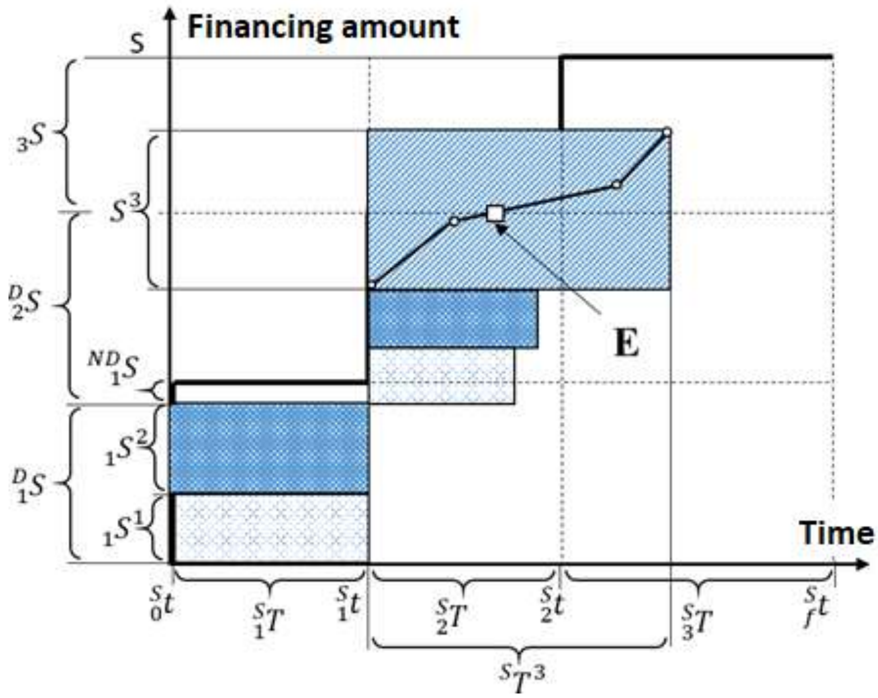


Figure 4.15 - Third project placement in second portfolio financing phase

Source: developed by author.

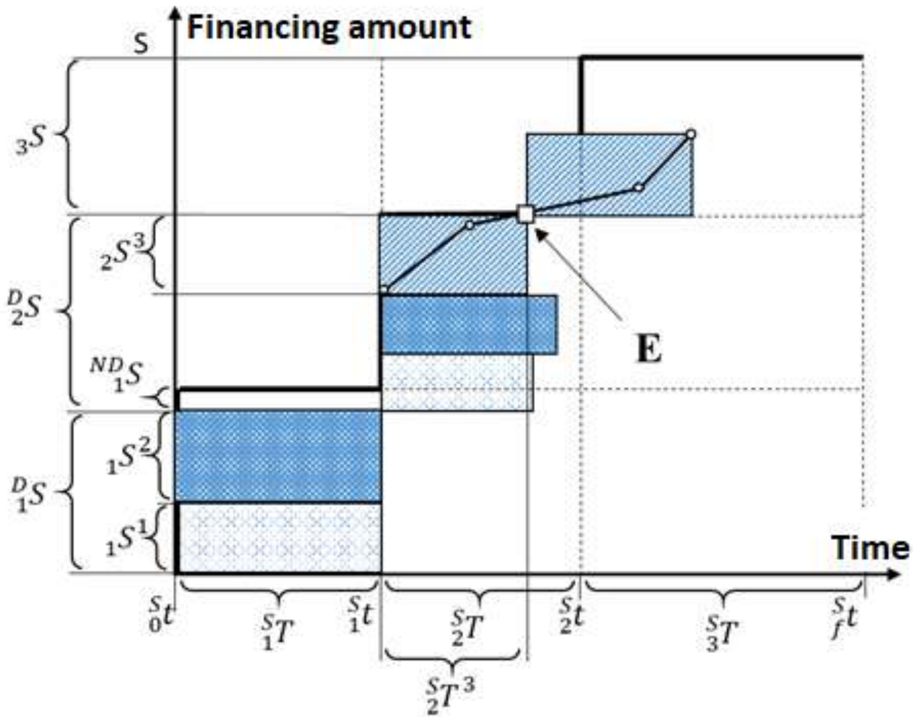


Figure 4.16 - Third project dividing into parts by portfolio financing phases

Source: developed by author.

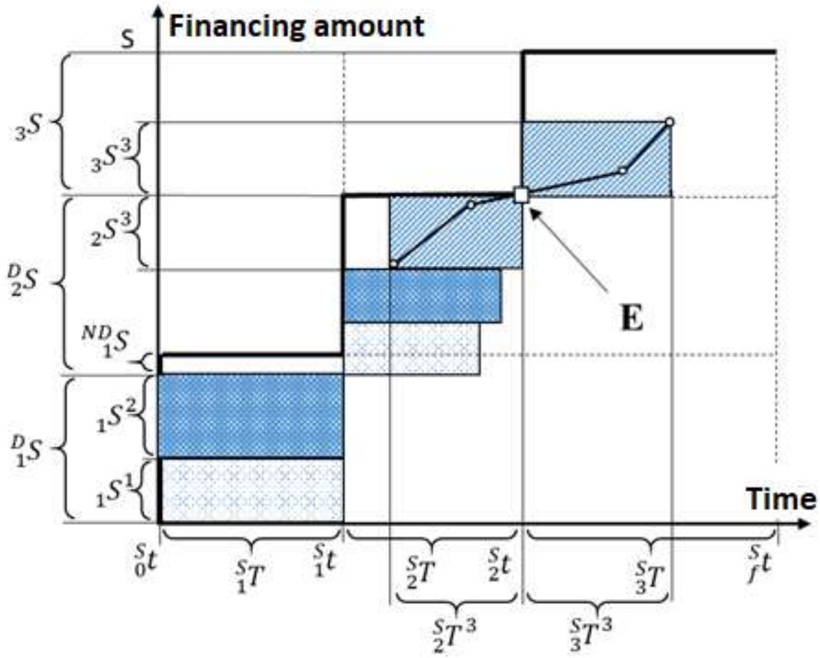


Figure 4.17 - Third project shift to point combination of its division into parts with third portfolio financing phase.

Source: developed by author.

According to above-described scheme, further project packaging is carried out until moment when last project finish begins to go beyond allotted time for project portfolio financing or beyond its planned financing amount.

Appendix E describes step-by-step algorithm and provides block diagram that develop on model proposals basis.

For holistic financing nature perception for each project within portfolio, we return previously deleted S-curves of all projects to corresponding rectangles (fig. 4.18).

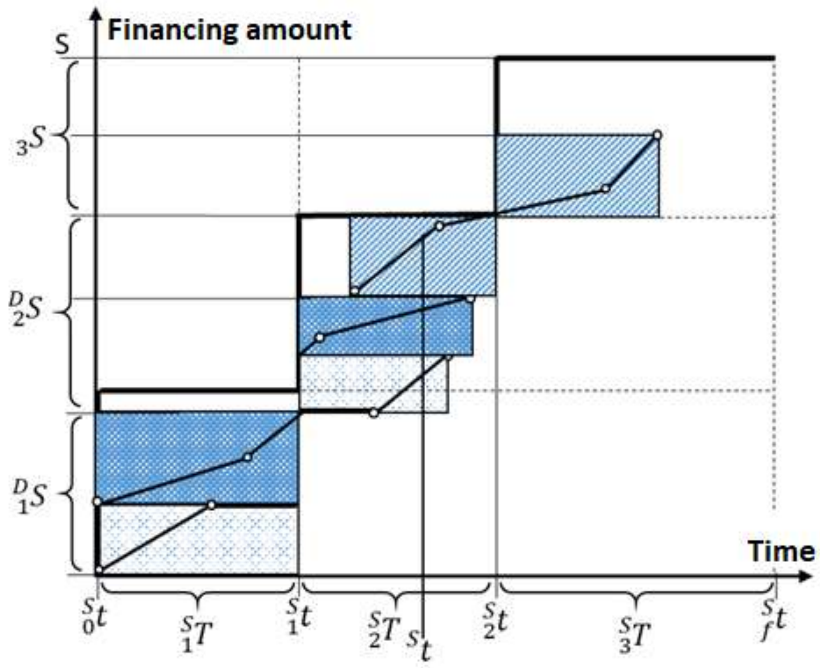


Figure 4.18 - Three projects placement on the portfolio financing field

Source: developed by author.

Figure 4.18 analysis shows that for any current point in time portfolio financing ${}^{s}t$ we can determine portfolio financing amount that is needed at specified point in time. And this make it possible to build an integrated portfolio cost curve based on the known S-cost project - candidates curves. In fact, such portfolio curve is project S-curve analogue [242]. Therefore, it is advisable to build it as configurator cost panel part (fig. 2.4)

4.2. Model for packing projects into portfolio with a systematic financing schedule

An analysis of project presentation submission roadmap shows that S-curve costs and S-curve results presented in it are related to each other by time period when the project product's effect appears if to compare to the project start (point 3.1 of Appendix E). It also confirmed by the information underlying rule for shifting effects in projects (section 1.1). It makes possible using the well-known model for placing S-curves of project costs in portfolio financing field (Fig. 4.18), to build a similar model for placing S-curve results in portfolio results field. Start of each result we determine by project start in portfolio. And this allows to build a result integral curve from use project portfolio products. Such curve is similar to project-candidates S-curve results. Therefore, its construction, as well as construction of an integral portfolio cost curve, should be carried out within configurator framework (fig. 2.2) on result panel. To do this, select additional areas for portfolio in corresponding panels (fig. 4.19).

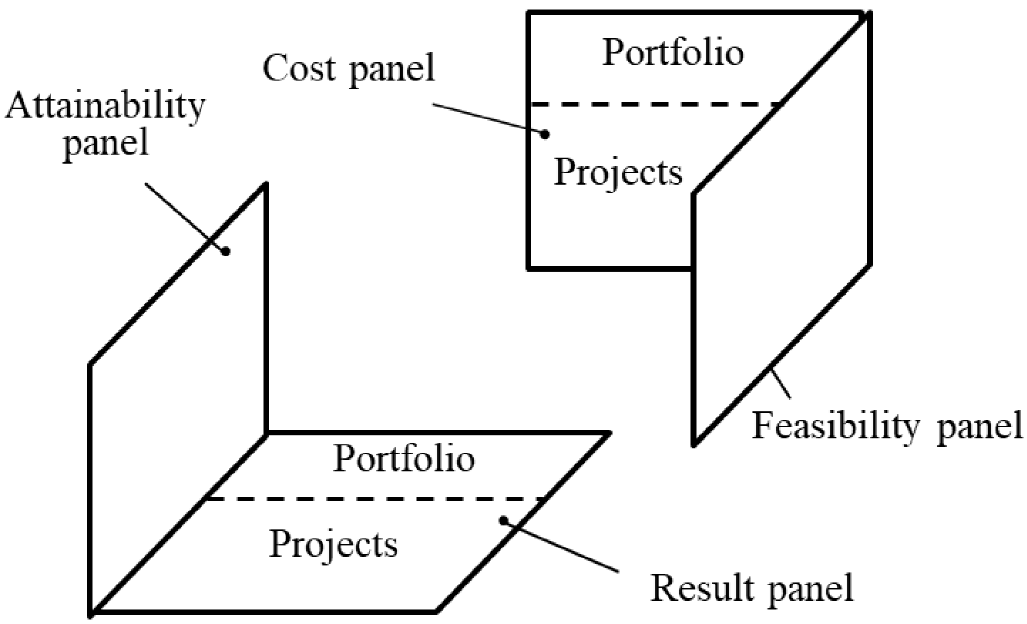


Figure 4.19 - Areas for representing project portfolio costs and results knowledge in corresponding configurator panels

Source: developed by author

Consider constructing task of project portfolio integrated cost curve (requested financing) based on the known S-shaped cost curves for project- candidates (hereinafter - projects) included in its structure. For projects, coordinate system in that portfolio costs we describe as global. We introduce “critical moments of the portfolio time” concept. By portfolio critical time moments, we mean projections values of project start and finish moments and their critical financing moments that coincide with change moments in financing rate.

Therefore, forming array task of portfolio critical moments in global coordinate system comes down to determining start, finish and critical moments projections of project financing already packed into portfolio. That’s why we introduce following notation:

${}^s t_0$ - initial moment (start) of project portfolio financing, ${}^s t_0 = 0$ {input value};

${}^s t_f$ - final moment (finish) of project portfolio financing {input value};

${}^s T$ - duration of project portfolio financing, ${}^s T = {}^s t_f - {}^s t_0$;

${}^s t$ - current moment (time) of project portfolio financing, ${}^s t \in \left[{}^s t_0; {}^s t_f\right]$;

j - selected project number in project portfolio, $j = 1,2,...,N$, where N - the project number in portfolio, $N \le M$;

Δ^j - time after that they begin to finance j - project after portfolio financing start;

${}^s t_0^j$ - initial financing moment (start) of j-project in project portfolio, ${}^s t_0^j = {}^s \tau_0^j + \Delta^j$;

${}^s t_f^j$ - final financing moment (finish) of j- project in project portfolio, ${}^s t_f^j = {}^s t_0^j + {}^s T^j$;

${}^s t_1^j$, ${}^s t_2^j$ - critical financing moments (pace change) of j- project in project portfolio, ${}^s t_1^j = {}^s t_0^j + T_1^j$, ${}^s t_2^j = {}^s t_0^j + T_2^j$, ${}^s t_1^j < {}^s t_2^j$, ${}^s t_1^j \in \left[{}^s t_0^j; {}^s t_f^j\right]$, ${}^s t_2^j \in \left[{}^s t_0^j; {}^s t_f^j\right]$.

Based on expressions obtained for initial moments of project portfolio financing, their critical moments and financing completion moments, we form an project portfolio critical moments array as set obtained power by combining start, critical and finish moments of all j - projects

$$K = \left| \bigcup_j \left\{ {}^s t_0^j, {}^s t_1^j, {}^s t_2^j, {}^s t_f^j \right\} \right|, \qquad (4.1)$$

K - number of project portfolio financing critical moments (change in pace).

We mark project portfolio financing critical moments, ${}^s t_k$, introducing condition that ${}^s t_k < {}^s t_{k+1}$, and ${}^s t_k \in \left[{}^s t_0 ; {}^s t_f \right]$, $k = 1,2,..,K-1$. Then we build graphical portfolio critical points model (fig. 4.20). Let's move on to solving portfolio costs determining problem to finance its projects. To do this, we introduce following notation:

s_0 - project portfolio initial costs, costs at moment t_0, t_0, $s_0 = \{s_0^j$, if $\Delta^j = 0\}$;

S - total project portfolio costs incurred for whole time T till moment t_f.

Then costs s_k^j for i - project financing for project portfolio critical moments ${}^s t_k$ can be calculated as

$$s_k^j = \begin{cases} 0, & {}^s t_k < {}^s t_0^j \\ \sigma^j({}^s t_k - \Delta^j), & {}^s t_0^j \le {}^s t_k < {}^s t_f^j \quad {}^s t_0^j = {}^s \tau_0^j + \Delta^j \\ S^k, & {}^s t_k \ge {}^s t_f^j \end{cases}. \qquad (4.2)$$

Fig. 4.21 shows cost components for each project that financed at moment ${}^s t_k$. As we can see from figure, after project completion, fixed costs are assigned to this project that numerically equal to the accumulated project financing costs (for example, at *K-1* moment).

Fig. 4.22. shows portfolio cost formation process at its critical points. As we can see, financing schedule for the first project that extended until entire project financing is straight parallel to the time axis, is curved basis on that similar funding schedule for the second project is superimposed. As a result, new curvilinear basis formed for third project financing schedule. And this process continues until last portfolio project completion.

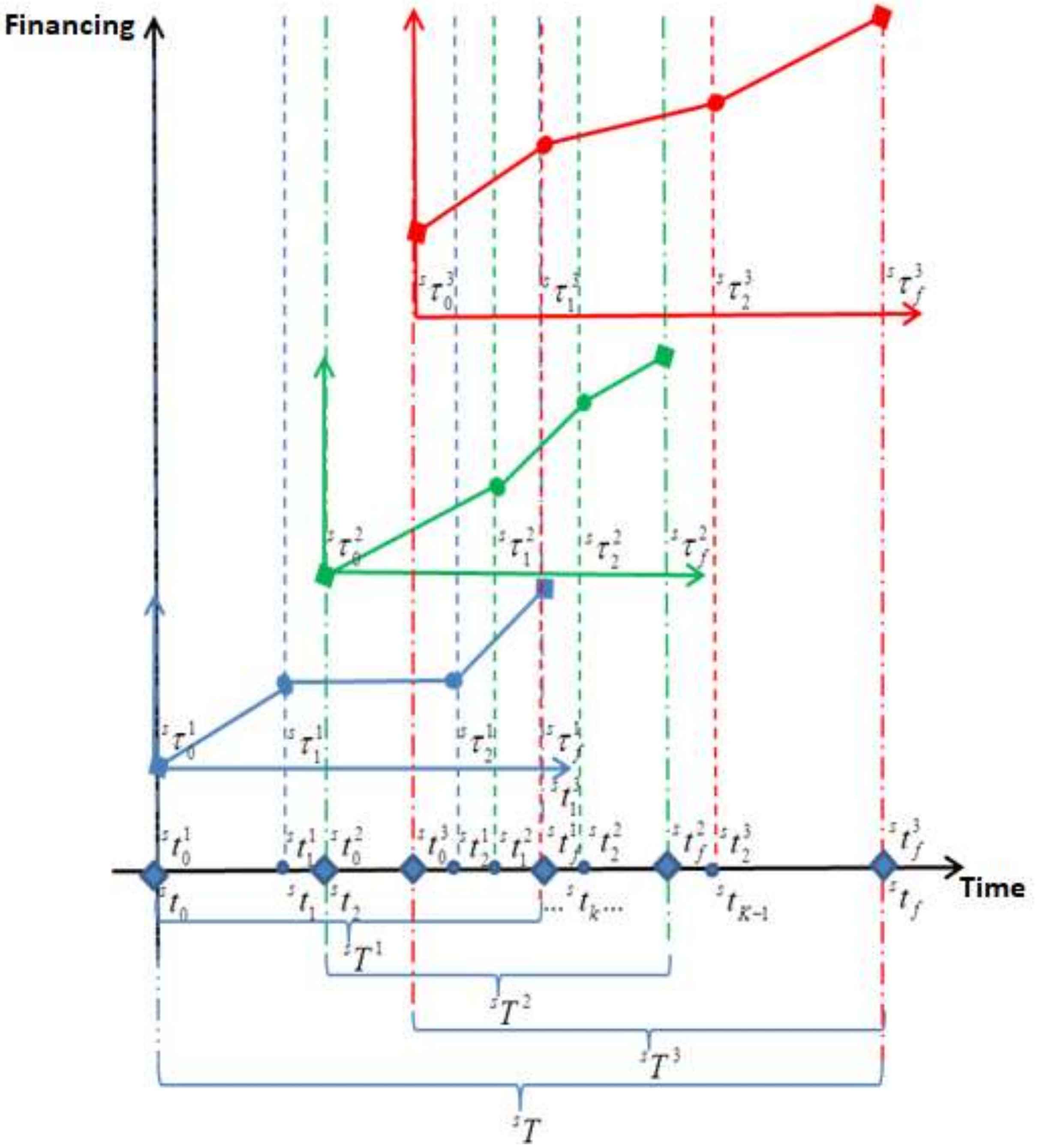


Figure 4.20. An example of critical points formation for financing three projects portfolio

Source: developed by author.

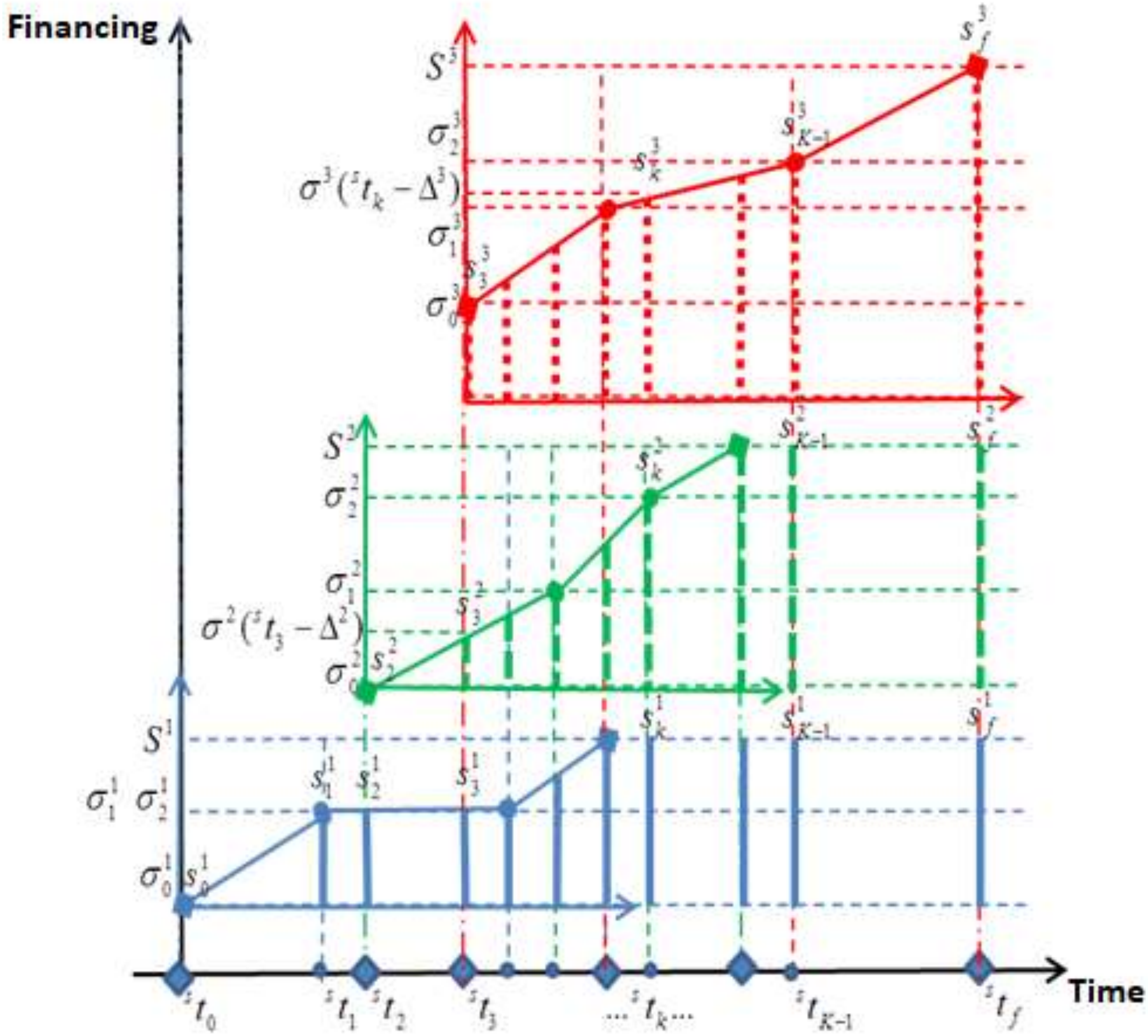


Figure 4.21. Project cost components for portfolio financing at critical moments (case of three projects portfolio)

Source: developed by author.

Denote by s_k project portfolio costs at critical moments ${}^s t_k$. They determined by summing project costs according to formula

$$s_k = \sum_{j=1}^{N} s_k^j \,, k = 1,2,.., K \,. \tag{4.3}$$

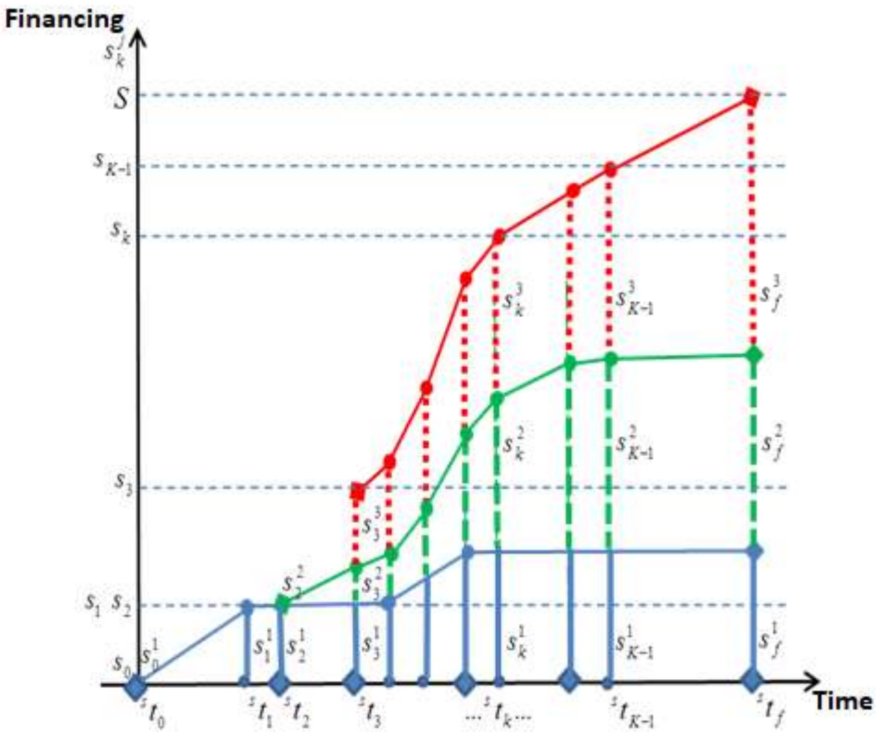


Figure 4.22. Project portfolio cost formation at critical moments

Source: developed by author

According to this model, project portfolio costs formation at moment ${}^{s}t$, can represented by piecewise linear function $s({}^{s}t)$, that has following form:

$$s({}^{s}t)=\begin{cases}\dfrac{s_1-s_0}{{}^{s}t_1-{}^{s}t_0}({}^{s}t-{}^{s}t_0)+s_0, & {}^{s}t_0<{}^{s}t<{}^{s}t_1\\ \dfrac{s_2-s_1}{{}^{s}t_2-{}^{s}t_1}({}^{s}t-{}^{s}t_1)+s_1, & {}^{s}t_1<{}^{s}t<{}^{s}t_2\\ \ldots & \\ \dfrac{s_{k+1}-s_k}{{}^{s}t_{k+1}-{}^{s}t_k}({}^{s}t-{}^{s}t_k)+s_k, & {}^{s}t_k<{}^{s}t<{}^{s}t_{k+1}\\ \ldots & \\ \dfrac{S-s_J}{{}^{s}t_f-{}^{s}t_K}({}^{s}t-{}^{s}t_K)+s_K, & {}^{s}t_K<{}^{s}t<{}^{s}t_f\end{cases}, \qquad (4.4)$$

where, ${}^{s}t_k$ - function change point, $k=1,2,..,K$.

Fig. 4.23 show piecewise linear function for project portfolio that S-shaped curves are shown in fig. 4.20.

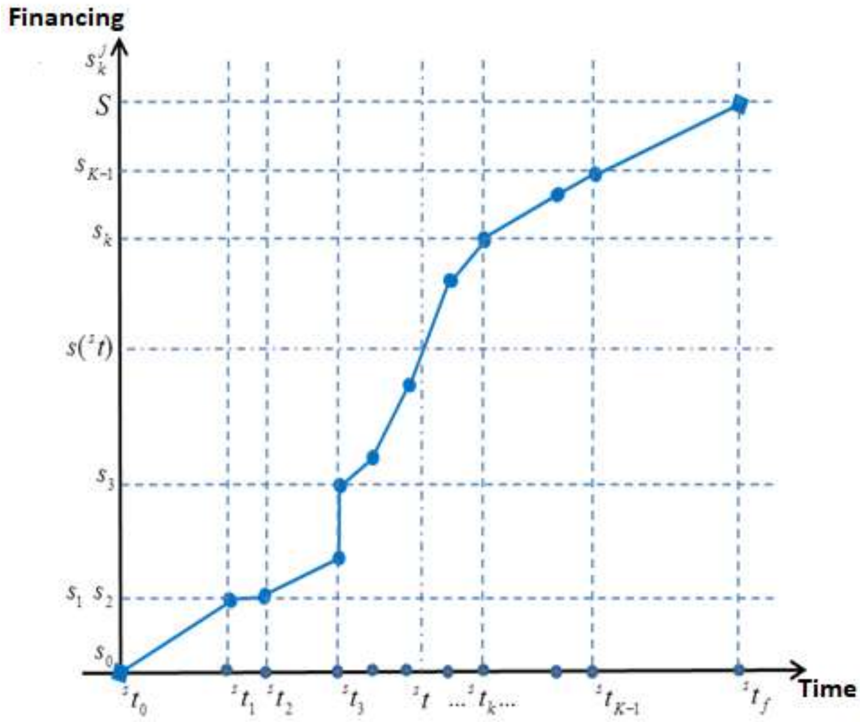


Figure 4.23. - Project portfolio financing schedule

Source: developed by author.

At its core, schedule is an integral curve that displays planned use of allocated funds to portfolio financing.

For perception integrity and further convenience of information use about mathematical model and its graphical interpretation (fig. 4.23) in table. 4.1 summarized indicator designations that we use to describe j- project in portfolio.

Described model represents new knowledge about project that give an idea of its place and role in project portfolio. Therefore, its location on the project configurator cost panel is logically justified.

Consider describing results task (effect) that is expected to be obtained from project portfolio product operation. For some portfolios, effect manifestation can theoretically be immediately different from zero at the time project is completed. This is because, for example, project product result may be the suspension or certain negative process liquidation. And this mathematically corresponds to the discontinuity of a function of the first kind, i.e. its abrupt change.

Table 4.1 - Designation of j- project indicators in portfolio

Project timing				Financing		Product effect	
				time	value	time	value
Moments	Input values	initial		${}^{s}t_0^j$	s_0^j	${}^{r}t_0^j$	r_0^j
Moments	Input values	critical moments	1	${}^{s}t_1^j$	s_1^j	${}^{r}t_1^j$	r_1^j
Moments	Input values	critical moments	2	${}^{s}t_2^j$	s_2^j	${}^{r}t_2^j$	r_2^j
Moments	Input values	portfolio critical points		${}^{s}t_k$	s_k^j	${}^{r}t_k^j$	r_k^j
Moments	Input values	final		${}^{s}t_f^j$	S^j	${}^{r}t_0^j \; {}^{r}r_f^j$	R^j
Moments	current			${}^{s}t^j$	$s^j({}^{s}t^j)$	${}^{r}t^j$	$r^j({}^{r}t^j)$
Duration	from portfolio beginning to project start			${}^{s}\Delta^j$	–	${}^{r}\Delta^j$	–
Duration	to critical moment		1	${}^{s}T_1^i$	–	${}^{r}T_1^i$	–
Duration	to critical moment		2	${}^{s}T_2^i$	–	${}^{r}T_2^i$	–
Duration	whole project			${}^{s}T^i$	–	${}^{r}T^i$	–

With this in mind, we introduce following notation for indicated problem:

${}^{r}t_0$ - obtaining effect initial moment (start) of project portfolio product;

${}^{r}t_f$ - final moment (finish) of obtaining project portfolio product effect;

${}^{r}T$ - duration of project portfolio product effect, ${}^{r}T = {}^{r}t_f - {}^{r}t_0$;

${}^{r}t$ - current moment (time) of effect project portfolio product obtaining, ${}^{r}t \in \left[{}^{r}t_0; {}^{r}t_f\right]$.

Then number of critical moments (change in pace) to obtain project portfolio product effect - G, we find as set obtained power by combining starts pairs, critical moments and finishes of all j- projects (formula 4.5).

$$G = \left| \bigcup_j \left\{ {}^{r}t_0, {}^{r}t_1, {}^{r}t_2, {}^{r}t_f \right\} \right| \qquad (4.5)$$

where ${}^{r}t_g$ - critical moments of getting project portfolio product effect, ${}^{r}t_g < {}^{r}t_{g+1}$, ${}^{r}t_j \in \left[{}^{r}t_0; {}^{r}t_f\right]$, $g = 1,2,..,G$;

r_0 - initial project portfolio product effect, effect at time ${}^{r}t_0$;

R - final project portfolio product effect received all the time ${}^{R}T$ till moment ${}^{r}t_f$

r_g - project portfolio product effect at critical moments ${}^{r}t_g$, $g = 1,2,..,G$.

Then, by analogy with (6), we write piecewise linear function equation $r({}^{r}t)$ project portfolio product effect at moment ${}^{r}t$:

$$r({}^{r}t) = \begin{cases} \dfrac{r_1 - r_0}{{}^{r}t_1 - {}^{r}t_0}({}^{r}t - {}^{r}t_0) + r_0, & {}^{r}t_0 < {}^{r}t < {}^{r}t_1 \\ \dfrac{r_2 - r_1}{{}^{r}t_2 - {}^{r}t_1}({}^{r}t - {}^{r}t_1) + r_1, & {}^{r}t_1 < {}^{r}t < {}^{r}t_2 \\ \ldots \\ \dfrac{r_{g+1} - r_g}{{}^{r}t_{g+1} - {}^{r}t_g}({}^{r}t - {}^{r}t_g) + r_g, & {}^{r}t_j < {}^{r}t < {}^{r}t_{j+1} \\ \ldots \\ \dfrac{R - r_G}{{}^{r}t_f - {}^{r}t_G}({}^{r}t - {}^{r}t_G) + r_G, & {}^{r}t_J < {}^{r}t < {}^{r}t_f \end{cases}, \qquad (4.6)$$

where, ${}^{r}t_g$ - function change point, $g = 1,2,..,G$.

Above equation describes change in integral result (effect) that obtained from beginning of its appearance to manifestation end of the most distant effect. It should be noted that occurrence sequence of effect does not correspond to the sequence of project financing in portfolio.

For information perception integrity on proposed mathematical model for project portfolio products operation assessing effect, we reduce notation used in table 4.2.

Described model of integral effect represents new knowledge about project. Therefore, its location on project configurator result panel is also with logical decision [243].

Following the obtaining new synthesized knowledge logic at retention configurator points that we use in Section 2.3, together with knowledge presented consideration on cost and result panels, it is necessary to consider knowledge on the configurator attainability and feasibility panels. For this reason, these panels highlight areas for representing knowledge about project portfolio (fig. 4.24). This knowledge should be knowledge analogues about project feasibility standards ${}^{\sigma}d^{i}$ and attainability of the result from project product using ${}^{r}d^{i}$. To obtain generation of such knowledge, we use following graphical model (fig. 4.25). Find portfolio realizability value norm at the critical point ${}^{s}t_{k}$. This critical portfolio point formed by critical project point projection *j*+3. At this point in time, project *j* with feasibility norm already implemented in portfolio ${}^{\sigma}d^{j}$.

Table 4.2 - Designation of j - project indicators in portfolio

<table>
<tr><td colspan="3" rowspan="2">Project timing</td><td colspan="2">Financing</td><td colspan="2">Product effect</td></tr>
<tr><td>time</td><td>value</td><td>time</td><td>value</td></tr>
<tr><td rowspan="4">Moments</td><td rowspan="3">Input quantities</td><td>initial</td><td>${}^{s}t_0$</td><td>s_0</td><td>${}^{r}t_0$</td><td>r_0</td></tr>
<tr><td>critical moments</td><td>${}^{s}t_k$</td><td>s_k</td><td>${}^{r}t_k$</td><td>r_k</td></tr>
<tr><td>final</td><td>${}^{s}t_f$</td><td>S</td><td>${}^{r}t_f$</td><td>R</td></tr>
<tr><td colspan="2">current</td><td>${}^{s}t$</td><td>$s({}^{s}t)$</td><td>${}^{r}r$</td><td>$r({}^{r}t)$</td></tr>
<tr><td colspan="3">Duration of whole project</td><td>${}^{s}T$</td><td>–</td><td>${}^{r}T$</td><td>–</td></tr>
</table>

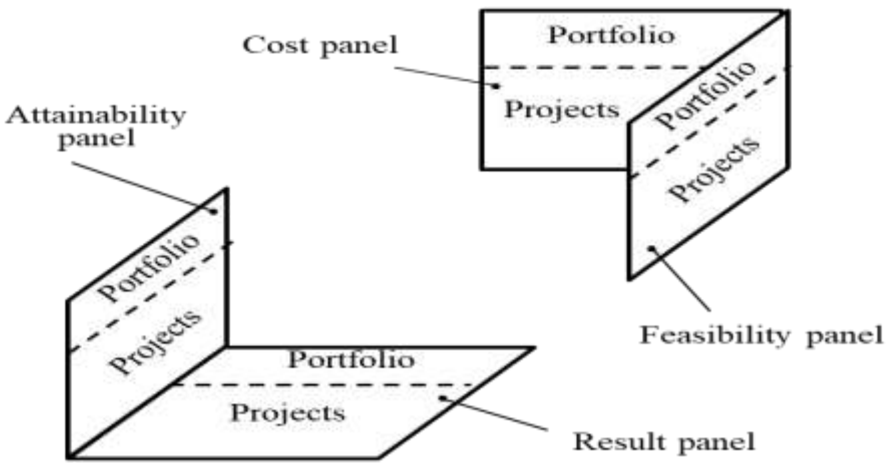


Figure 4.24. Areas for representing knowledge about feasibility and attainability standards in configurator corresponding panels

Note: developed by the author

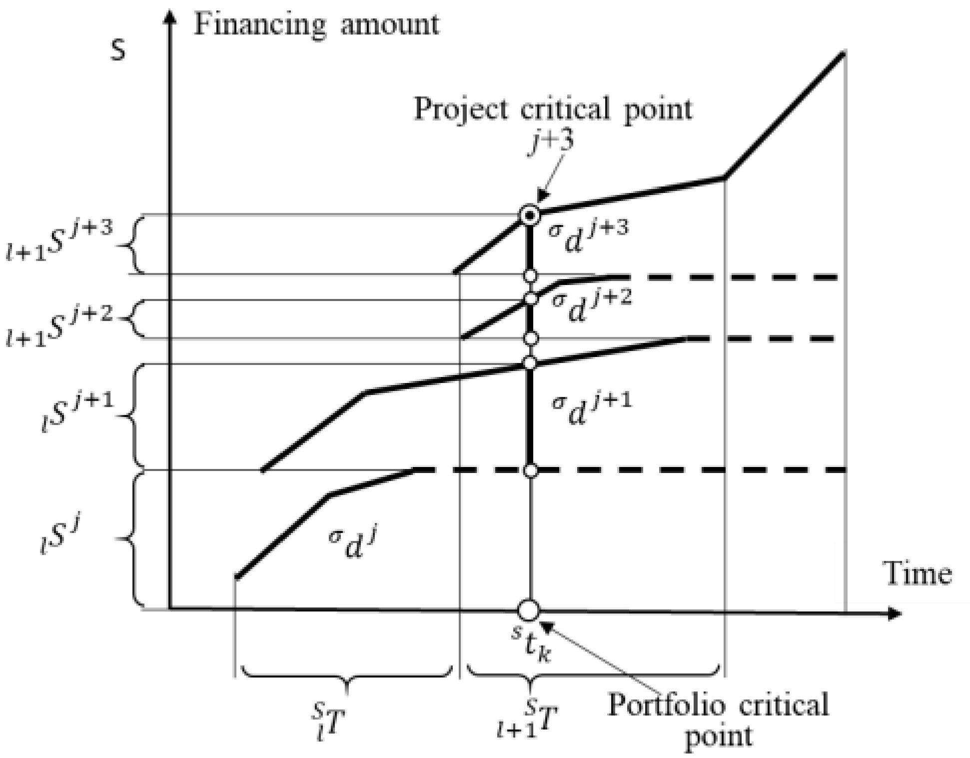


Figure 4.25. Project parameters used to calculate portfolio realizability rates at critical points

Source: developed by author

This is evidenced by dash with dotted straight line that ends at the end of portfolio financing. Therefore, this project is not considered in calculating portfolio realizability rate. At point ${}^{s}t_k$ three projects continue to implement *j*+1, *j*+2 and *j*+3. At this point, each of these projects should receive funds in amount of ${}_{l}S^{j+1}$, ${}_{l+1}S^{j+2}$ и ${}_{l+1}S^{j+3}$ respectively. But each of projects has its own rate of feasibility ${}^{\sigma}d^{j+1}$, ${}^{\sigma}d^{j+2}$, и ${}^{\sigma}d^{j+3}$. Therefore, to calculate portfolio realizability rate at this critical point, it is advisable to apply arithmetic mean formula. In our case, it has following form

$$ {}_{k}^{s}d = \frac{\sum_{m=1}^{m_f} {}^{\sigma}d^{m} * {}_{l}S^{m}}{\sum_{l} S^{m}} \qquad (4.7) $$

where m_f - number of projects that are implemented at critical point in portfolio.

A similar formula can obtain for calculating portfolio attainability standard.

$$ {}_{k}^{R}d = \frac{\sum_{m=1}^{m_f} {}^{r}d^{m} * {}_{l}R^{m}}{\sum_{l} R^{m}} \qquad (4.8) $$

where m_f number of project products that show their effect at critical effect point.

Obtained formulas for portfolio feasibility and attainability standards calculating allow us to write new synthesized knowledge at retention points of the portfolio configurator, similar to the knowledge at retention project configurator points (2.XX and 2, XX), in next form

$$ {}^{S}V = F\left(\sum_{k={}^{s}t_0}^{{}^{s}t_f} \frac{S_k}{\left(1+{}_{k}^{S}d\right)^{k}}\right), \qquad (4.9) $$

$$ {}^{R}V = F\left(\sum_{k={}^{r}t_0}^{{}^{r}t_f} \frac{R_k}{\left(1+{}_{k}^{R}d\right)^{k}}\right), \qquad (4.10) $$

where ${}^{S}V$ - portfolio feasibility indicator;

${}^{R}V -$ indicator of portfolio result attainability;

$S_k -$ flow parameter value that describe portfolio costs in k - *time* its implementation period;

$R_k -$ flow parametervalue that describes portfolio result in k- *period* of operating time of products created in its implementation process.

CHAPTER 5
PROJECT PORTFOLIO CONFIGURING BY ATTRACTIVENESS CRITERION

5.1. Development of a benchmark indicator for the project and portfolio attractiveness

Term “attractiveness” we use to describe categorization model and prioritize project-candidates (section 3.1) as well as method for transforming diverse projects outcomes (section 3.2). We did consciously, as in portfolio formation, quite often criteria-based indicators of project attractiveness are used [244-249]. In various sources, this indicator, as a rule, does not have clear fixed definition and each one uses it intuitively in different contexts. Therefore, in each study, to remove ambiguity of its understanding, it is necessary to clarify attractiveness essence. In context of this research, «project attractiveness» concept means an integral indicator that determined by flowing diversity characteristics of project costs ${}^{\sigma}V^{i}$, expected result ${}^{r}V^{i}$ and its strategic importance ${}^{s}V^{i}$. Firstly, project attractiveness V^{i} depends on interest degree in project by portfolio management council part as well as on degree of demand for project product on its potential user’s part.

We display project attractiveness indicator in functionality form

$$V^{i} = F\left({}^{\sigma}V^{i}, {}^{r}V^{i}, {}^{s}V^{i} \right) \qquad (5.1)$$

Further, 5.1 we use as criterion indicator structural basis. In project configurator, it is located in project integrated indicator zone for configuration and reflects new synthesized knowledge (fig. 5.1). It should be noted that new knowledge about project should be considered along with knowledge about project portfolio financing nature ${}_{T}^{S}S$ that also located in project integral indicator zone (fig. 5.1).

Section 3.3 shows that discount procedure use for accumulated value of any flow parameter allows one to indicator obtain *ADACF* that meet requirements for project integral indicator configuration. Indicator *ADACF* allows to reflect existing differences between projects by nature and changes duration in their flow parameters and to make quantitative comparison between them. However, to transfer such indicator into criteria category, it is necessary to conduct an additional study of it. To do this, we verify its compliance with following assumptions: projects with costs decreasing nature over periods and with shorter duration are more attractive.

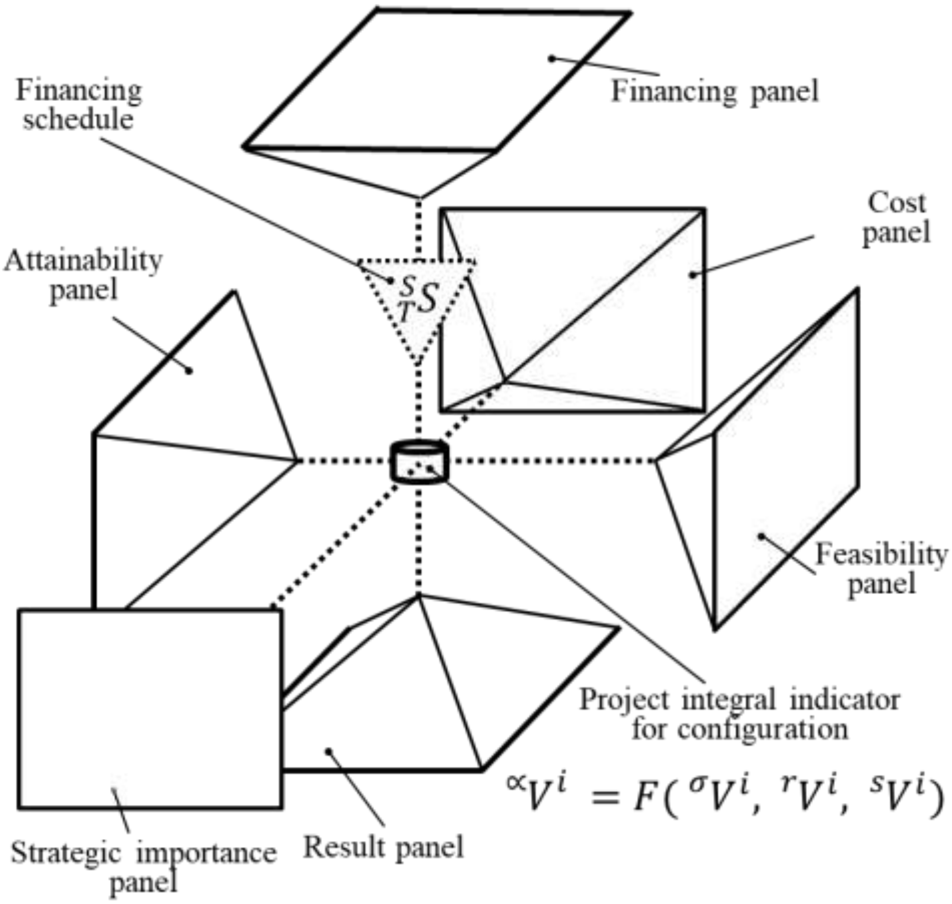


Figure 5.1 - Project attractiveness indicator location in project - candidate configurator

Source: developed by author.

Costs nature assumption arises from rapid innovation concept [250] and understanding that financing costs of project later periods is always more risky. Project duration assumption flow out from imperative of rapid entry into market [250], according to that early benefits from project product operation provide more benefits.

From introduced assumptions points and change nature analysis, the most attractive in flow characteristics given in table. 3.3.1 is project 1. This conclusion is due to the fact that project 1 has cost decreasing nature by periods compared with project 2, and shorter duration compared to project 3. Of the remaining projects 2 and 3, project 3 is less attractive since its duration significantly exceeds project 2 duration. Findings comparison with data for three projects (table 5.1) shows correlation absence between established degree of project attractiveness and indicator *ADACF* values.

Table 5.1 - Accumulated flow discounted value for projects with various flow parameters

№	Discount rate, %	project 1	project 2	project 3
		AACF		
1	0	1420	920	2580
		ADACF		
2	1	1378	887	2431
3	2	1336	856	2294
4	3	1300	827	2167
5	4	1263	799	2050

Such fact necessitates introduction of some additional indicator that would calculated based on use different project cash flows amounts. From quality mathematics standpoint, it should be noted that geometric accumulated flow sum value interpretation is area of figure formed by horizontal flow lifetime axis and accumulated flow value curve.

As such an additional indicator, we consider discounted accumulated flow ratio (*ADACF*) to the sum of same, but not discounted flow (*AACF*). Amount *AACF* is constant value for project, regardless of accepted discount rate. In addition, dividing variable *ADACF* operation (depending on the discount coefficient) by constant, larger in value *AACF* is standardization procedure. Therefore, entered indicator we call normalized discounted accumulated *NDA* flow, value of that always be less than unity

$$NDA = ADACF/AACF \qquad (5.2)$$

Table. 5.2 shows that *NDA* value decreases from project 1 to project 3.

Table 5.2 - Normalized discounted accumulated cash flow

№	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

Moreover, this correlates with attractiveness degree of projects defined above (project 1 is most attractive, project 2 is less attractive, project 3 is least attractive). Therefore, formula (5.2) can use as basis for developing components of attractiveness criteria associated with feasibility indicators ${}^{\sigma}V^{i}$ (3.8) and attainability result $[\,{}^{r}V^{i}]_{t}$ (3.9). However, before that, we agree dimension norms that go into these formulas.

In Section 1.2, we validated that period that we use during demonstrating multi-reason venture portfolios for LSEE improvement ought to be equivalent to one month. Section 2.3 displays that proposed terms are "project feasibility rate" ${}^{\sigma}d^{i}$ and "attainability result rate from project product use" ${}^{r}d^{i}$ are analogues of "discount rate" term. Traditionally, discount rate is set in annual equivalent. This has already become the rule in implementation of this procedure in practice. Therefore, norms must also be set in annual equivalent. During project portfolio forming, portfolio management council members also think in "year" category. In light of this, we present in the estimation equations ${}^{\sigma}V^{i}$ and $[\,{}^{r}V^{i}]_{t}$ numerical factor 12. At that point, considering this coefficient and 5.2 equation structure, segment of engaging quality model related with possibility pointer displayed as follows:

$$
{}^{\sigma}W^{i} = \frac{\sum\limits_{l={}^{s}n_{0}^{i}=0}^{{}^{s}n_{f}^{i}} \dfrac{(\sigma^{i})_{l}}{\left(1+\dfrac{{}^{s}d^{i}}{12}\right)^{l}}}{\sum\limits_{l={}^{s}n_{0}^{i}=0}^{{}^{s}n_{f}^{i}} (\sigma^{i})_{l}} \qquad (5.3)
$$

where, ${}^{s}n_{0}^{i}$ - initial period of *i*-project in the local coordinate system, in that each of project is considered separately (independently of each other and other restrictions or conditions), thus ${}^{s}n_{0}^{i}$ =0;

${}^{s}n_{f}^{i}$ - final (last) cost period of *i*-project;

l - current implementation period value of *i*-project $l \in \left\{ {}^{s}n_{0}^{i} \dots {}^{s}n_{f}^{i} \right\}$;

$(\sigma^{i})_{l}$ - current accumulated value in monetary units for *i*-project in period *l;*

${}^{s}d^{i}$ - annual unrealizability rate of *i*-project.

Similarly, we present the attractiveness criterion component associated with project result attainability indicator.

$$
{}^{r}W^{i} = \frac{\sum\limits_{l={}^{r}n_{0}^{i}}^{{}^{r}n_{f}^{i}} \frac{(r^{i})_{l}}{\left(1+\frac{{}^{r}d^{i}}{12}\right)^{l}}}{\sum\limits_{l={}^{r}n_{0}^{i}}^{{}^{r}n_{f}^{i}} (r^{i})_{l}} \qquad (5.4)
$$

where ${}^{r}n_{0}^{i}$ - zero time period (start) of *i*-project result manifestation;

${}^{r}n_{f}^{i}$ - final (last) period of *i*-project result manifestation;

c - current value of *i*-project result manifestation period, $l \in \left\{ {}^{r}n_{0}^{i} \dots {}^{r}n_{f}^{i} \right\}$;

$(r^{i})_{l}$ - current accumulated value in result manifestation points of *i*-project in *l*-period;

${}^{r}d^{i}$ - unreachable result annual rate of *i*-project.

Component (5.3) we defined as potential level index of project feasibility, and component (5.4) as index of project result attainability potential level. Based on nature of these indices, the most attractive project for portfolio is project in that both indices are maximum.

When comparing projects where start of financing coincides with zero period, project with maximum attractiveness index is preferred for portfolio.

$$ {}^{\sigma r}W^{i}=\left(\frac{\sum_{l={}^{s}n_0^i}^{{}^{s}n_f^i}\frac{(\sigma^i)_l}{\left(1+\frac{{}^{s}d^i}{12}\right)^l}}{\sum_{l={}^{s}n_0^i}^{{}^{s}n_f^i}(\sigma^i)_l}\right)\left(\frac{\sum_{l={}^{r}n_0^i}^{{}^{r}n_f^i}\frac{(r^i)_l}{\left(1+\frac{{}^{r}d^i}{12}\right)^p}}{\sum_{l={}^{r}n_0^i}^{{}^{r}n_f^i}(r^i)_l}\right)\to\max . \qquad (5.5) $$

So as to have option to utilize appeal list equation while framing a portfolio, documentation utilized in nearby arrange arrangement of the undertaking we change into documentation comparing to worldwide portfolio organize framework (table 5.3).

Table 5.3 - Transformation of project indicators designation from project local coordinate system into portfolio global coordinate system

№	Indicators	Designation in coordinate system	
		project	portfolio
1	Project index	i	j
2	Period number	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 result	${}^{r}n_0^i$	${}^{r}m_0^j$
6	Result finish	${}^{r}n_f^i$	${}^{r}m_f^j$

Based on project attractiveness criterion essence (5.5), we formulate portfolio optimality criterion. We consider optimal portfolio where flow characteristics of the selected projects, taking into account ranks of their strategic importance ${}^{\alpha}V^{j}(\ldots)$, maximize project attractiveness amount of indices within a given funding flow $S\{\ldots\}$

$$ {}^{\alpha}V^{j}\left(\sum_{j\in T}\left(\left(\frac{\sum_{p={}^{s}m_0^j}^{{}^{s}m_f^j}\frac{(\sigma^j)_p}{\left(1+\frac{{}^{s}d^j}{12}\right)^p}}{\sum_{p={}^{s}m_0^i}^{{}^{s}n_f^j}(\sigma^j)_p}\right)\left(\frac{\sum_{p={}^{r}m_0^j}^{{}^{r}m_f^j}\frac{(r^j)_p}{\left(1+\frac{{}^{r}d^j}{12}\right)^p}}{\sum_{p={}^{r}m_0^j}^{{}^{r}m_f^j}(r^j)_p}\right)\right)\right)\to\max , \qquad (5.6) $$

where T - an array of selected projects.

Financing flow is set in the multi-stage schedule form, each step of that is portfolio phase.

$$S = \{S_\beta\}, M = \{M_\beta\}, \beta = 1, 2 \dots R, \qquad (5.7)$$

where S_β - accumulated amount of financing from the portfolio start including β phase;

R - financing phases number;

M_β - portfolio phase β funding end period number.

Portfolio is optimal if, at each phase of financing, condition (9) is met, subject to the following restrictions:

$$\sum_{j=0}^{M_\beta} \left(\sum_{p={}^s m_s^j}^{\gamma_K^j} (\sigma^j)_p \right) \le S_\beta \qquad (5.8)$$

where, $\gamma_K^j = \begin{cases} {}^s m_f^j, \text{если } {}^s m_f^j \le M_\beta \\ M_\beta, \text{если } {}^s m_f^j > M_\beta \end{cases}$ for all j that ${}^s m_f^j < M_\beta$,

K - rank that got j-project in portfolio in its formation process.

From (5.8) analysis it follows that at each phase there may be projects for that financing is just beginning, beginning and ending, continuing or ending.

Developed models and methods are implemented as part of systemic model research component for project portfolio formation (section 1.3, fig. 1.4). Therefore, according to inter-component relationships, it is necessary to switch to the development of project portfolio configuration software.

5.2. Computer program structure and functionality for project portfolio configuring

Before computer program developing for project portfolio configuring, we describe service model of its work. From triadic project management paradigm basic principles position, service model is an obligatory component of structuring any type of project together with schematic and system models [251].

To represent service model, we use functional modeling methodology IDEF0. This methodology we use to create functional models. Such service model presenting way allows you to display program structure and functions, as well as information and material object flows connect these functions [252]. Visual language for describing dependencies between program blocks and functions implemented by them greatly facilitates understanding of how program works by its users. Model basic components delineated in rectangular squares structure, correspondence in bolts structure. Each square contains its name and number. Name must be an active verb or verb phrase describing a function. Under function in IDEF0 refers an activity, process, or transformation (modeled by block) that describes what needs to be done. Block numbers we use to identify them in IDEF0 diagram and in diagram description corresponding text. Arrows not always represent flow or sequence of events, as in traditional flowcharts or processes. They identify data or material objects that are necessary to perform function or produced by it. Each arrow must be marked with noun or unnoun. Arrangement of blocks on diagram diagonally - from upper left corner of diagram to lower right in assigned numbers order, shows “dominance” of higher ones over lower ones. However, depending on the author’s vision, block arrangement can reflect not only “dominance”, that is, influence of some blocks on others, but also their logical use sequence.

Developed computer program service model includes eight base blocks (fig. 5.2). These are blocks for choosing an interface language, background information about program’s work, registering user data, block for entering data on projects, analyzing data and portfolio configuring, storing data, editing data, and displaying program work results. In our case, their diagonal arrangement reflects fact that only one user can work with program under one account. At the same time, at specific points in time, person can perform actions associated only with separate block function; blocks arrangement on IDEF0 diagram reflects general work logic with program. This approach complies with requirements for software description [253], according to that it is necessary to allocate parts (blocks) reasonably in program structure, indicate relationships between them, and describe their purpose with main functions disclosure.

We display in more detail blocks content (purpose) and their corresponding functions.

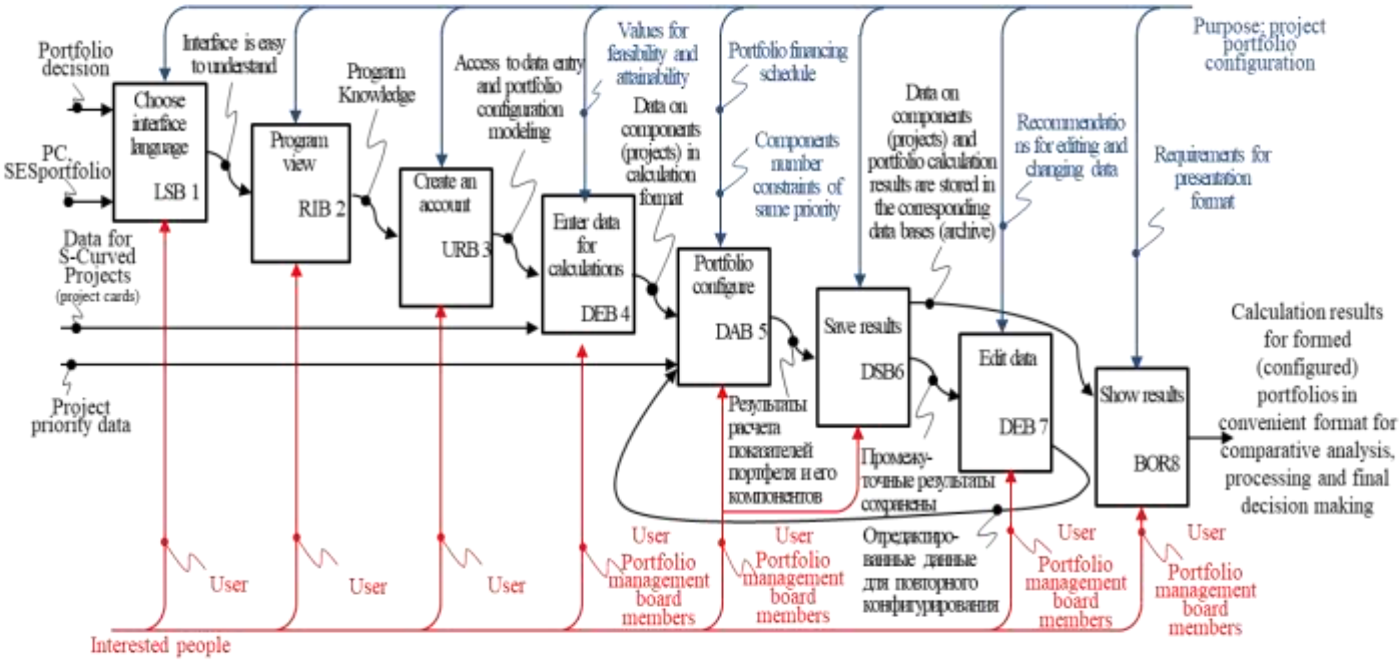


Figure 5.2 - Service model diagram describing computer program work for configuring project portfolio

Source: developed by author.

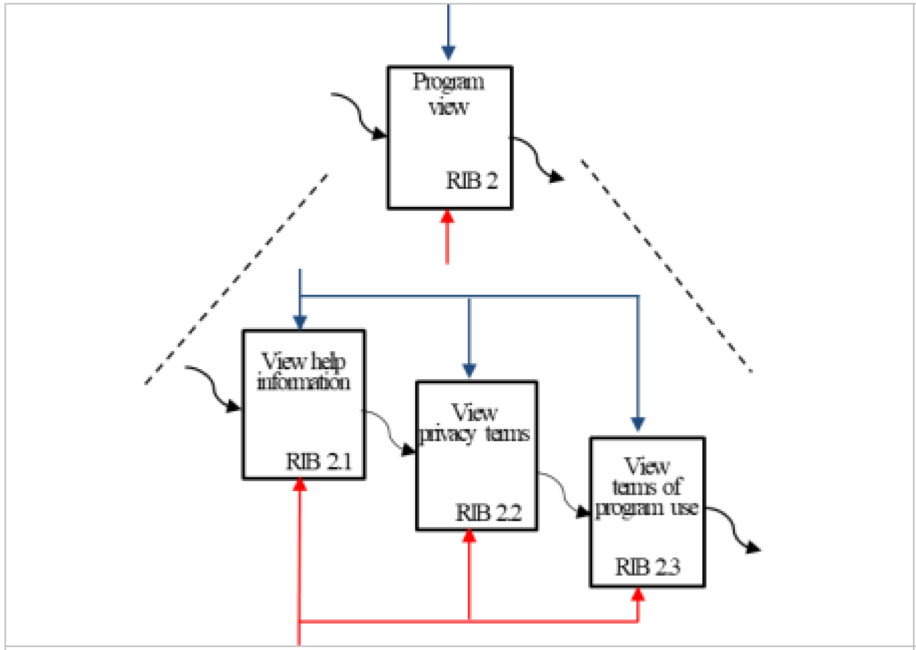


Figure 5.3 - Help block daughter chart

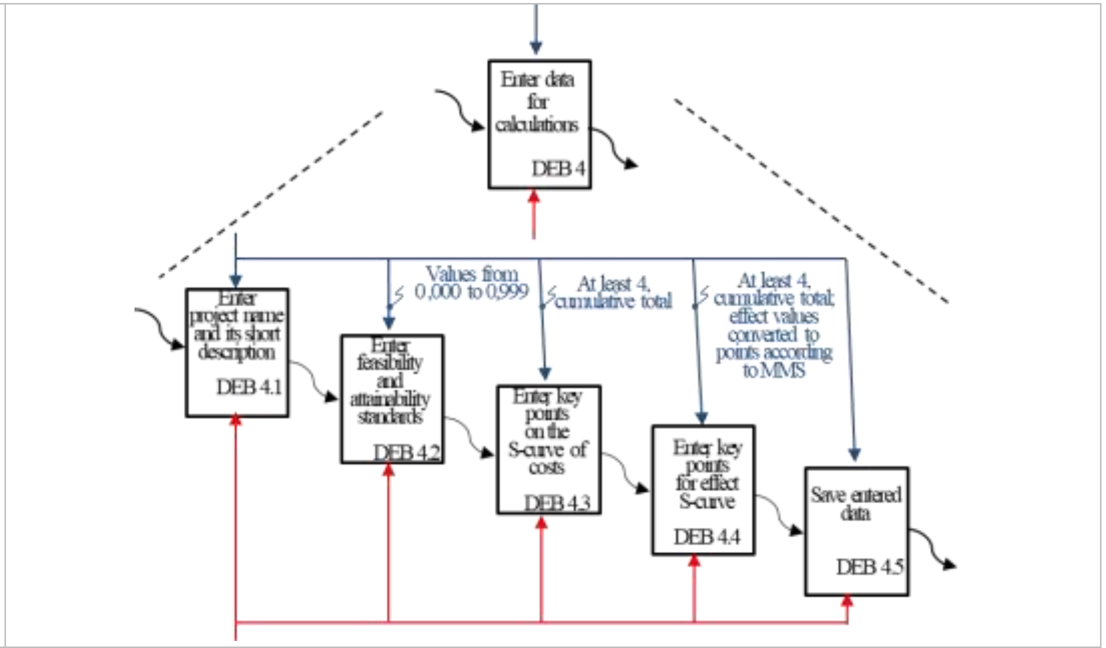


Figure 5.5 - Data entry unit daughter chart

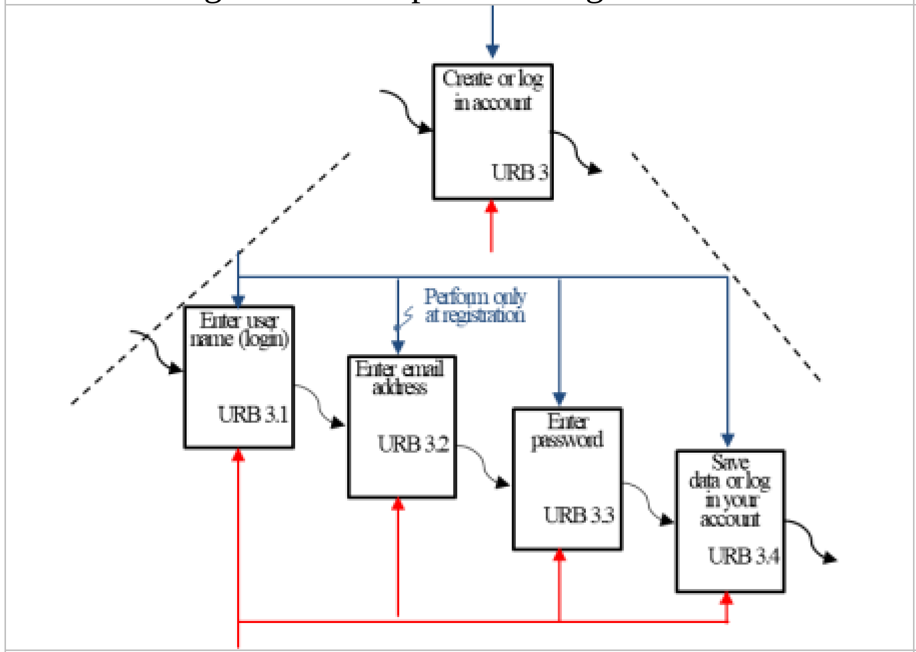


Figure 5.4 - Registration block daughter chart

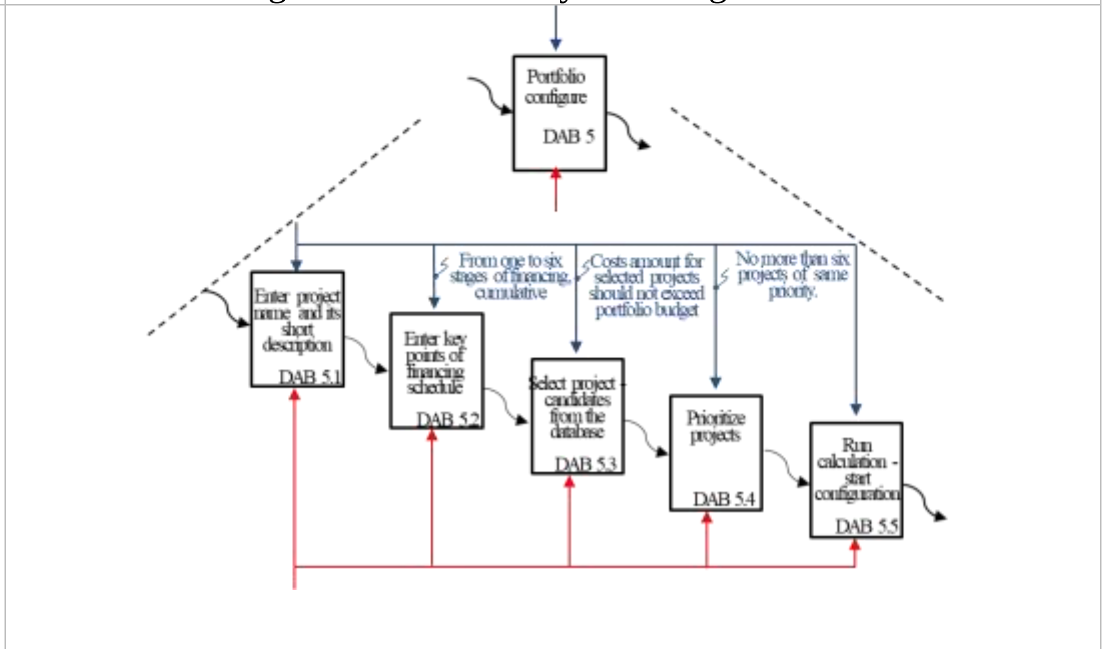


Figure 5.6 - Configuration block daughter diagram

Interface language selection block (LSB). Main function of unit is organizational and communicative, provides for use of two languages to choose from - English or Ukrainian, with automatic translation of all interface sections into selected language at any time computer program using.

Reference information block (RIB). Main function is to familiarize user with program by informing it of its use capabilities, rules and conditions. The user cannot edit block data. RIB block consists of three daughter blocks (fig. 5.3): familiarization with reference information (contains information on contacts for communication with program developers, as well as instructions for installing program and users guide, in separate files form with downloading and duplication possibility); familiarization with confidentiality terms (information that user data collected for authorization, as well as data entered into program or obtained during modeling cannot be transferred to third parties except as provided by law); familiarization with use program terms (information on computer program use terms that are regulate by Ukrainian and international legislation in intellectual property field).

User registration block (URB). Main function - create an account that provide individual access to user-created portfolios and their components (projects, programs, auxiliary portfolios). Block contains child blocks (fig. 5.4) containing following information: (username, password), contacts (e-mail), account creation and editing date, as well as additional information about user, entered by him at optional. User can edit all information in block.

Data entry block (DEB). Main function - providing input data on (projects) and portfolio individual component parameters in required format. Block contain five daughter blocks (fig. 5.5) and provides following information input about project: name, short description; project initial data in form of annual unrealizability standards ${}^{\sigma}d^{i}$ and unattractiveness ${}^{r}d^{i}$ (are set in numerical terms in range from 0 to 0.999); funding flow key points (in time terms and funding needed amount $\sigma^{i}({}^{s}\tau^{i})$ in cumulative terms) in table format with automatic cumulative financing curve construction; effect manifestation initial moment ${}^{r}\Delta^{j}$

and key moments increase in effect flow (according to time values and magnitude of increase in effect $r^i({}^{r}\tau^i)$ in grade expression) in table format with automatic cumulative effect curve construction. Entering portfolio information includes - name, brief portfolio description; assigning key points to portfolio financing (by time values ${}^{s}_{1}T + {}^{s}_{2}T + {}^{s}_{3}T + \dots {}^{s}_{f}T = {}^{s}T$ and planned financing amount ${}_{1}S + {}_{2}S + {}_{3}S + \dots {}_{f}S = S$) in table format with automatic stepped financing schedule construction; components (projects) selection from list stored in database with their priority indication.

Data analysis block (DAB). Main function - to carry out calculations on project portfolio configuration (formation) and present the results in an accessible form for analysis. Block contains five child blocks (fig. 5.6). Information on portfolio presented in graphical form as a program-defined sequence of projects displayed by costs (financing) curves as portfolio financing stepped schedule part and with corresponding effect manifestations graphs. Moreover, also in tabular form, with definition for each project its number in portfolio structure, attractiveness coefficient calculation over time, project feasibility factors ${}^{\sigma}V^i$ and its effect attainability ${}^{r}V^i$, attractiveness ratio V^i as separately considered project, and in portfolio structure ${}^{\sigma}W^j$, ${}^{r}W^j$, ${}^{\sigma}W^{ij}$. In general, for simulated portfolio option, data on start date calculated ${}^{s}t_0$ and portfolio finish ${}^{s}t_f$, actual financing duration ${}^{s}T$, amount of funding needed S manifestation date, completion, and effects total duration, portfolio realizability coefficients, portfolio effect attainability, and portfolio attractiveness ${}^{\sigma r}W^j$.

Data storage block (DSB). Main function - to store both source data and results obtained as modeling result. Saved project data in portfolio initial components database we can present in expanded form (tabular, flows indicating intermediate accumulated values) and compact form (indicating only flows total accumulated values). Portfolio data obtained as modeling result are stored in project portfolio database.

Data editing block (DEB). Main function - ability to edit and delete source data for projects and portfolios. To do this, it is possible to use template from previously generated portfolio components versions or the portfolio itself, stored in corresponding data storage unit databases, as well as necessary tools for adjusting and deleting source data itself.

Block output (integration) of results (BOR). Main function - ability to display and save portfolio-modeling results in document formats allowing further processing and data conversion and graphic images contained in them outside computer program body and structure.

Described service model is basis for computer program SESPortfolio development. Program designed to configure (form) project portfolios based on selection and balancing of their components. By modeling various portfolio configurations, user receives necessary information for informed decision-making regarding their structure (project implementation number and sequence), taking into account socio-economic effect parameters that planned to achieve through portfolio project products use with given funding schedule.

SES Portfolio based on tools used containerized virtualization Docker under Windows system, designed for WEB implementation and has several advantages inherent in applications working with cloud technologies. Necessary requirements for installing and using this software solution on personal computers is Windows operating system presence - 64 bit, setting in Bios hardware virtualization mode “Virtualization Technology” (paragraph - Enable); any installed Internet browser and permanent at work time with program, Internet connection. SES Portfolio installation and startup procedures in this section does not describe, they are fully described in installation instructions (Appendix F). Detailed description of operating procedure in computer program and its functionality given in user manual (Appendix G).

5.3.Applied aspects of configuring multipurpose project portfolios

Consider some application aspects of proposed method for configuring multi-purpose project portfolios. To test operability and adequacy method, we simulate simple situations, each of that aimed at specific heuristic hypothesis testing. Heuristic hypothesis is understand as relationship assumption that stimulate further scientific research [254]. In our case, hypothesis is formulate as a kind of assumption regarding a known phenomenon, fact or consequence in portfolio management theory. This assumption requires confirmation or refutation based on experiments number and calculations using the method developed (proposed) by us. From functional point of view, such hypotheses are explanatory and predictive in nature and, according to the construction mechanism, are predominantly inductive. Basis of their construction is known, observable facts, phenomena, and verification result is confirmation, refutation, and in some cases, prediction or information generalization. Logical research chain built from private to general [255]. It follows from this that for heuristic hypothesis; it is not contradiction of proposed method that known to theoretical positions.

First hypothesis block (H1) we formulate based on the following restrictions. Portfolio financing specified in the single stage form (tranche), amount of that is equal to or exceeds sum of costs necessary for implementation of all the considered project-candidates. Financing duration is set no less than duration of financing of the longest project-candidates. It assumed that under such conditions, all project-candidates: a) we recommend for inclusion in portfolio structure; b) we plan for implementation simultaneously with portfolio start and in parallel to each other.

Chosen financing schedule form, in what all 100% of funds are available at portfolio beginning is rarely realized in practice. However, during conducting experiments on configuring portfolios to test hypotheses, this form is most suitable, since it eliminates influence of restrictions associated with financing schedule features on time delays and project sequence. This makes it possible under the same conditions to consider projects that have various parameters, including accumulated (cumulative) type costs and effects flows. These data are basis for calculating projects feasibility, reachability and attractiveness coefficients according to the developed method. Thus, when conducting experiments, hypotheses we tested about influence of various project parameters on the order (priority) of their financing in portfolio, that determined by estimated value of project attractiveness coefficient in portfolio. The higher value of attractiveness coefficient, more project priority is for financing and should be implement in first place. In addition to calculations that allow numerically assessing projects attractiveness, developed SESPortfolio program provides graphical order (priority) display of their implementation in portfolio structure by displaying on financing schedule accumulated curves of cost flows for projects. In this case, situations of two types can be observed: a) cost curves for simultaneously starting projects are shifted relative to Y axis - cost axis (closer project's start point to axis beginning the higher project priority) - such situations are most typical for one-stage financing; b) projects cost curves are shifted relative to X axis (the closer project start point to axis beginning, more project priority for financing) - such situations are most typical for multi-stage portfolio financing.

Initial conditions for hypothesis H1.1. All project-candidates has the same parameters: values of feasibility and reachability standards; type of cumulative flow costs characteristics (budget sizes - costs amount, time and nature of increase in costs); cumulative flow effects characteristics type (effects magnitude, manifestation time and their increase nature); priorities - project ranks.

Hypothesis H1.1: projects with the same parameters have equal individual attractiveness, as well as attractiveness for portfolio and, as consequence, the same financing priority.

Initial data about project-candidates for H1.1 hypothesis testing and subsequent hypotheses, as well as results calculation obtained using SESPortfolio program, presented in H Appendix. Fig. 5.7 shows graphs that automatically generated in SESPortfolio and reflect decision to configure portfolio according to maximizing attractiveness criterion.

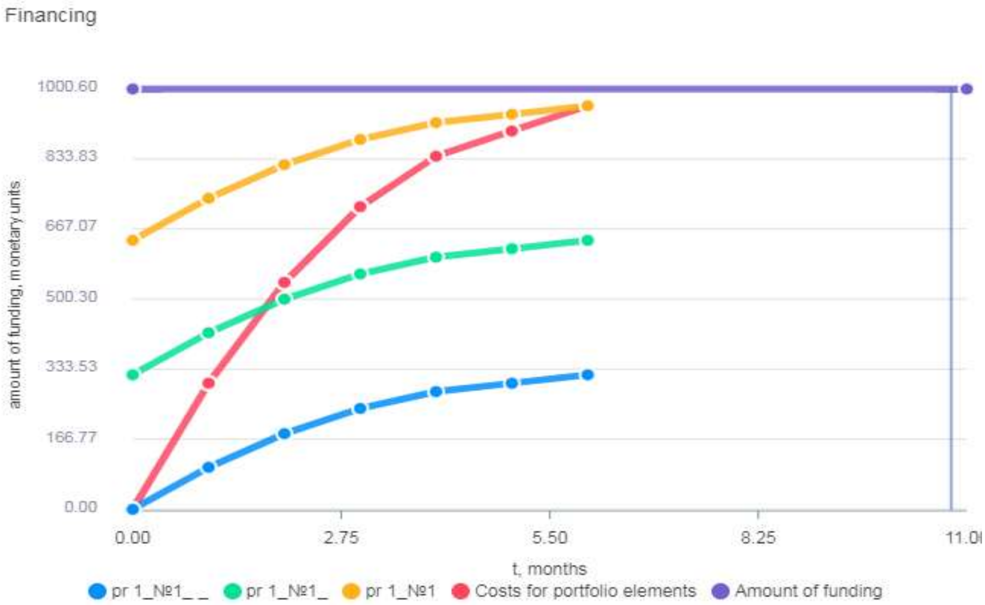


Figure 5.7 - Cost curves graph for projects and total costs for portfolio with projects financing sequence in portfolio during hypothesis H1.1 testing

Source: developed by author

Investigation of the graphical portrayal of estimation results shows that all ventures viable have equivalent individual task estimations engaging quality coefficients and undertaking allure coefficients in portfolio. This explained by equality of their parameters and shifts absence in the implementation schedule (simultaneous start of projects). In this case, projects has the same priority for portfolio financing. This confirms our H1.1 hypothesis. However, it should be noted that in equality spite of project attractiveness coefficients values that essentially determine their order of implementation and financing in portfolio, in this example, SESPortfolio program assigned to each projects its own serial number for implementation (see tables in Appendix H). This explained by the fact that, according to the program algorithm, each project should have its own, non-duplicate implementation number in portfolio structure. Difference presence in adjacent numbers values does not exclude possibility of simultaneous implementation of their respective projects having the same attractiveness for the portfolio. Thus, data presented in annex obtained using SESPortfolio program do not contradict logic of the used method and well-known theoretical portfolio management principles.

Initial conditions for H1.2 hypothesis. Project-candidates has same parameters, with time exception and increase nature in costs.

Hypothesis H 1.2: the most attractive projects to include in portfolio and receive priority financing are those projects that have shorter duration and higher costs (cost growth) in the initial periods of their implementation.

Full portfolio computation report as a component of hypothesis test H1.2 introduced in Appendix H. From application information and Fig. 5.8 we can see that pr4_norm 4 venture is the most alluring for incorporation in portfolio viable and need for financing. Values of its individual attractiveness coefficient and attractiveness coefficient in portfolio are the largest of considered project - candidates. This is the shortest project in duration terms and having rather high cost indicators in the initial implementation periods (compared to the projects pr 2_st_norm 4 and pr 3_st_norm 4).

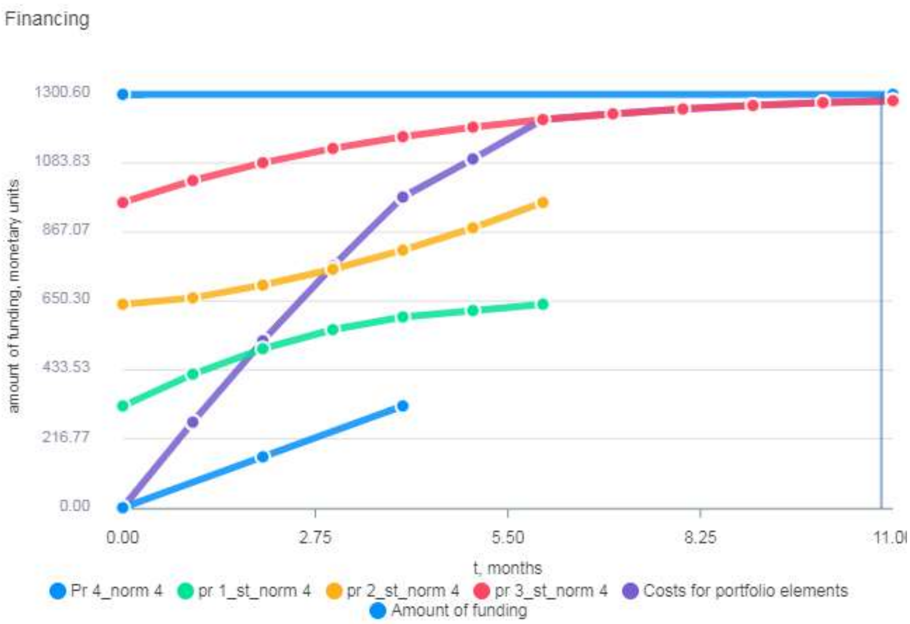


Figure 5.8 - Cost curves schedule for projects and total costs for portfolio with financing project sequence in portfolio (hypothesis test H1.2)

Source: developed by author

Second most attractive project with coefficient value of 0.89 is project pr 1_st_norm 4 that has the same duration as project pr 2_st_norm 4, but the large accumulated cost values stream in similar implementation periods. The least attractive project was pr 3_st_norm 4 that has the longest duration - 11 periods and low rates of increasing cost flows. Obtained projects arrangement on cost curves graph confirms hypothesis H1.2 and indicates correct logic that embedded in developed method.

Hypothesis H1.3 baselines. Project - candidates have same parameters, with time exception and nature of the increase effects.

H 1.3 hypothesis: The most attractive projects to include in portfolio and receive priority financing are those projects that reach planned maximum effect value in shorter time frame and / or have large effect growth values in initial its manifestation periods.

Full portfolio calculation report as part of hypothesis testing H1.3 presented in Appendix H. From application data as well as fig. 5.7 and fig. 5.8 it can be seen that the most attractive project for obtaining priority financing is project pr1_№1_ _ef. In this project, maximum effect value achieved in shorter time compared to other projects. Second, most attractive project is pr1_№1ef that compared to pr1_№1_ef project with the same duration of effect manifestation, has large values of its growth in the initial periods. As we can see from fig.5.9 – 5.10, order of priority (priority) of financing projects corresponds to the calculated values of the attractiveness coefficients of projects in the portfolio that take into account different effect nature. Therefore, H1.3 hypothesis confirmed.

Initial conditions for H1.4 hypothesis. Project-candidates have same parameters, with initial terms exception for effects manifestation (effect shift in time relative to the project start).

H 1.4 hypothesis: The most attractive projects to include in portfolio and receive priority financing are that where effect from implementation manifested in earlier periods relative to projects start.

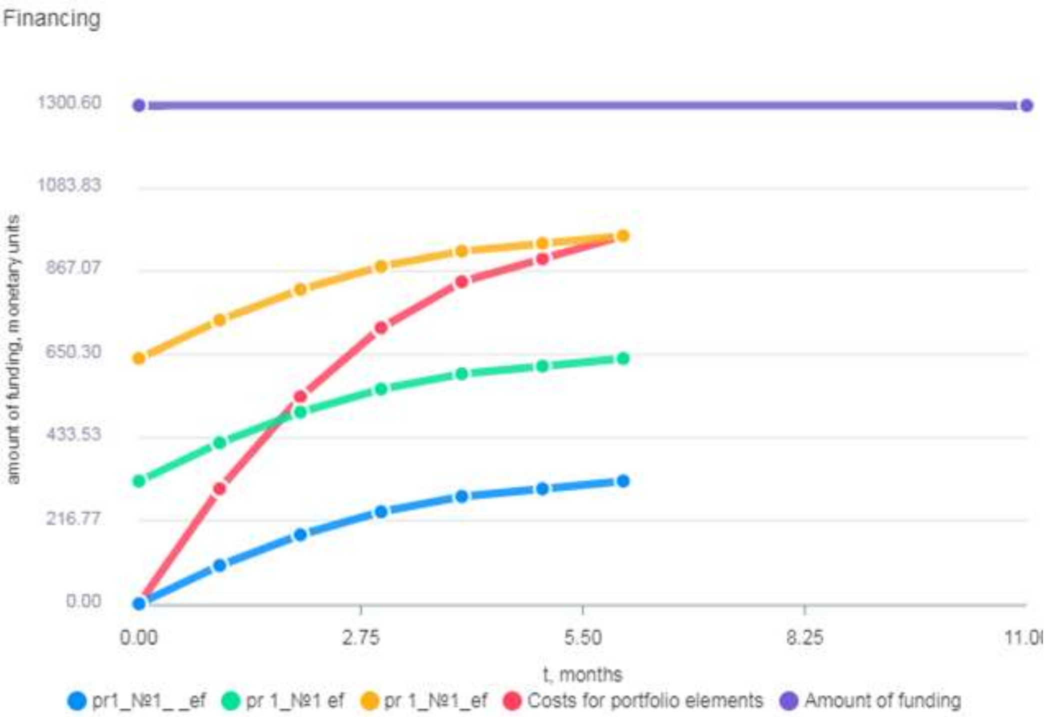


Figure 5.9 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.3 hypothesis testing)

Source: developed by author.

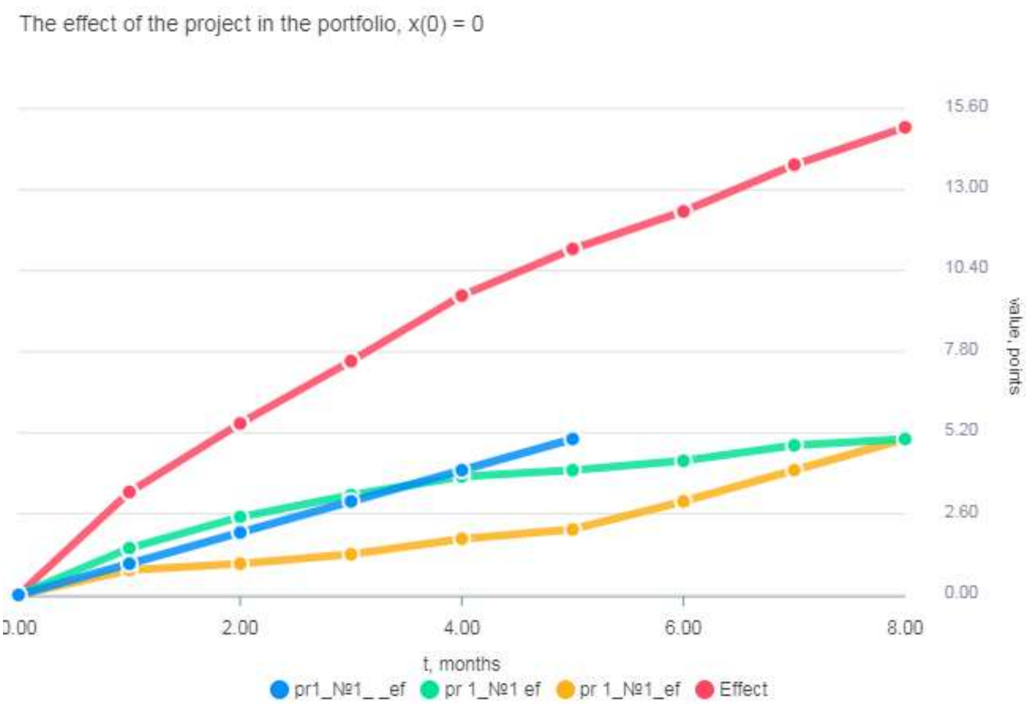


Figure 5.10 Effect curves graph for projects and total (summary) effect for portfolio (H1.3 hypothesis testing)

Source: developed by author

Full portfolio calculation report as part of H1.4 hypothesis test. presented in Appendix H. From application data as well as fig. 5.11 and fig. 5.12 shows that three projects considered in portfolio, project pr 1_№1_ n01sdvig 0 has the greatest appeal. For this project, effect begins to appear immediately after project start. Also, project pr 1_№1_ n01sdvig 8 has the least attractiveness. This project has the greatest effect shift (by eight periods) relative to the start moment. Therefore, hypothesis H1.4 confirmed.

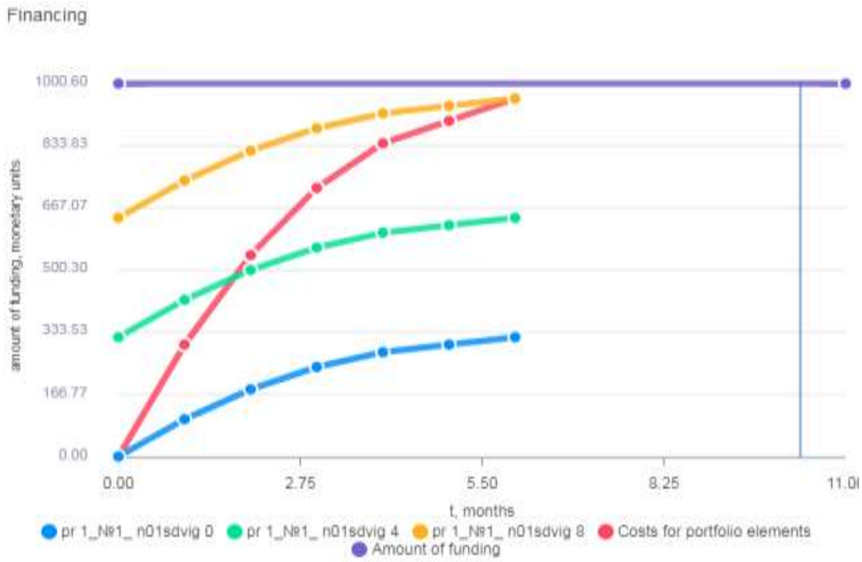


Figure 5.11 Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.4 hypothesis testing)

Source: developed by author.

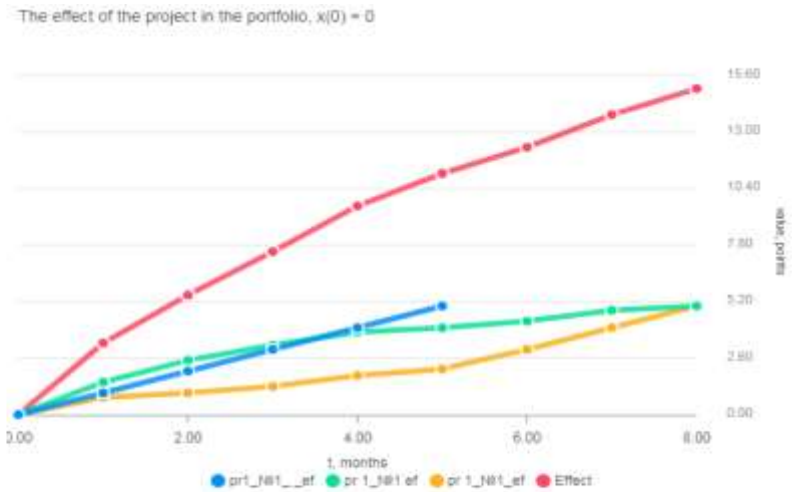


Figure 5.12 - Effect curves graph for projects and total (summary) effect for portfolio (H1.4 hypothesis testing)

Source: developed by author

Initial conditions for H1.5 hypothesis. Project- candidates have same parameters, with norms exception (unfeasibility and unattractiveness).

H 1.5 hypothesis: The most attractive projects for inclusion in portfolio and obtaining priority financing are that where corresponding norms have less significance.

Full portfolio calculation report as part of H1.5 hypothesis testing presented in Appendix H. From application data as well as fig. 5.13 we can see that from six projects considered in portfolio, the most attractive project is pr 1_ nor 000_000 where norms values are zero. The least attractive projects are pr 1_ nor 048_030; pr 1_ nor 030_048 having the highest norms values considered in this example.

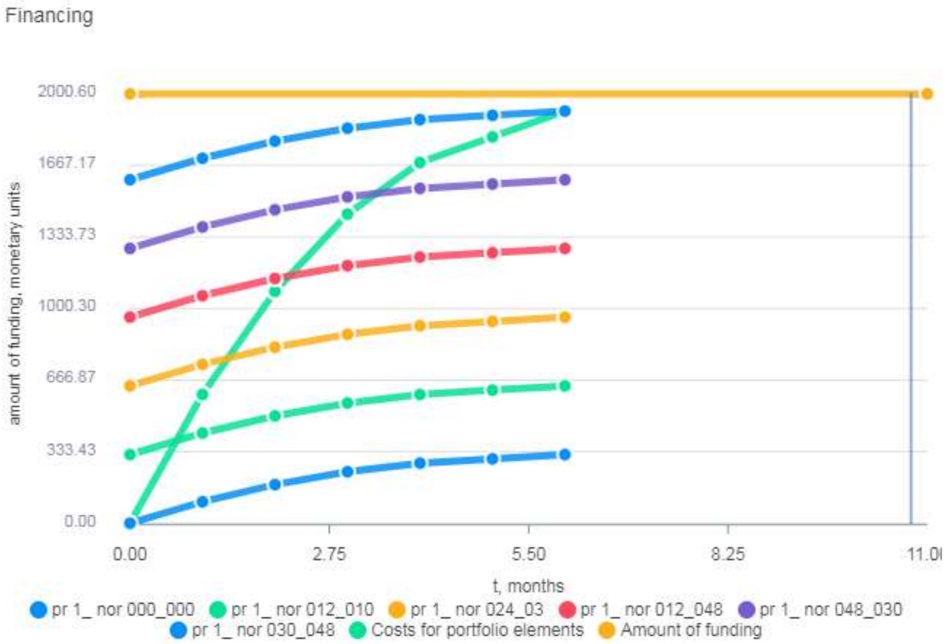


Figure 5.13 Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.5 hypothesis testing)

Source: developed by author.

Other projects have intermediate attractiveness values, while there is general pattern - if values of one of the norms are equal, an increase in second norm values leads to project attractiveness coefficient decrease in portfolio.

It is also logical that different norms values combination applicable to different flow characteristics (costs and effects) can result in close or coinciding projects attractiveness coefficient values in portfolio. This fact indicates need for additional research in this direction. Based on fact that in considered example change in two variable parameters of simultaneously affecting expected calculations result was considered, it can be argued that hypothesis H.1.5 confirmed.

Initial conditions for H1.6 hypothesis. Project - candidates have the same parameters, with exception of accumulative flow type costs characteristics (cost - budget size, time and cost increase nature).

H 1.6 hypothesis: Those projects where implementation time and budget are shorter and cost increases nature (cost growth) in the initial implementation periods are more attractive for inclusion in portfolio and obtaining priority financing.

Full portfolio calculation report as part of H1.6 hypothesis testing presented in Appendix H. From application data and fig. 5.14 analysis we can see that H1.6 hypothesis confirmed.

At the same time, it should be noted that during simulation, for various initial data, situations were observed when obtained values of the project attractiveness coefficients in portfolio did not differ significantly (by percent fraction). These differences are due to the fact that in calculations several variable parameters were simultaneously changed, influence of that could be mutually compensated. So, for example, slight increase in project duration (as a negative project attractiveness factor) can be compensated by more intensive costs distribution at its initial implementation stages (positively affecting factor). As a result, attractiveness coefficient value of this project in portfolio turned out to be comparable with another project value with shorter duration and less intensive costs distribution nature. This fact necessitates further research in direction of method sensitivity studying to possible ratios and several variables changes at once in ranges of their potentially acceptable values.

Initial conditions for H1.7 hypothesis. Project- candidates have the same parameters, with cumulative flow effect characteristics type exception (effect magnitude, time and effect increase nature).

H 1.7 hypothesis: The most attractive projects to include in portfolio and receive priority financing are projects where maximum effect is higher, achieved faster, and effect increase nature (growth effect) in the initial manifestation periods are greater.

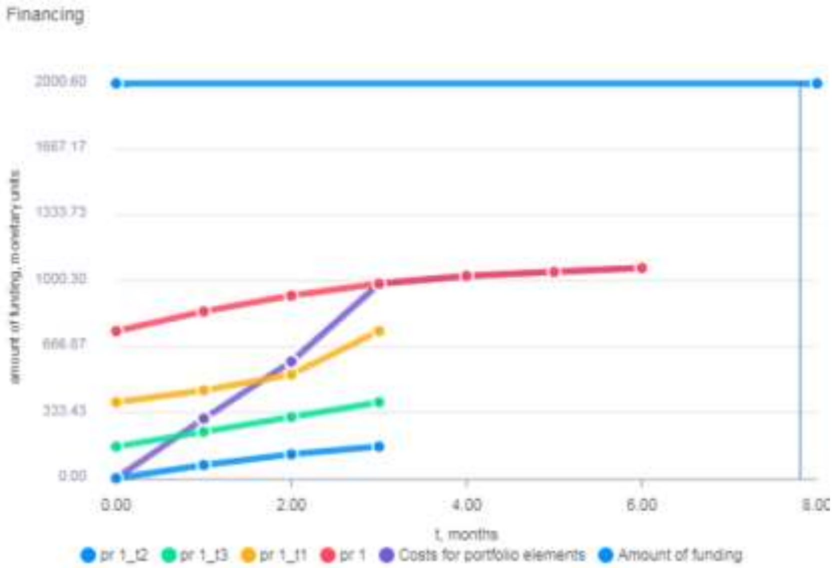


Figure 5.14 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.6 hypothesis testing)

Source: developed by author.

Full portfolio calculation report as part of hypothesis H1.7 testing presented in Appendix H. From application data and fig.5.15-5.16 analysis we can see that H1.7 hypothesis confirmed.

However, as in the situation with H1.6 hypothesis confirmation, there is a fact that attractiveness factors proximity for projects does not satisfy conditions for effect value maximizing and its rapid growth in the initial manifestation periods. This may be due with a large variables number that can take different values and compensate for each other's influence. This fact also requires additional studies regarding method sensitivity.

Figure 5.15 - Effect curves graph for projects and total (summary) effect for portfolio (H1.7 hypothesis testing)

Source: developed by author.

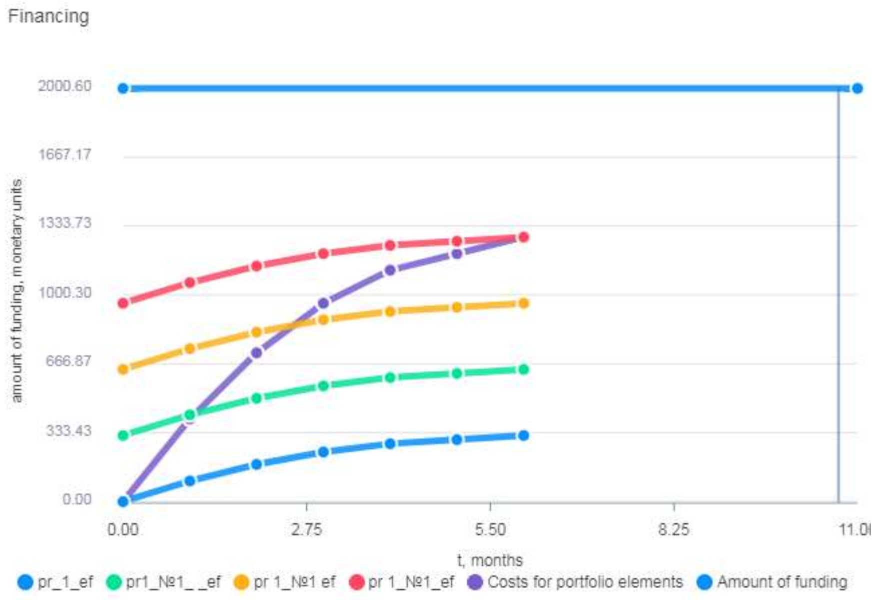


Figure 5.16 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.7 hypothesis testing)

Source: developed by author.

Initial conditions for H1.8 hypothesis. Project - candidates have various ranks - projects priority indicators in compliance terms with their strategic portfolio objectives.

H1.8 hypothesis: Projects with higher rank values (1-max value) are most attractive for inclusion in portfolio and obtaining priority financing. If ranks are equal, financing order is determined on project attractiveness coefficient value basis in portfolio.

Full portfolio calculation report as part of H1.8 hypothesis testing presented in Appendix H. For comparative analysis, we used initial data from examples for testing hypotheses H1.1, H1.4, H1.5. Main results are shown in fig. 5.17-5.19 and table 5.4.

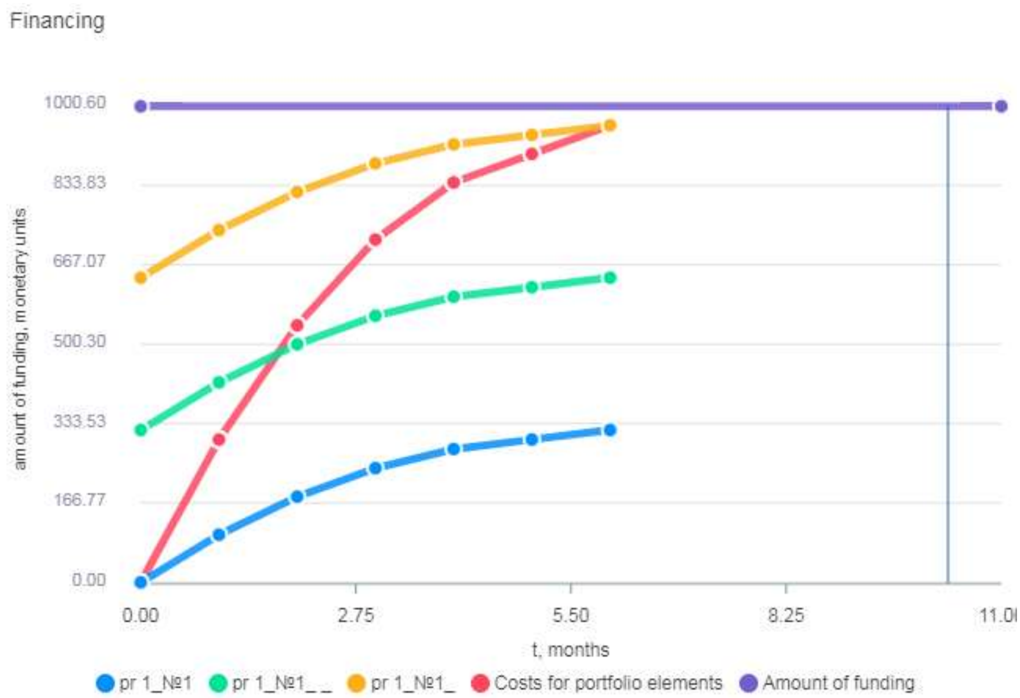


Figure 5.17 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.8 hypothesis testing) based on data of an example for H1.1 hypothesis testing

Source: developed by author.

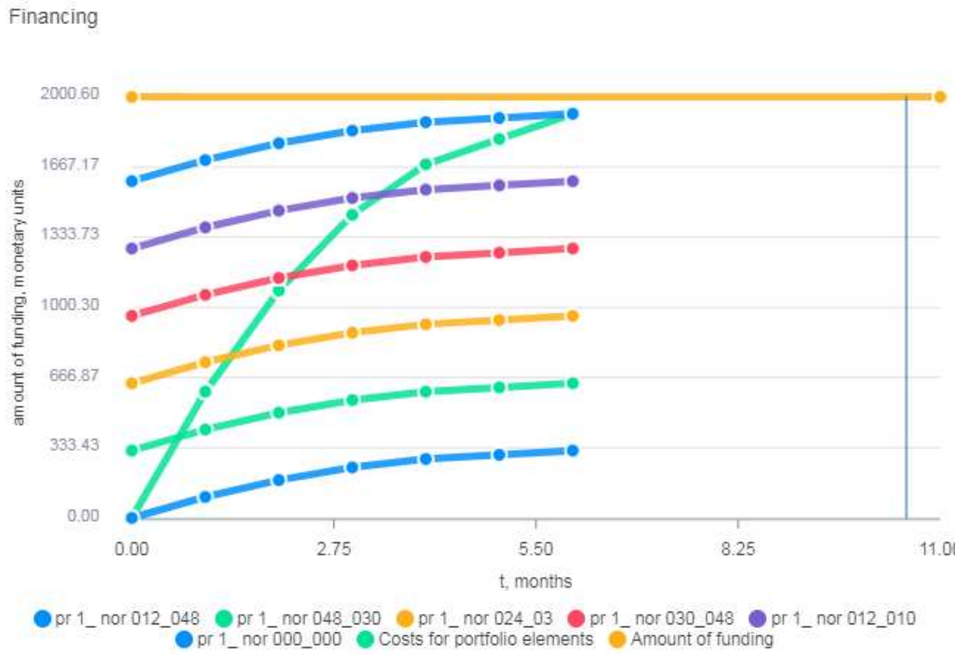


Figure 5.18 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.8 hypothesis testing) based on data of an example for H1.5 hypothesis testing

Source: developed by author.

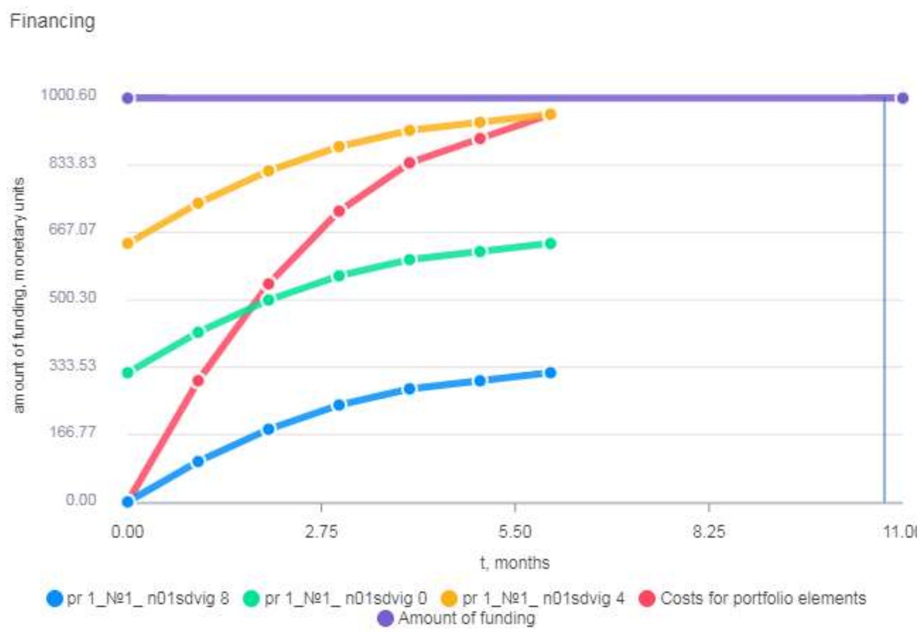


Figure 5.19 - Cost curves graph for projects and total costs for portfolio with project financing priority (steps) in portfolio (H1.8 hypothesis testing) based on data of an example for H1.4 hypothesis testing

Source: developed by author.

Table 5.4 - Initial data from examples

Name	Priority (rang)	# in portfolio	Coefficient of project attractiveness W in the portfolio	Portfolio attractiveness coefficient W	Name	Priority(rang)	# in portfolio	Coefficient of project attractiveness W in the portfolio	Portfolio attractiveness coefficient W
H1.1					H1.6				
pr 1_№1_ _	1	1	0,82	0,820	pr 1_№1	1	1	0,82	0,820
pr 1_№1_	1	2	0,82		pr 1_№1_ _	2	2	0,82	
pr 1_№1	1	3	0,82		pr 1_№1_	2	3	0,82	
H1.4					H1.6				
pr 1_№1_n01sdvig0	1	1	0,865	0,827	pr 1_№1_n01sdvig8	1	1	0,81	0,827
pr 1_№1_n01sdvig4	1	2	0,837		pr 1_№1_n01sdvig0	2	2	0,865	
pr 1_№1_n01sdvig8	1	3	0,81		pr 1_№1_n01sdvig4	2	3	0,837	
H1.5					H1.6				
pr 1_ nor 000_000	1	1	1	0,880	pr 1_ nor 012_048	1	1	0,853	0,880
pr 1_ nor 012_010			0,944		pr 1_ nor 048_030			0,82	
pr 1_ nor 024_030			0,868		pr 1_ nor 024_030			0,868	
pr 1_ nor 012_048			0,853		pr 1_ nor 030_048			0,816	
pr 1_ nor 048_030			0,82		pr 1_ nor 012_010			0,944	
pr 1_ nor 030_048			0,816		pr 1_ nor 000_000			1	

Data analysis shows that change in rank values has led to change in project financing sequence in portfolios. That is, project rank value is decisive for project financing order in relation to other factors that are taken into account during project attractiveness factors calculating. Also, project attractiveness coefficient value in portfolio affects their financing order only in equal priority ranks case. Therefore, H 1.8 hypothesis provisions confirmed.

It should be noted that changes in project financing procedure with various ranks introduction in single-stage financing context did not affect changes in portfolio duration and estimated portfolio attractiveness indicator values. WE can assume that multi-stage schedules introduction (for all variants of considered hypotheses) we lead to shift in projects implementation over time due to limitations in duration and funding amount. And this can also affect projects sequence in portfolio and, accordingly, change in both projects' attractiveness coefficient values in portfolio and portfolio attractiveness indicator itself.

Second block of hypotheses **(H2)** considers portfolio financing that is given in **several tranches** (several stages) form. At the same time, portfolio financing total amount is greater than or equal to necessary costs sum for implementation of all project - candidates under consideration. This condition is common to all hypotheses of this block. In this case, we are considering separate type of tasks for project portfolio configuring that do not involve selection of the most attractive or exclusion of less attractive projects. Task is more focused on coordinating the initial portfolio financing schedule. It is initially developed by project portfolio management council but can subsequently change within certain boundaries. For example, schedule changing purpose may be including of all initially selected project-candidates into portfolio, or to find the most attractive portfolio configuration.

Multi-stage (multi-layered) financing schedule always reflects time number and financial constraints that can affect emerging portfolio structure. Therefore, initially it is necessary to determine general recommendations regarding its construction. Most of these recommendations are outlined in section 4.1. Recall that it is recommended to set from 3 to 6 stages of financing. Moreover, first stage should be at least 20-25% of the total portfolio financing, and its duration should be at least 15-20% of planned entire portfolio duration.

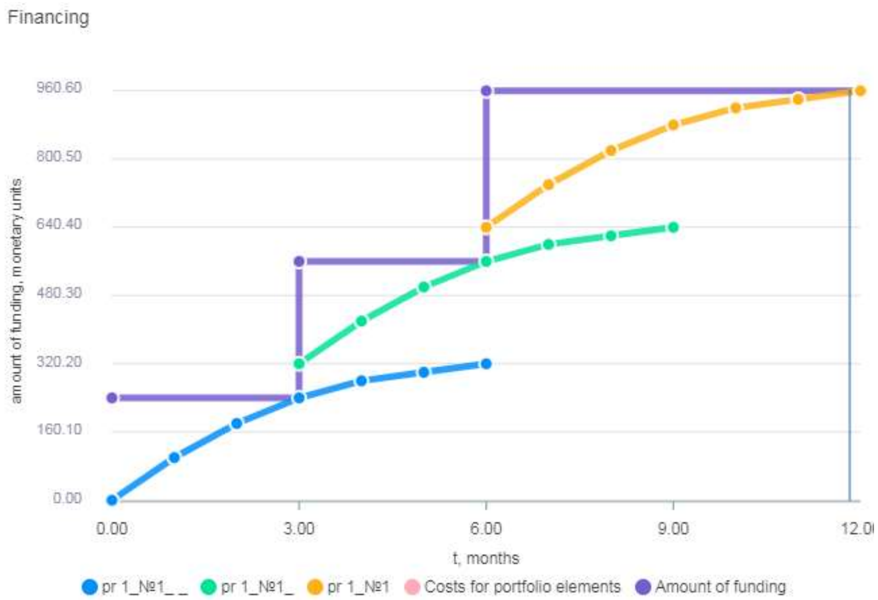
Results of our preliminary experiments allowed us to formulate additional recommendations. So, in order to be able to correctly compare various options for portfolio configurations and choose the most attractive of them, duration of the last stages of financing schedules should be no less than maximum project duration from the list of all considered project- candidates. This is due with software algorithm implementation peculiarities for enumerating all possible portfolio configurations and choosing the most attractive option for conditions under consideration for financing schedule parameters correlation and data on project-candidates.

Based on foregoing, and for developed method operability test, we consider a number of hypotheses.

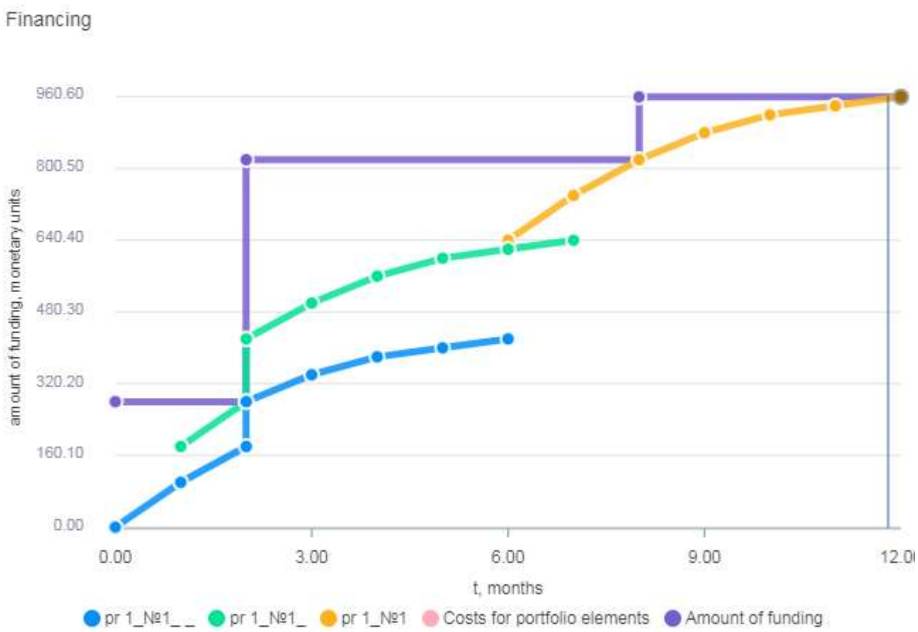
Initial conditions for H2.1 hypothesis. Portfolio financing is three-stage. Project-candidates have same parameters.

H 2.1 hypothesis: projects implementation order is determined taking into account fulfillment of sufficient funding condition to compensate projects cost curves and their continuity in time, within limits set by the multi-stage portfolio financing schedule form.

As can be seen from fig. 5.20a and 5.20b in comparison with fig. 5.7. where projects with similar parameters were considered, using of multi-stage financing leads to projects shift in implementation time terms relative to portfolio start. With sufficient amount and timing of financing, projects can be implemented both within framework of one or several stages, but with mandatory financing continuity condition fulfillment. If indicated conditions, due to discrepancy between financing schedule form (financing amount and its stages duration), do not meet project parameters (primarily accumulated cost flows type - their size, duration, accumulation nature), then program can exclude unsuitable projects from portfolio structure (see H Appendix). In this case, it is necessary to make adjustments to the initial financing schedule and re-perform calculations on portfolio configuration. Adjustments are made until all projects are included in portfolio structure. Moreover, this goal can be achieved by various forms of financing schedules (fig. 5.20a and 5.20b). Data analysis of table. 5.5. and table 5.6 shows that Portf 3 same 1 portfolio configuration (attractiveness ratio 0.645) is the most attractive in comparison with Portf 3 same 3 (0.630). This fact is explained by project pr1_№1_ displacement (5.20a and 5.20b) closer to portfolio start, and, accordingly, change in total costs cumulative flow form and portfolio effect. According to H1.6 and H1.7 hypothesis provisions, this is due to an increase in the attainability effect coefficients and this project feasibility in portfolio, and, accordingly, an increase in portfolio attainability, feasibility and attractiveness as a whole.



a)Portf 3 same 3 portfolio



b)Portf same 1

Figure 5.20 - Cost curves graphs for projects with priority (steps) of their provision (financing) in portfolios with various initial financing schedule forms (H2.1 hypothesis verification)

Source: developed by author.

Obtained calculation results and their analysis shows that hypothesis H 2.1 confirmed.

Table 5.5 - Calculation results

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf 3 same 3									
pr 1_№1_ _	1	1	0,667	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	0,89	0,922	0,82	**0,791**	**0,856**	**0,677**
pr 1_№1	1	3	0,667	0,89	0,922	0,82	0,703	0,795	0,559
Portf 3 same 1									
pr 1_№1_ _	1	1	0,667	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	0,89	0,922	0,82	**0,855**	**0,899**	**0,769**
pr 1_№1	1	3	0,667	0,89	0,922	0,82	0,703	0,795	0,559

Table 5.6 – Calculations analysis

The total portfolio performance	Portf 3 same 3	Portf 3 same 1
The start date of the portfolio:	0,000	0,000
The finish end date of the portfolio:	12,000	12,000
Duration of financing:	12,000	12,000
The amount of expenses for financing the portfolio:	960	960
Effect start date:	0,000	0,000
Effect end date:	12,000	12,000
Duration of effect:	12,000	12,000
Portfolio realizability coefficient:	**0,758**	**0,769**
Portfolio effect reachability coefficient:	**0,832**	**0,839**
Portfolio attractiveness coefficient W:	**0,630**	**0,645**

Initial conditions for H2.2 hypothesis. We use four schedules with an increase in stage number from one to four stages for portfolio financing. Project - candidates have various cost flow parameters.

H2.2 hypothesis: Constraints determined by portfolio financing schedule form, as well as conditions for project financing sufficiency and continuity, are more significant for determining their financing order in relation to project attractiveness indicators. In other words, high individual project attractiveness indicators do not guarantee it priority financing in portfolio due to possible project parameters mismatch with financing schedule form at its individual stages.

According to fig. 5.21 and table. 5.7 and 5.8 changing of project financing schedules form leads to change in project implementation start timing and their implementation sequence. So, comparison of graphs shows that with single-stage financing following project order was the highest priority for implementation: pr 4_norm 4; pr 1_st_norm 4; pr 2_st_norm 4; pr 3_st_norm 4. It was determined by type and nature of their cost flows. This order is consistent with H1.2 hypothesis.

Replacing the one-stage financing schedule with two-, three-, and four-stage financing schedules led to various options for changing above-mentioned projects implementation sequence (table 5.7). This order does not correlate with project attractiveness individual indicators (coefficients) values. Recall that individual projects attractiveness determined by parameters that influence was investigated in hypothesis testing framework (H.1.2-H.1.7). Projects attractiveness in portfolio depends on their place in portfolio structure relative to other projects position and portfolio start. Also, their revenge determines temporary project start displacement and is taken into account during discounting streaming characteristics.

During block H1 hypotheses testing, financing schedule one-stage view was set, then all projects started simultaneously, without delays and displacements. This ensured individual project attractiveness values equality and project attractiveness values in portfolio. Thus, it can be argued that in multi-stage financing conditions and sufficiency conditions fulfillment and project financing continuity, procedure for their financing determined, first of all, by projects priority ranks (Appendix H) and restrictions set by portfolio financing schedule form. Therefore, H.2.2 hypothesis confirmed.

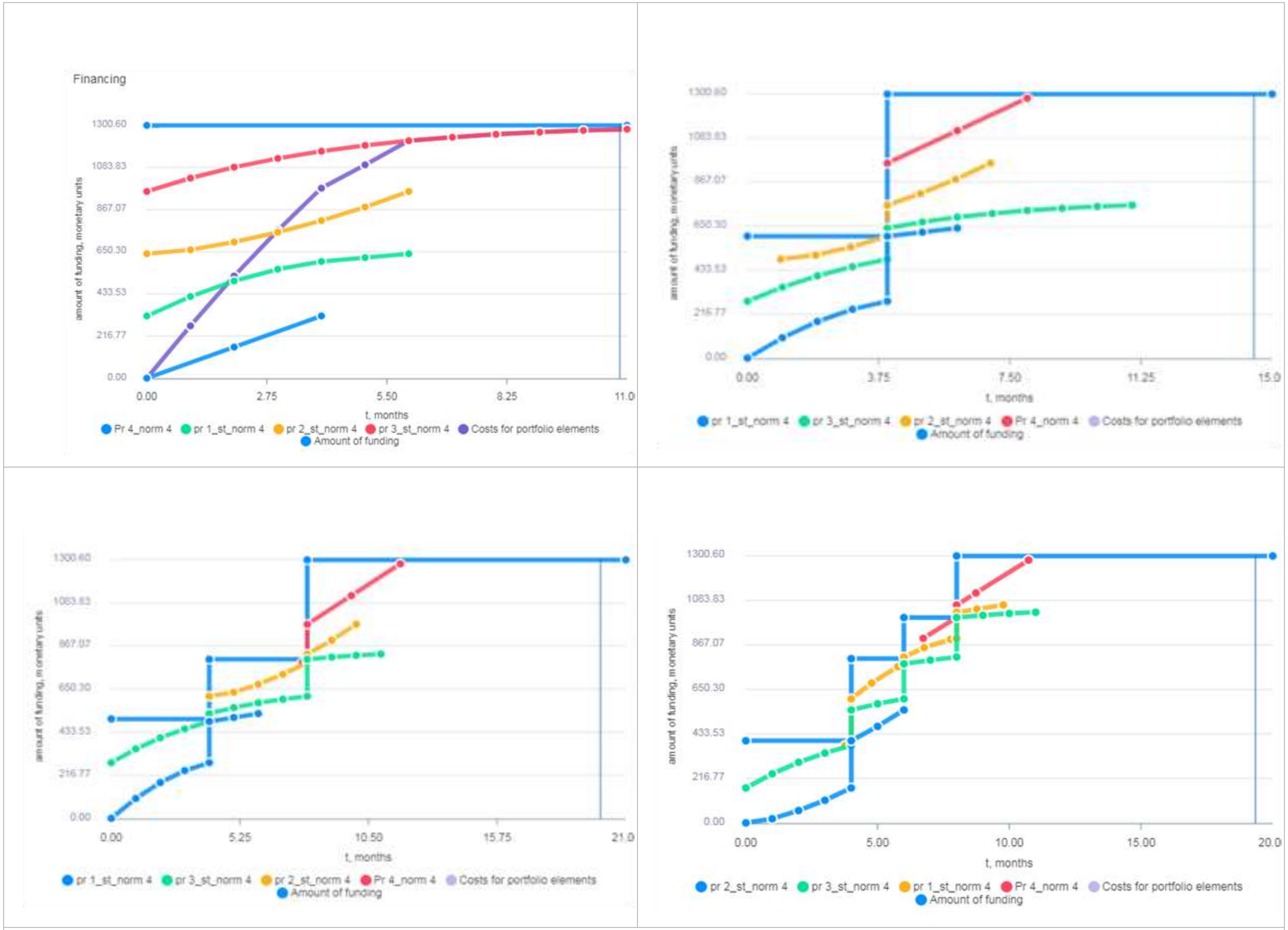


Figure 5.21 - Cost curves graphs for projects in portfolios with different initial financing schedules forms (H2.2 hypothesis verification)

Table 5.7 - Projects design parameters under project portfolio various configurations due to change in financing schedules form (H2.2 hypothesis verification)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Coefficient of realizability of	Coefficient of project effect reach		The project's coefficient of realization in	Project effect reachability coefficient in	
Portf2 pr4 norm4 portfolio data corresponding to fig. 5.20 (one-stage financing)									
pr 4_norm 4	1	1	0,852	0,925	1	**0,925**	0,925	1	**0,925**
pr 1_st_norm 4	1	2	0,778	0,89	1	**0,89**	0,89	1	**0,89**
pr 2_st_norm 4	1	3	0,778	0,868	1	**0,868**	0,868	1	**0,868**
pr 3_st_norm 4	1	4	0,593	0,795	1	**0,795**	0,795	1	**0,795**
portfolio Portf pr step 2 data corresponding to figure 5.20 (two-stage financing)									
pr 1_st_norm 4	**1**	**1**	0,778	0,89	1	**0,89**	0,89	1	**0,89**
pr 3_st_norm 4	**1**	**2**	0,593	0,795	1	**0,795**	0,795	1	**0,795**
pr 2_st_norm 4	**1**	**3**	0,778	0,868	1	**0,868**	0,859	1	**0,859**
pr 4_norm 4	**1**	**4**	0,852	0,925	1	**0,925**	0,791	1	**0,791**
portfolio Portf pr step3 data corresponding to figure 5.20 (three-stage financing)									
pr 1_st_norm 4	1	1	0,778	0,89	1	**0,89**	0,89	1	**0,89**
pr 3_st_norm 4	1	2	0,593	0,795	1	**0,795**	0,795	1	**0,795**
pr 2_st_norm 4	1	3	0,778	0,868	1	**0,868**	0,742	1	**0,742**
pr 4_norm 4	1	4	0,852	0,925	1	**0,925**	0,697	1	**0,697**
portfolio Portf pr step4 data corresponding to figure 20 (four-stage financing)									
pr 2_st_norm 4	1	1	0,778	0,868	1	**0,868**	0,868	1	**0,868**
pr 3_st_norm 4	1	2	0,593	0,795	1	**0,795**	0,795	1	**0,795**
pr 1_st_norm 4	1	3	0,778	0,89	1	**0,89**	0,781	1	**0,781**
pr 4_norm 4	1	4	0,852	0,925	1	**0,925**	0,725	1	**0,725**

Table 5.8 - Project portfolio estimated parameters of various configurations due to changes in financing schedules form

The total portfolio performance	Portf2 pr4 norm4	Portf pr step2	Portf pr step3	Portf pr step4
The start date of the portfolio:	0,000	0,000	0,000	0,000
The finish end date of the portfolio:	**11,000**	**11,000**	**11,8**	**11,000**
Duration of financing:	11,000	11,000	11,8	11,000
The amount of expenses for financing the portfolio:	1280,000	1280,000	1280,000	1280,000
Effect start date:	0,000	0,000	0,000	0,000
Effect end date:	11,000	11,000	11,8	11,000
Duration of effect:	11,000	11,000	11,8	11,000
Portfolio realizability coefficient:	0,798	0,782	0,780	0,770
Portfolio effect reachability coefficient:	1,000	1,000	1,000	1,000
Portfolio attractiveness coefficient W:	**0,798**	**0,782**	**0,780**	**0,770**

In fig. 5.22, an option presented to configure project portfolio for projects priority ranks various values (pr4_norm 4 has the highest - first priority rank; pr2_st_norm 4 - second rank; pr3_st_norm 4 and pr1_st_norm 4 - third rank). This ranks assignment is not accidental. It significantly changed projects sequence in portfolio compared to two-stage financing situation presented in fig. 5.21 and table. 5.7. In latter case, projects under consideration had equal priorities.

As can be seen from calculation results, ranks assignment is determining factor that affects project implementation sequence with any funding schedule form. It should be noted that in comparison with ranks equality situation for projects, overall portfolio attractiveness reduced. In considered example for Portf pr step 2 project, it decreased from 0.782 (table 5.8) to 0.748 (table 5.8).

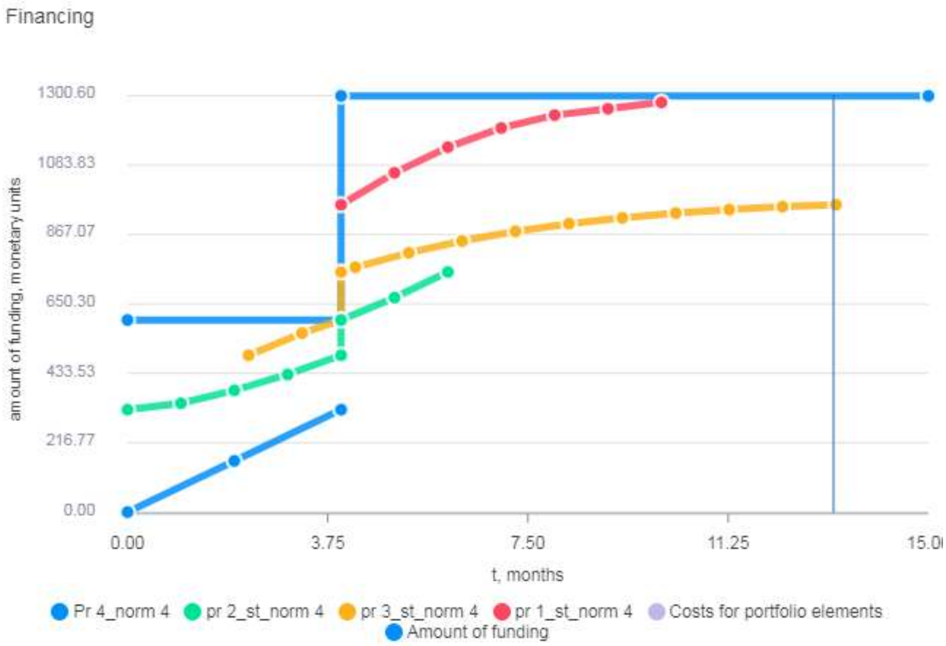


Figure 5.22 - Cost curves graphs for projects with priority (steps) designation for their provision (financing) in given projects priority ranks (H2.2 hypothesis verification)

Source: developed by author.

Table 5.9 - Portf pr portfolio step 2 configuration parameters for various project priority ranks

Name	Priority	# in portfolio	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio	The amount of expenses for financing the portfolio	The finish end date of the portfolio	Portfolio realizability coefficient	Portfolio effect reachability coefficient	Portfolio attractiveness coefficient
			The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio						
Pr 4_norm 4	**1**	**1**	0,925	1	0,925	1280	13,27	0,748	1	**0,748**
pr 2_st_norm 4	**2**	**2**	0,868	1	0,868					
pr 3_st_norm 4	**3**	**3**	0,732	1	0,732					
pr 1_st_norm 4	**3**	**4**	0,761	1	0,761					

Thus, as consideration result and hypotheses number verification, using simplified examples, it was shown that there are no contradictions between general results and conclusions obtained by proposed method logic for configuring project portfolio and theoretical principles used in project portfolios forming practice. At the same time, experiments showed that during solving even one type of problem (including all project-candidates in portfolio), there are many possible factor combinations (projects priority, their parameters, schedule forms) that must be taken into account simultaneously. Moreover, as a calculation result, some factors influence can be compensated by others influence that complicates general results analysis. You should also take into account proposed method feature that based on simulated project configurations number comparative analysis in their attractiveness terms. That is, in order to make final decision according to formed portfolio, it is not enough to carry out one calculation to configure portfolio for given initial data. It is necessary to conduct at least two calculations for selected project-candidates and compare their results. But, if necessary, portfolio management board can adjust portfolio financing schedule forms. And this can fundamentally affect portfolio structure and its attractiveness indicators.

Thus, it is not possible to establish any dependencies between initial data and calculation results in this study framework.

5.4. Formalization, limitations, and development prospects for project portfolio configuring method based on cumulative (accumulated) flows discounting

For holistic developed method essence perception for projects portfolio configuring, we formalize it. To do this, we use template that has been successfully used for many years in scientific school where studies have been Table 5.10 shows completed template for developed method.

Table 5.10 - Method formalization for configuring a project portfolio based on flow characteristics

№	Structural element of method	Structural method element description
1	Name	Method for configuring multi-purpose project portfolio based on flow characteristics of expenses and project results for a given step-by-step portfolio financing schedule
2	Application area	Practical activities on multi-purpose projects portfolio formation and management of large socio-economic systems.
3	Goal	Formation of the optimal (given the criteria and limitations) project portfolio structure (configuration) with given funding schedule.
4	Method essence	Method essence is to normalize values, discounted cumulative flows of costs and results both for individual projects and for various portfolio configurations that makes it possible to compare and choose them.
5	Objective basis	Change in money value (costs, investments) and results (benefits) value over time (that is typical for portfolios with a sufficiently long implementation time).
6	Basic rules (conditions) for method using	Portfolio financing schedule should be set in step-by-step schedule form (recommended value of steps is from 1 to 7, maximum steps value is not limited). Minimum time period for financing adopted in method for describing projects and portfolio flow characteristics as well as performing calculations based on them, is a month; Procedure for financing projects is determined by their prioritization, taking into account strategic importance to achieve portfolio strategic goals (minimax ranking method is recommended); For possibility of various projects results (values) comparing and discounting that differ in their natural essence, they must first be brought into system of single point marks (using the multi-criteria scale method).

		To carry out discounting procedures, it is necessary to set projects feasibility (not feasibility) standards values and their results reachability (not attainability). Values are set based on year (in range from 0 to 1). To enable the most complete and efficient use of the given - planned portfolio financing schedule, program uses a combinatorial method for calculating portfolio configuration options, with condition for project financing continuity at various portfolio financing stages (steps) being met. In this regard, last financing stage duration should be no less than duration of the longest of project -candidates considered in portfolio.
7	Result	Presented in normalized values form for indicators of unrealizability, unattainability and attractiveness for both individual projects and portfolio as a whole.
8	Result application	Based on received information (indicators values of unrealizability, unattainability and attractiveness), decision is made on choosing a specific portfolio configuration with subsequent planned financing schedule optimization for actually selected portfolio option. Modeling portfolio options with different configurations by changing financing schedules forms or initial project-candidates' parameters, as well as their number.
9	What methods and techniques are used in the described method	For correct method use, initial data projects in portfolio are collected using developed project-candidates map template. Experts (members of portfolio management council) prioritize projects (ranking them by strategic importance) using the minimax method. Diversified results (values) for projects are compared using the multi-criteria scale method. Unrealizability and unattainability norm values are determined on the opinion's consistency method basis between different expert groups. Accumulated stream project and portfolio parameters characteristics presented in S-curve format are converted to numerical values by discount procedure. Portfolio configuration within given financing schedule is carried out using solving combinatorial problems methods.

For place obtained holistic view in the use of new knowledge model portfolio configuration process algorithm (fig. 5.23). As can be seen from model analysis of each section of the research have been applied during project portfolio configuration.

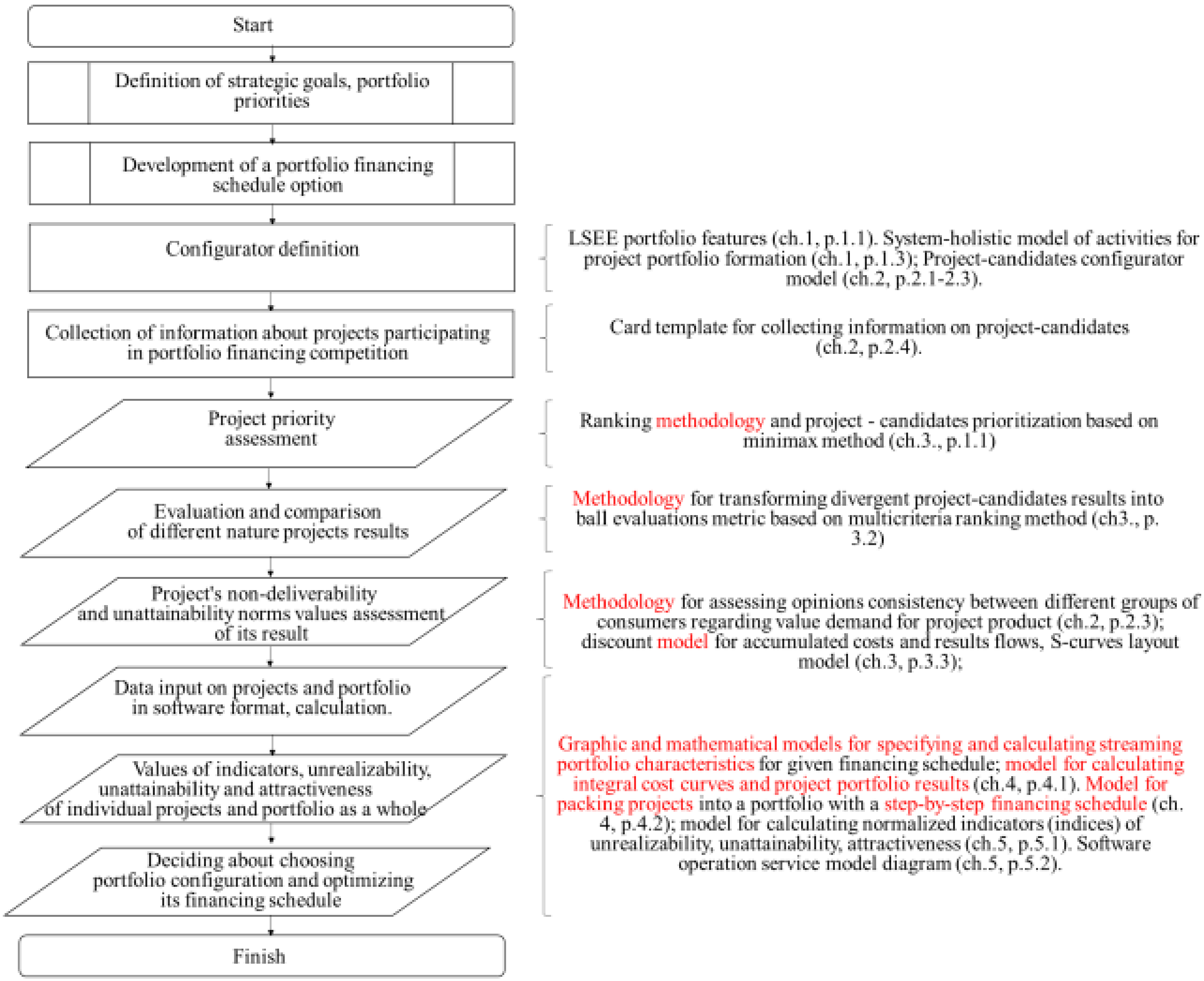


Figure 5.23 - Projects portfolio configuring process model based on developed method

Source: developed by author.

Research results and pilot application analysis of developed software product implements that developed method makes possible to determine its application limits. In addition, new tasks identified in the research process, solution of that was not reflected in our and other studies, allows us to outline ways for further method improvement and development.

Using the method, in its compliance terms with theoretical portfolio management provisions, limited primarily by the fact that procedure aimed method at separate project portfolio configuring under project-candidates consideration. In practice, it becomes necessary to include components such as subsidiaries, programs, interdependent projects, or works in portfolio. It is not contrary to portfolio definition.

For such tasks, additional studies are required regarding the presentation and consideration of the flow listed components characteristics in S-curves form, their categorization by scale and contribution level to strategic goals achievement and more than two divergent accumulated flows integration into one number. Promising area for further research is approaches and methods development for determining numerical standards values for effects attainability and projects feasibility by experts, portfolio management council members based on information obtained from project-candidates maps. Separate study requires studying the procedures for transforming method of divergent results into ball points from transformations impact assessing perspective on "sensitivity" result attainability indicator level to initial effect appearance parameters that are presented to experts.

As the simulation results showed, cost flows for projects can vary significantly in volume, time, and accumulation nature terms. However, effect's values conversion from projects using implementation of single point scale actually normalizes them in manifestation magnitude termi. Also, it makes accumulated effect curve less sensitive with respect to magnitude and change nature in source data.

Note that in this paper does not address performance or optimization issues. Main emphasis was placed on portfolio structure configuring features at the planning stage (phase). That is, portfolio forming task considered, moreover, in the statement, when all project - candidates should be included in portfolio. In practice, other options for setting goals are possible, for example, choice (selecting) the most attractive projects from participants total number involved in configuration process into portfolio. To apply developed method to such problem's solution, it is necessary to conduct additional research in at least two directions.

First direction is related to modeling situations when total costs amount for project-candidates exceeds allocated financing amount, that is, there is a shortage of it. At the same time, it is necessary to study portfolios configured various options for different financing schedules options and to establish including features in portfolio only project-candidates part providing maximum its attractiveness indicators. Based on testing results hypotheses described in Section 5.3, it can be assumed that, according to proposed method logic, a program with one-stage limited funding exclude from simulation projects that have lower values of individual attractiveness until the remaining projects part with greater attractiveness cannot get enough in volume financing. As it was shown in Section 5.3 in multi-stage financing conditions with funds lack, the projects selection affected by: priority ranks availability; costs flow planned parameters compliance for projects with financing stages parameters; conditions for ensuring financing process continuity at related stages, etc. Latter should be study subject for portfolio financing scheduling correctness understanding possibility.

Second direction is to carry out project portfolio configuration by adding missing amount to planned financing schedule in additional stage form. To do this, implement the following procedures. After projects financing priority determining in portfolio for initially specified financing schedule, exclude those projects that are planned for implementation at the last stage. Then re-carry out procedure for configuring portfolios with planned volume, but with different financing schedules forms. Based on our portfolio modeling results, it can be assumed that a change in both financing schedule form and project - candidates composition (list) can lead to change in configurable portfolio structure (composition). Therefore, in modeling process, it is necessary to check whether projects exclusion from the additionally introduced financing stage is permissible.

Separately, it is advisable to consider project portfolio using prospects configuration method based on discounting cumulative (accumulated) flows at such portfolio life cycle stages (phases) as execution and optimization. It should be noted that according to the general continuous portfolio life cycle provisions, all stages are flexible and mutually complementary. Based on this, balancing and projects portfolio optimizing tasks can be considered both at the stage of its formation and in the implementation process. Portfolio balancing refers to portfolio components combining process taking into account their priorities, relationships presence, synergy effect manifestation, and potential level for achieving strategic goals that allows more efficient planning and resources allocation [212]. Also, under optimization, creating and subsequently process of periodically portfolio evaluating in order to maximize effective available resources use for portfolio components, taking into account the risk-return (effect) ratio. Some sources use slightly different interpretations. So portfolio balancing is considered as approximating process actual costs distribution to those planned within achieving strategic goals framework by transforming project groups, and portfolio optimization as increasing portfolio manageability and attractiveness as a whole by changing projects parameters included in it.

Based on the above definitions, it can be argued that our proposed method can be used in the future for portfolio optimization purposes. At its core, it is based on a comparative analysis of various portfolio configurations with various financing schedules, in order to choose the most efficient time and financial resources use. Method allows components addition and exclusion with subsequent portfolio configuration and the most optimal financing schedule selection. It consistent with one of the portfolio optimization previously mentioned concepts. However, method requires refinement in procedures description aspect for actions and methods for calculating portfolio components attractiveness indicators and portfolio as a whole, provided it is partially implemented with “new” component (s) subsequent addition or “old” component (s) replacement with a “new”, or "old" component (s) exclusion from portfolio, or by changing components parameters without changing portfolio structure. That is, method should be supplemented by indicators of the actual and planned project portfolio status.

Relative to second "portfolio optimization" definition. Method developed by us allows modeling various portfolios configurations possibility with a fixed funding schedule by changing both number of project - candidates and their individual parameters, as well as by simultaneously changing both projects and funding schedule. Such portfolio formation options can be used when project-candidates are planned in the same organization that is involved in portfolio implementation. Projects parameters changing and their number in this case during modeling is understandable. As part of our study, we examined conditions for multi-purpose portfolios formation for large socio-economic entities based on project-candidate initiated by various stakeholders.

In this regard, changes in considered project-candidate list and their parameters not provided. In general, we can conclude that there is a significant potential for further development and developed method modification for project portfolio optimization and balancing.

To facilitate developed method application scope analysis and comparing it possibility with other methods used to solve a wide range of problems in project portfolio formation and management we proposed a graphical model [233] (fig.5.24).

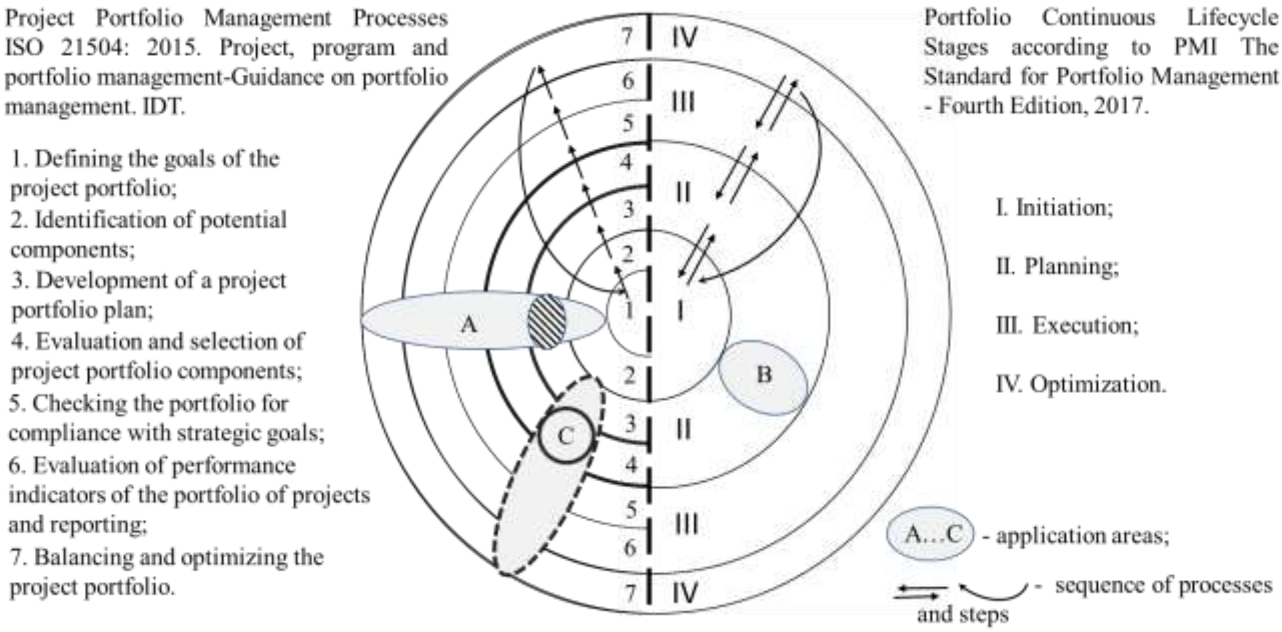


Figure 5.24 - Model imaging applications portfolio management projects

Source: developed by author.

More detailed studies should be continued regarding the hypotheses verification described in Section 5.3 and results analysis obtained during the experiments. Such need arises from situations that we encountered in some portfolios configuring results analyzing process. So, for example, according to the table 5.5 Portf2 pr4 portfolio configuration (portfolio attractiveness coefficient 0.798) is the most attractive, while Portf pr step4 portfolio (portfolio attractiveness coefficient 0.77) is the least attractive. It explained by cost flows and effects resulting curves type (form) on portfolios as a whole that depend on the projects configuration (placement) in portfolio structure. Since with multi-stage financing more restrictions are set on terms and financing amount within each stage, compared with single-stage financing, it affects projects location in portfolio and, accordingly, its final flow curves. However, we noticed that an increase in stages number does not always lead to a significant decrease in portfolio attractiveness coefficient. So, difference between project portfolios attractiveness configured with two-stage and three-stage financing is 0.002. From such statement we can conclude that it is important not only stages number but also their parameters (duration and financing amount) in comparison with project-candidate’s parameters. Based on this, following hypothesis can be put forward. Theoretically, situations are possible when portfolio configuration with more financing stages are more attractive than with fewer stages (except for a one-stage financing schedule).

Such assumption confirmation requires additional modeling and is promising area for further research. As a result, additional information can be obtained regarding recommended relationships between the initial project parameters (primarily cost flows) range and financing schedule form (financing stages number, their duration and volume).

From developed method practical implementation point of view of there are some limitations associated with operations capabilities and speed performed by the SESPortfolio software product during searching for portfolio configuration solutions. For fast and correct program operation it is recommended not to assign same value priority ranks to more than six projects. At the same time, initial projects total number should preferably not exceed thirty units.

CONCLUSION

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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Appendix A

Projects and project portfolio implementation features of large socio-economic entities (LSEE)

№	Features	Rules
1	LSEE projects are diverse, they relate to all aspects of human life (aspects — economic, political, social, cultural)	Multidimensionality rule: projects in portfolio should create products that affect simultaneously several different LSEE subject's life aspects.
2	Project products use most of LSEE	Mass rule: products and project portfolio results are focused on their use and benefits for the most part (a wide range) of LSEE entities of different levels (categories).
3	Criteria (indicators) complexity for evaluating project results (effects)	Complexity rule: project result assessment should be carried out according to (indicators, criteria), characterizing result (effect) simultaneously from several parameters (properties) position of different essence (and level) related to various LSEE subject life aspects.
4	Effects from project product appear with certain delay from project start date	Effect (result) manifestation rule: project product effect manifestation onset (or its intermediate configurations) can occur with a certain delay in time from project start date and be recorded both during project implementation and after its completion. In portfolio, taking into account project interdependencies and certain order of their implementation, effects are manifested during its implementation and after closing.
5	Short periods of LSEE guaranteed financing projects (minimum - month, quarter; maximum - year). Most projects are planned for up to 3 years, portfolios up to 6 years, that is due to their implementation peculiarities in LSEE (for example, Nigeria).	Limited phased funding rule: portfolio budget is planned for entire period of its implementation in step-by-step schedule form, according to that intermediate guaranteed financing is issued in separate parts (tranches) for separate stages. In case of non-use tranche, up to 20% of its volume can be redistributed to the next stage.
7	Continuity of financing more priority projects to obtain key results that determine portfolio success. Many projects have a long duration and are located immediately at several portfolio financing stages.	Continuity rule: project can be included in portfolio taking into account its priority, as well as subject to sufficiency and continuity of its provision at guaranteed financing stages.

8	Public-private partnership schemes widespread use in projects implementation in LSEE. Using co-financing from government, international development bank, some projects are implemented through grants.	Cooperation rule: portfolio financing and projects part implementation can be carried out on private basis, state and international partnerships. It increases general interest in successful portfolio completion and responsibility for assigned tasks implementation, but at the same time requires simple understandable schemes development and tools for managing multi-purpose portfolios.
9	Conducting a projects and portfolios social examination (beneficiaries, experts) during their development and implementation.	Involvement rule: projects examination, their products must be carried out at the portfolio formation stage (during developing conceptual frameworks, identifying projects and portfolios features) with project product main users' representatives participation (target audience, beneficiaries, external experts).
10	There is difference in approaches and tools used during projects and project portfolios managing in terms of their methodological compatibility and convenience for analysis and management decision making. Using common approaches and tools at project and project portfolio management level.	Single approach rule: it is necessary to apply uniform approaches, tools, principles to the processes of planning and evaluating projects, as well as project portfolios in different entities and at different LSEE management levels.

Appendix B

Comparative analysis of approaches to life cycle stages description and project portfolio management processes

Table B1 - Options for describing the project portfolio life cycle stages

Information source	Levine, Harvey A. Project portfolio management : a practical guide to selecting projects, managing portfolios, and maximizing benefits, 2005.	Standard for Portfolio Management, 2017.	Robert K. Wysocki. Effective Project Management: Traditional, Agile, Extreme, 2011.	Management of Portfolios. MOP,2011
Distinguished stages (phases) of project portfolio life cycle	initiation	Initiation	Establish	Understand
	project selection		Evaluate	Categorize
			Prioritize	Prioritize
			Select	Balance
	planning	Planning		Plan
	implementation management	Execution	Manage	
		Optimization		

Table B2 - Standards comparison for project portfolio managing of GOST R series and ISO on management processes structure

GOST R 54870-2011. Protect management. Requirements for projects portfolio management.	ISO 21504:2015. Project, programme and portfolio management-Guidance on portfolio management. IDT.
Collecting information process about conditions, limitations and requirements for project portfolio; **Formalizing management** procedures and project portfolio assessment parameters process;	**Creation of conditions** for project portfolio management
Identifying portfolio components process**;**	Project portfolio potential components i**dentification**
Process of evaluating project portfolio components; **Priority setting process;** **Optimization and balancing process**;	**Development** of a project portfolio plan
	Evaluation and selection of project portfolio components
Project portfolio authorization process;	**Project portfolio checking for compliance with strategic goals**
Monitoring process of project portfolio implementation;	**Assessment of project portfolio performance** indicators and reporting
Change management process.	Project portfolio **balancing and optimization**

Analysis of the standards allows us to conclude that they are comparable in content and complement each other (Table A2). Differences are mainly manifested in portfolio optimization and balancing processes understanding that realized both during portfolio initial formation (at the planning stage) and during changes are made to it (at the implementation stage).

Table B3 - Comparison of PMI series standards on management processes structure

Standard for PM, 2006		Standard for PM, 2008		Standard for Portfolio Management, 2012		
processes	groups	processes	groups	processes	processes	knowledge areas
Identification	Aligning Process Group	Identify Components	Aligning Process Group	Develop Portfolio Mgt. Plan	Defining Process Group	Portfolio Govemance Mgt.
Categorization		Categorize Components				
Evaluation		Evaluate Components		Define Portfolio	Defining Process Group	
Selection		Select Components				
		Identify Portfolio Risks		Develop Portfolio Risk Management. Plan	Defining Process Group	Portfolio Risk Mgt.
		Analyze Portfolio Risks				
Prioritization		Prioritize Components		Define Portfolio	Defining Process Group	Portfolio Govemance
		Develop Portfolio Risk Responses		Manage Portfolio Risk	Aligning Process Group	Portfolio Risk Mgt.
Portfolio Balancing		Balance Portfolio		Optimize Portfolio	Aligning Process Group	Portfolio Govemance
		Communicate Portfolio Adjustment		Develop Portfolio Communication Plan	Defining Process Group	Portfolio Communica tion Mgt.
				Manage Portfolio Information	Aligning Process Group	
Authorization		Authorize Components		Authorize Portfolio	Authorizing and Controlling Process Group	Portfolio Govemance Mgt.
Portfolio Reporting and Review	Monitoring and Controlling Process Group	Monitor and Control Portfolio Risks	Monitoring and Controlling Process Group	Manage Portfolio Risk	Aligning Process Group	Portfolio Risk Mgt.
				Provide Portfolio Oversight	Authorizing and Controlling Process Group	Portfolio Govemance Mgt.
		Review and Report Portfolio Performance		Develop Portfolio Performance Plan	Defining Process Group	Portfolio Performance Mgt.
				Manage Supply and Demand	Aligning Process Group	
				Manage Portfolio Value		
Strategic Change		Monitor Business Strategy Changes		Develop Portfolio Strategic Plan	Defining Process Group	Portfolio Strategic Mgt.
				Develop Portfolio Charter	Defining Process Group	
				Define Portfolio Roadmap	Defining Process Group	
				Manage Strategic Change	Aligning Process Group	

Appendix C

Comparative analysis of standards for managing a project portfolio of various series based on a single process model

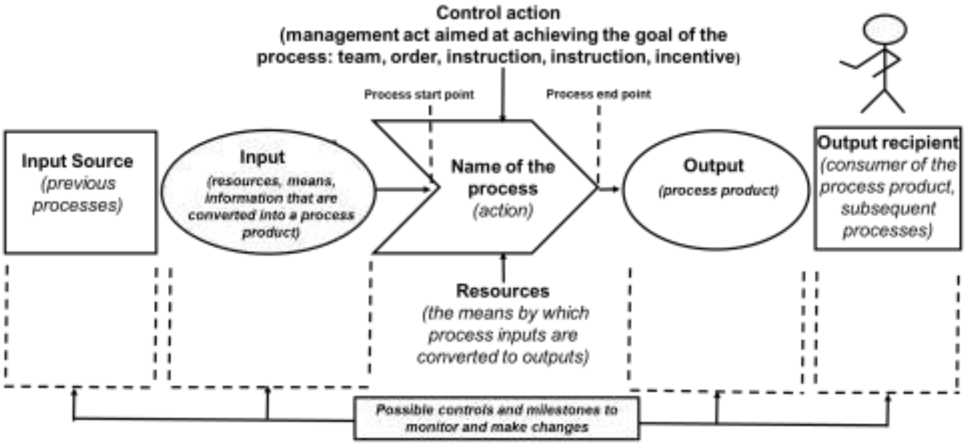


Figure C1. Schematic single process elements depiction

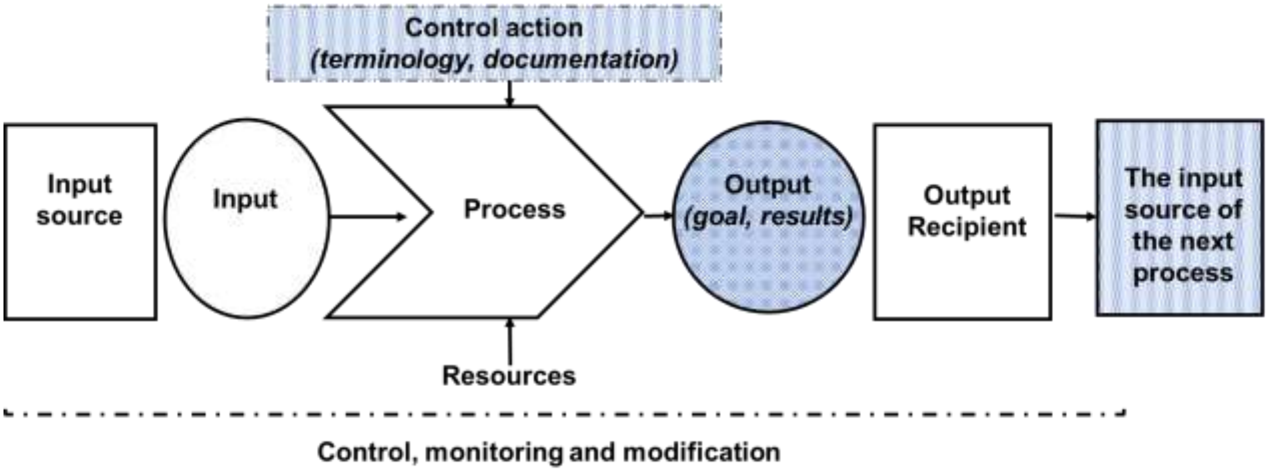


Figure C2. Structural single portfolio management process scheme filling according to GOST R 54870-2011 Requirements for projects portfolio management

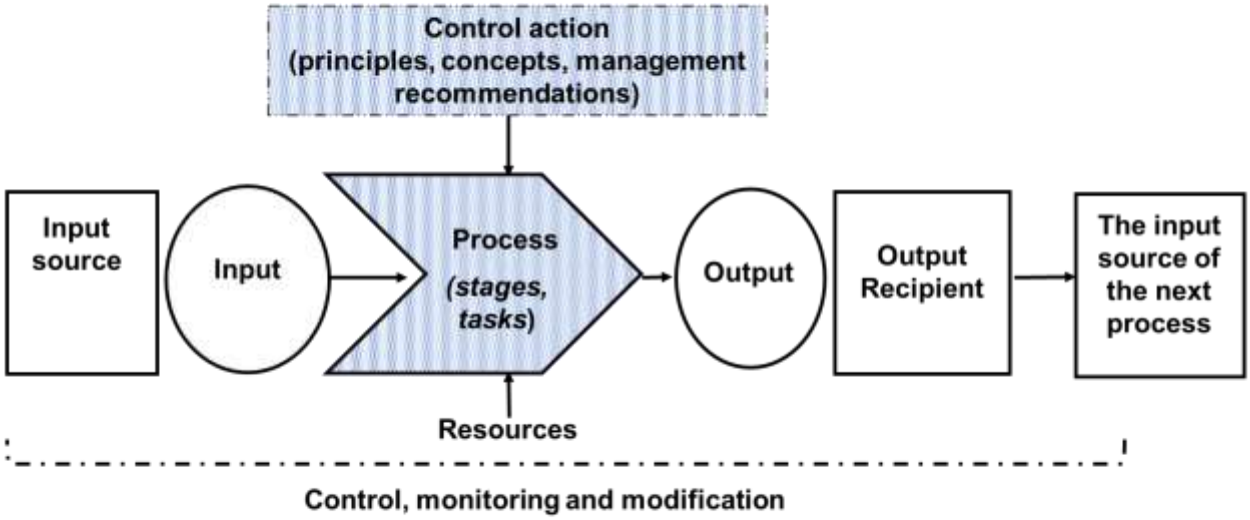


Figure C3. Structural single portfolio management process scheme filling according to ISO 21504:2015. Project, programme and portfolio management-Guidance on portfolio management

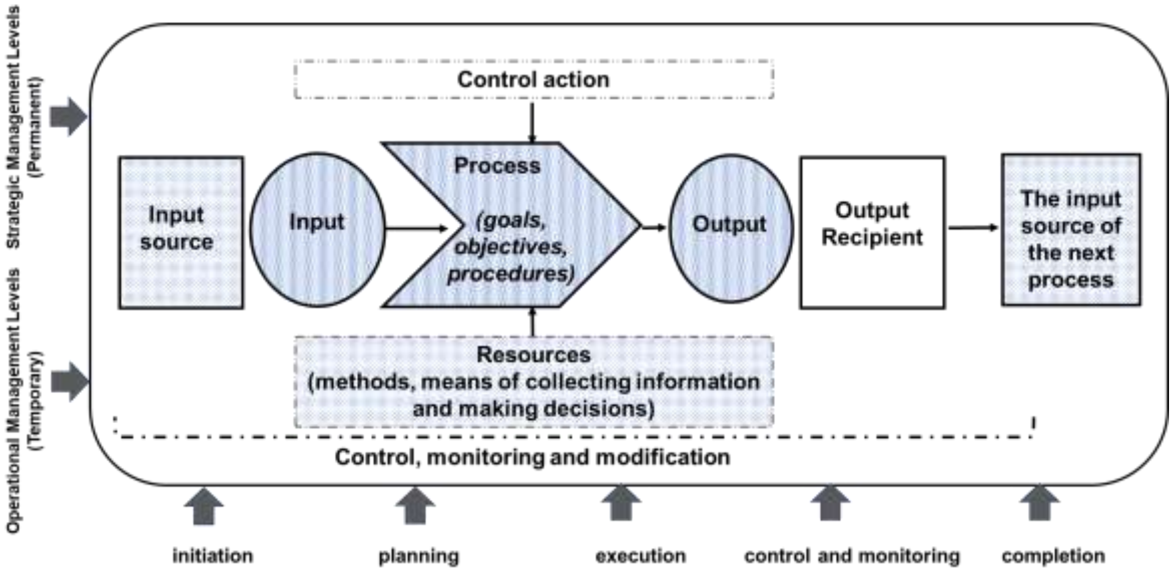


Figure C4. Structural single portfolio management process scheme filling according to DIN 69909-1:2013-03 Multi Project Management-Management of project portfolios, programs and projects

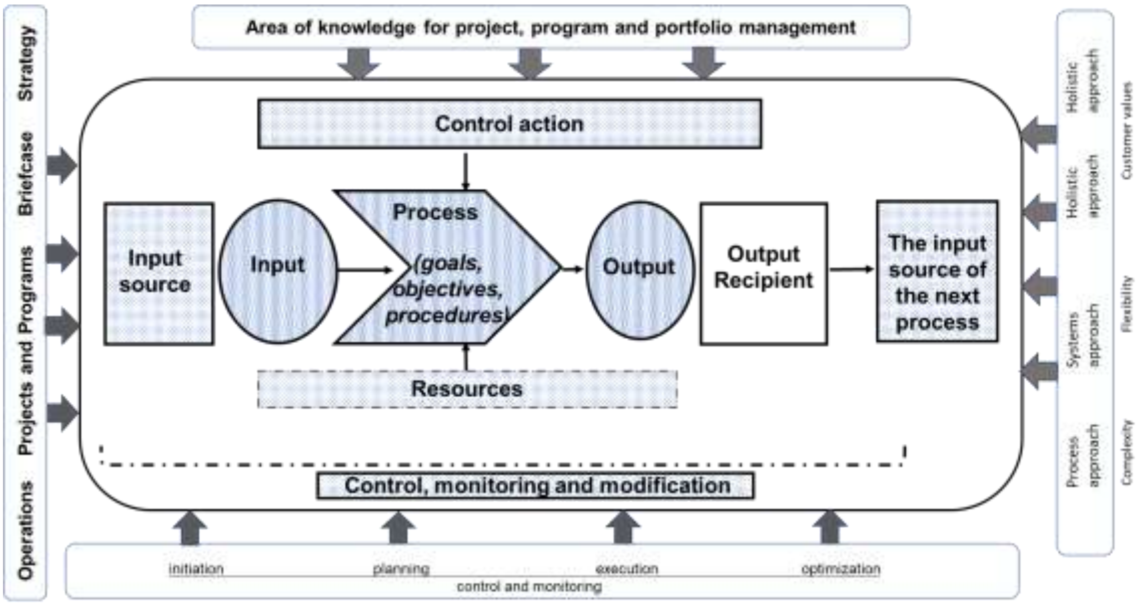


Figure C5. Structural single portfolio management process scheme filling according to PMI series of standards

Appendix D

Map of the project-candidate in portfolio ______________
(cipher)

1. Identification block of the project-candidate

1.1.Project name _________________

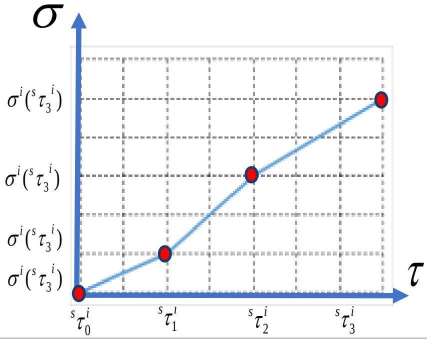
1.2. Name of organization responsible for the implementation of the project-candidate _________________________, representative contacts __________________

1.3. Project goal (in the form of product-effective description) ____________________________________ (an indication of relationship with objectives of project portfolio)

2. Feasibility description block of the project-candidate

2.1. Imagine the cumulative curve reflecting necessary funding for the project-candidate in coordinates: time (month)- expenses (thousand …..) using 4-6 key points to build it.

Moment number	Key moments	
	τ	σ
0		
1		
2		
3		
4		
5		



Give answers to the questions:

2.3 What type of innovation do you consider a project product for?

a	b	c	d	e
Process	Marketing	Organizational	Product	Mixed

2.4 What is the degree of innovation?

a	b	c	d	e
Idea level	Laboratory research	Current layout	Tested sample	First sale

2.5 What is the scale of novelty?

a	b	c	d
Local	Regional	National	International

2.6 What are the competitive advantages of your project product compared to peers? RANK

a	b	c	d	e
Resource	Technological	Intellectual	Market	Cultural

2.7. Availability of necessary permits

a	b	c	d
Not required	Required but not available	In process, in the presence of more than 50%	All documentation available

2.8 Ability to replace key technologies used to create project product

a	b	c	d
absent	low	average	high

2.9. What is the novelty of the technology used for contractors?

a	b	c	d
New technology	Famous technology	Technology is fully mastered	Sufficient experience of using technology

2.10. Number of organizations of performers involved in the project

a	b	c	d	e
0	until 3	until 5	until 7	more than 7

2.11. What % of project management team members have a certificate or special education in project management? _____________%_;

2.12. Project manager experience _____________ years;

2.13. Indicate% of project management team members working on an ongoing basis during the implementation of this project: _________%;

2.14. Indicate% of project management team members who previously worked together in common projects: _______%.

2.15. List the internal factors of the project that contribute to its successful implementation and their significance:

Factors				
Relevance				

2.16. List the internal factors of project that may impede its successful implementation and their significance in terms of expected negative impact

Factors				
Relevance				

3. Achievement description block of the project-candidate

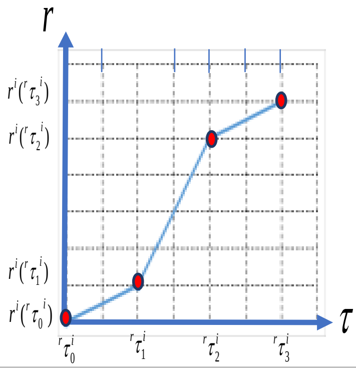
3.1. Determine moment of manifestation of effect of the project product in relation to the start (launch) of the project. Indicate the offset. (month)

3.2. Describe what effect is expected from the use of the project product.

3.3. Imagine cumulative curve reflecting the planned increasing effect of the use of the product of the project-candidate, in coordinates: time is the effect using 4-6 key points for its construction.

Off set __________

Moment number	Key moments	
	τ	r
0		
1		
2		
3		
4		
5		



Give answers to the questions:

3.4. Justify the degree of need for the project at the moment by answering these questions: Who needs a project? Who will be the specific user of the project product? Who will receive benefits, effect of the project results? What problem is solved by the project? How acute problem? In what time frame can it be solved and to what extent?

3.5. Due to what, the reduced dynamics of the increase in the result (effect) will be ensured. Describe the reasons for the change in the rise curve at characteristic points. 3.6. List the social groups, their numbers, and territories of distribution that are consumers of the project product.

Appendix E

Period	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	projec t 1	project 2	project 3	project 1	project 2	project 3
0	100	20	69	100	20	69
1	80	40	56	180	60	125
2	60	50	45	240	110	170
3	40	60	37	280	170	207
4	20	70	30	300	240	236
5	15	80	24	315	320	260
6			18			279
7			14			293
8			11			304
9			8			312
10			6			319
Amount	**315**	**320**	**319**	1415	920	2574
Period	discounted at monthly rate of 1%					
	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	projec t 1	project 2	project 3	project 1	project 2	project 3
0	100,0	20,0	69,0	100,0	20,0	69,0
1	79,2	39,6	55,3	178,2	59,4	123,5
2	58,8	49,0	44,3	235,3	107,8	166,6
3	38,8	58,2	35,5	271,8	165,0	200,5
4	19,2	67,3	28,5	288,3	230,6	227,0
5	14,3	76,1	22,8	299,7	304,5	247,6
6			17,4			262,6
7			13,3			273,2
8			10,1			280,6
9			7,7			285,6
10			5,9			288,6
Amount	**310**	**310**	**310**	1373	887	2425

Period	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	95	20	69	95	20	69
1	80	40	56	175	60	125
2	60	50	45	235	110	170
3	40	60	37	275	170	207
4	20	70	30	295	240	236
5	15	80	24	310	320	260
6			18			279
7			14			293
8			11			303
9			8			312
10			6			318
Amount	**310**	**320**	**318**	1385	920	2571
Period	discounted at monthly rate of 2%					
	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	95,0	20,0	69,0	95,0	20,0	69,0
1	78,4	39,2	54,7	171,6	58,8	122,3
2	57,7	48,1	43,5	225,9	105,7	163,4
3	37,7	56,5	34,5	259,1	160,2	194,7
4	18,5	64,7	27,4	272,5	221,7	218,2
5	13,6	72,5	21,7	280,8	289,8	235,7
6			16,3			247,4
7			12,2			254,8
8			9,2			258,9
9			6,9			260,7
10			5,2			260,8
Amount	**301**	**301**	**301**	1305	856	2286

Period	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	93	21	69	93	21	69
1	80	40	56	173	61	125
2	60	50	45	233	111	170
3	40	60	37	273	171	207
4	20	70	30	293	241	236
5	13,7	80	24	306,7	321	260
6			18			279
7			14			293
8			11			304
9			8			312
10			6			319
Amount	**306,7**	**321**	**319**	1372	926	2574

Period	discounted at monthly rate of 3%					
	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	93,0	21,0	69,0	93,0	21,0	69,0
1	77,7	38,8	54,2	168,0	59,2	121,1
2	56,6	47,1	42,6	219,6	104,6	160,2
3	36,6	54,9	33,5	249,8	156,5	189,1
4	17,8	62,2	26,3	260,3	214,1	209,9
5	11,8	69,0	20,7	264,6	276,9	224,5
6			15,5			233,4
7			11,6			238,2
8			8,6			239,9
9			6,5			239,4
10			4,8			237,2
Amount	**293**	**293**	**293**	1255	832	2162

Period	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	95	20	66	95	20	66
1	75	40	54	170	60	120
2	60	50	45	230	110	165
3	38	60	37	268	170	201
4	17	70	30	285	240	231
5	15	79,5	25	300	319,5	256
6			19			275
7			15			290
8			11			301
9			9			310
10			7			317
Amount	**300**	**319,5**	**317**	1348	920	2533
Period	discounted at monthly rate of 3%					
	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	95,0	20,0	65,9	95,0	20,0	65,9
1	72,1	38,5	52,1	163,5	57,7	115,5
2	55,5	46,2	41,2	212,6	101,7	152,2
3	33,8	53,3	32,5	238,3	151,1	178,9
4	14,5	59,8	25,7	243,6	205,2	197,7
5	12,3	65,3	20,3	246,6	262,6	210,4
6			15,1			217,4
7			11,3			220,3
8			8,4			220,3
9			6,3			218,1
10			4,7			214,3
Amount	**283**	**283**	**283**	1200	798	2011

Period	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	100	20	69	100	20	69
1	80	40	56	180	60	125
2	60	50	45	240	110	170
3	40	60	37	280	170	207
4	20	70	30	300	240	237
5	20	80	24	320	320	261
6			19			279
7			14			294
8			11			305
9			9			314
10			7			320
Amount	**320**	**320**	**320**	1420	920	2580
Period	discounted at monthly rate of 4%					
	cash flow $({}_0\sigma)_p$.			accumulated cash flow $(\sigma)_p$.		
	project 1	project 2	project 3	project 1	project 2	project 3
0	100,0	20,0	69,0	100,0	20,0	69,0
1	76,9	38,5	53,7	173,1	57,7	120,0
2	55,5	46,2	41,9	221,9	101,7	157,3
3	35,6	53,3	32,6	248,9	151,1	183,9
4	17,1	59,8	25,4	256,4	205,2	202,2
5	16,4	65,8	19,8	263,0	263,0	214,2
6			14,8			220,8
7			11,0			223,3
8			8,2			222,9
9			6,1			220,4
10			4,6			216,5
Amount	**301**	**284**	**287**	1263	799	2050

№	Amount	project 1	project 2	project 3
Discounted at monthly rate of 1%				
1	cash flow	315	320	319
2	discounted cash flow	310	310	310
3	accumulated cash flow	1415	920	2574
4	discounted accumulated cash flow	1373	887	2425
Discounted at monthly rate of 2%				
5	cash flow	310	320	318
6	discounted cash flow	301	301	301
7	accumulated cash flow	1385	920	2571
8	discounted accumulated cash flow	1305	856	2286
Discounted at monthly rate of 3%				
9	cash flow	307	321	319
10	discounted cash flow	293	293	293
11	accumulated cash flow	1372	926	2574
12	discounted accumulated cash flow	1255	832	2162
Discounted at monthly rate of 4%				
13	cash flow	300	320	317
14	discounted cash flow	283	283	283
15	accumulated cash flow	1348	920	2533
16	discounted accumulated cash flow	1200	798	2011
Discounted at monthly rate of 4 %				
17	cash flow	320	320	320
18	discounted cash flow	301	284	287
19	accumulated cash flow	1420	920	2580
20	discounted accumulated cash flow	1263	799	2050

Period	cash flow		
	project 1	project 2	project 3
0	100	20	69
1	80	40	56
2	60	50	45
3	40	60	37
4	20	70	30
5	20	80	24
6			19
7			14
8			11
9			9
10			7
Amount	**320**	**320**	**320**

Appendix F

Instruction for SES Portfolio computer program installing

Pay attention! *The following requirements for PC parameters are required for installation:* Windows - 64 bits , hardware virtualization virtualization bios settings - Virtualization Technology (Enable).Approximate installation time for all components (at first start-up) is 1 hour, depending on the configuration of the PC and possible problems during installation. When you reboot the already installed program (you must start with the section " Starting a software solution"), the time to start - 7-10 minutes.

Installing the server for further work on the basis of web technologies (the action is performed once, when you re-run the SES Portfolio program, you do not need to do this).

I. Installing the Docker.

1. Go to the Docker download page (https://docs.docker.com/toolbox/toolbox_install_windows/), and click the Get button. Docker Toolbox for Windows »(Fig.F1.1, p.1.1).

Figure F1.1. Download the Docker app

If there is no corresponding link on the specified page, you can use another alternative link to the program and the manual and installation (Figure F1.2, Figure F1.3): https://docs.docker.com/toolbox/overview/ .

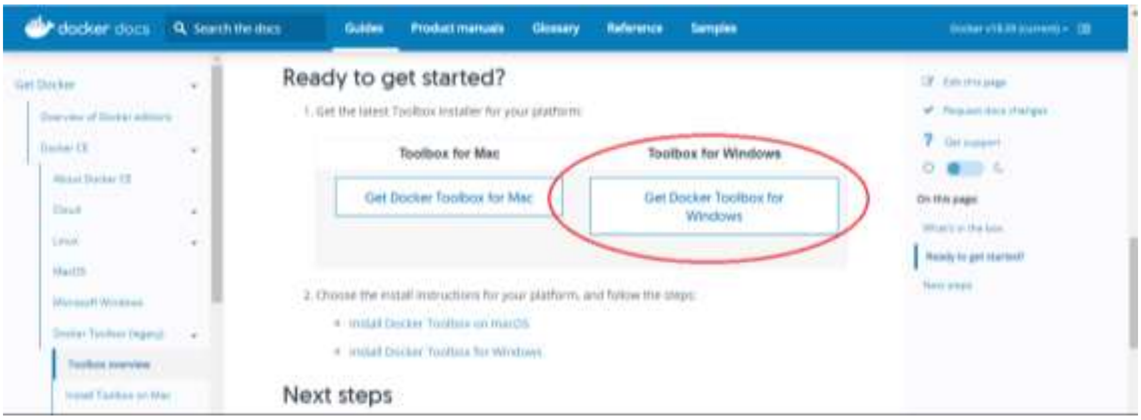


Figure F1.2.The button to download the program

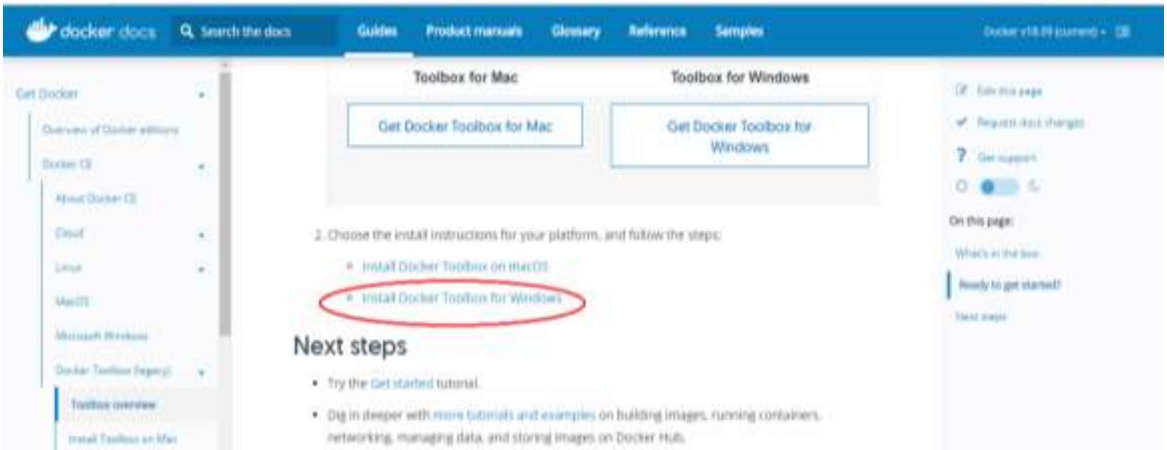


Figure F1.3. Links to the user manual

2. Run the downloaded file (Fig. F2).

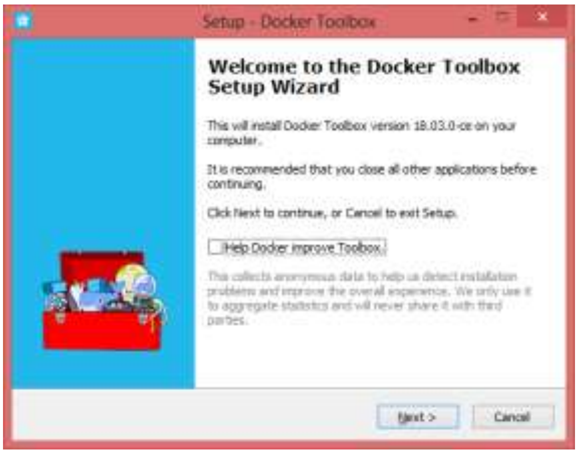


Figure F2. Launching the installation of the software

3. Click " Next ".
4. Select " Fullinstallation " (Fig. F3)

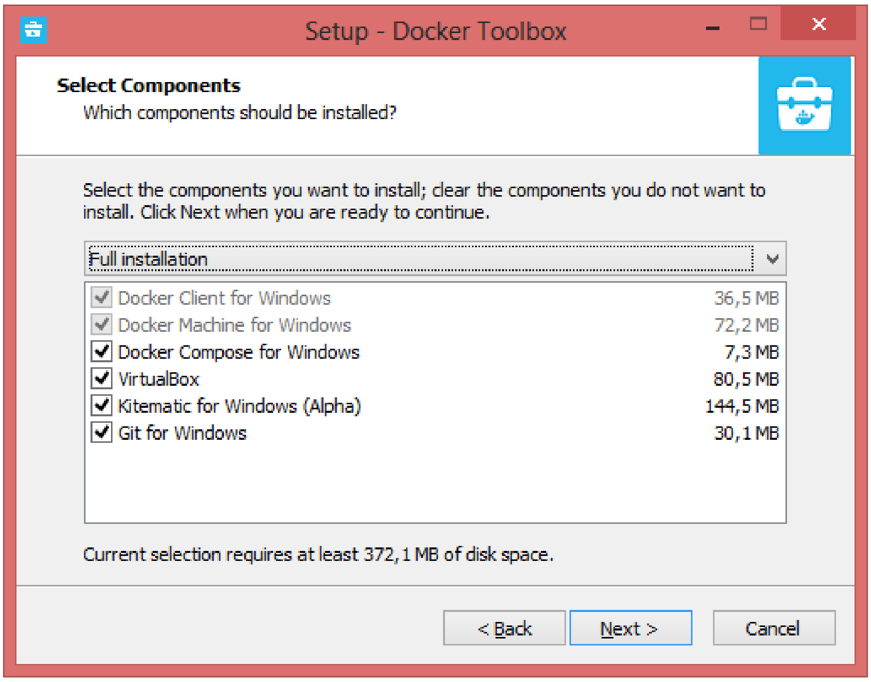


Figure F3.Restoration of the installation

5. Click " Next ".
6. Leave the checkboxes unchanged. And again press « Next » (fig. F4).

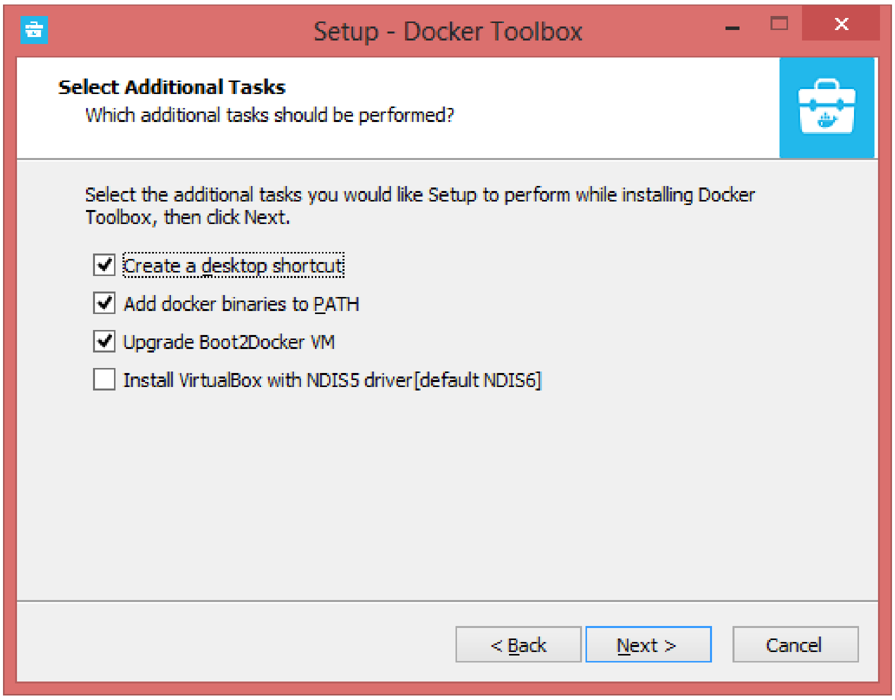


Figure F4.Select necessary changes

7. . Confirmation by clicking " Install " (Fig. F5).

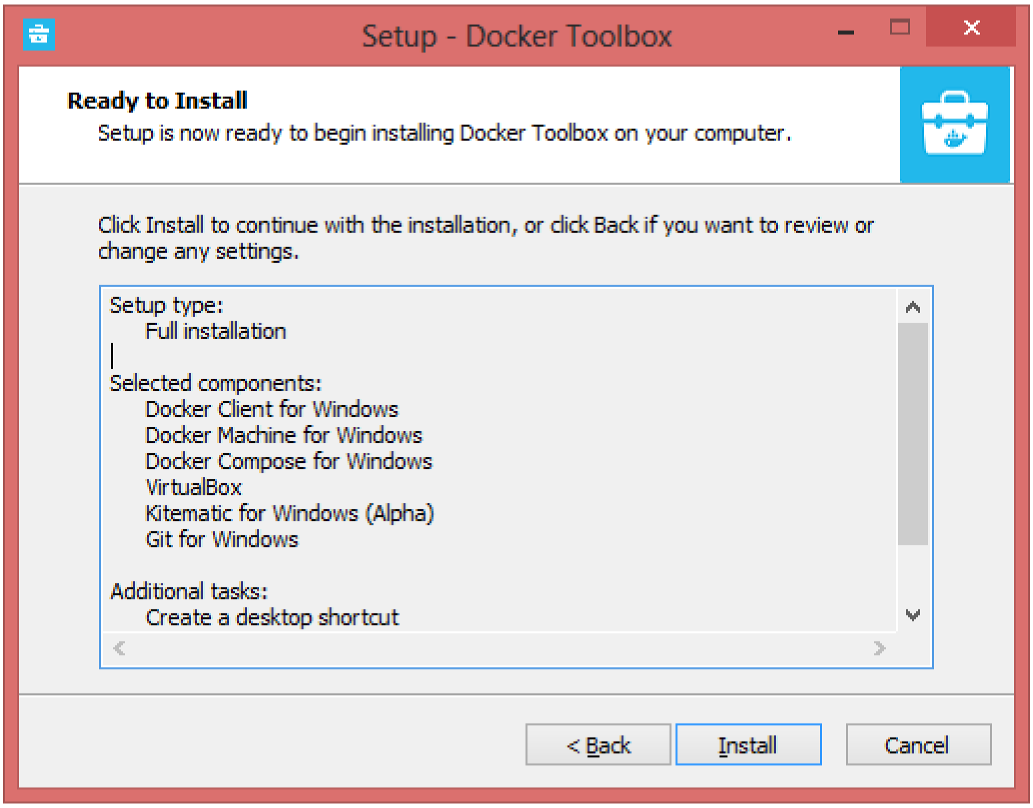


Figure F5: Confirmation of " Install "

8. If necessary, confirm the new settings, the required administrator privileges, etc., we agree (Install / Accept / Yes , etc.). (Fig. F6). The message appears several times.

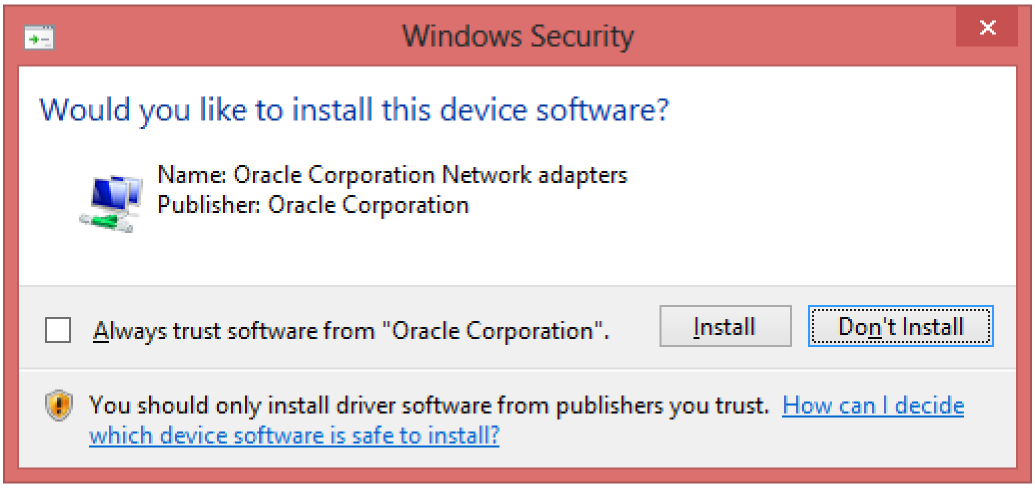


Figure F6 Confirm new settings

9. We confirm the successful installation (Fig. F7).

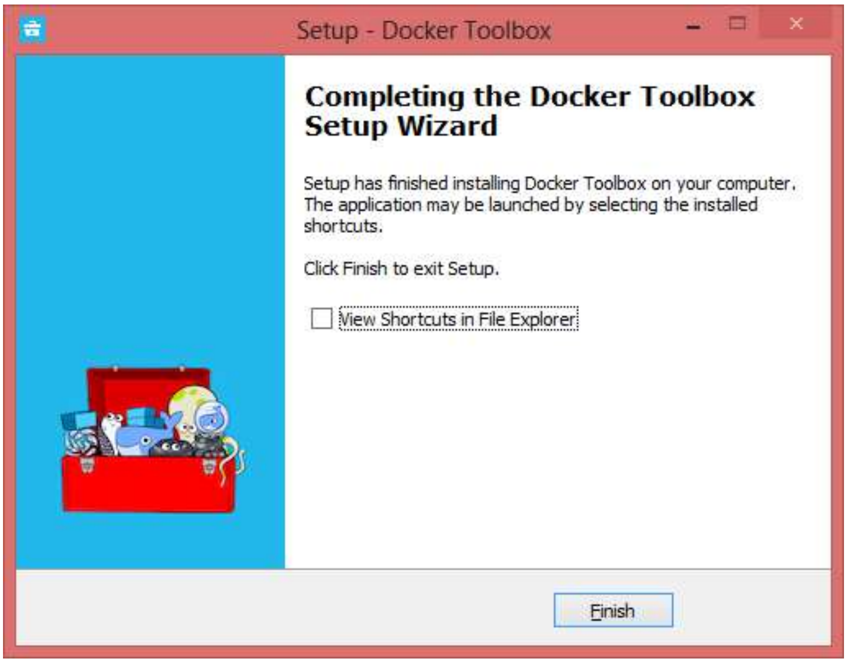


Figure F7. Completing the installation

II. Installs my software solution.

1. Run Kitematic (desktop shortcut).
2. Clicks my "Use VirtualBox" when a request occurs (the stage may not be present). Fig. F8a.

Figure F8a. Launch Kitematic

If you are prompted to log in to your account, click "skip / then (not now)" in Fig. 8b.

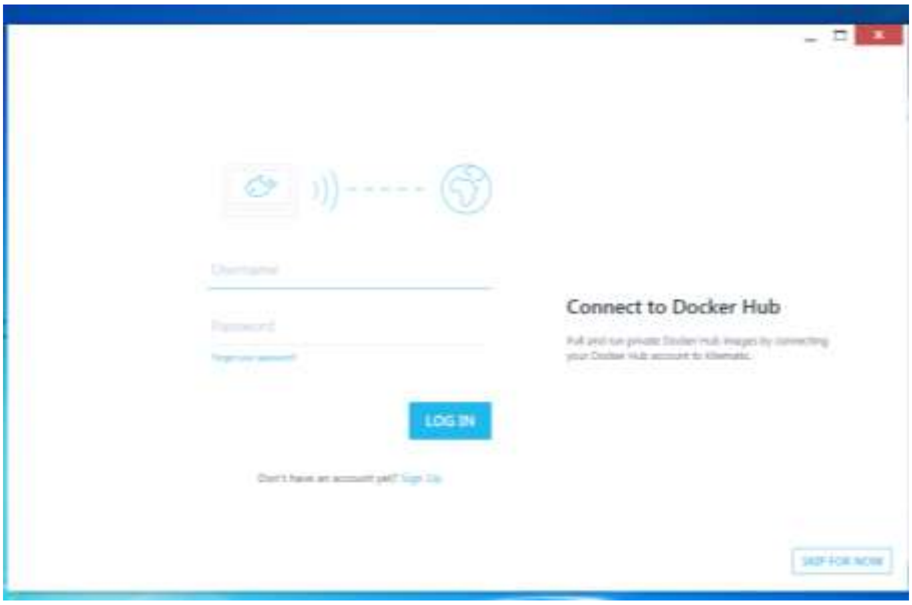


Figure 8b Registration in the program (not required)

When installing Kitematic can blame some errors (Fig. F8c), in the case of such messages, you must choose the following option: « Delete VM & Retry Setup » .

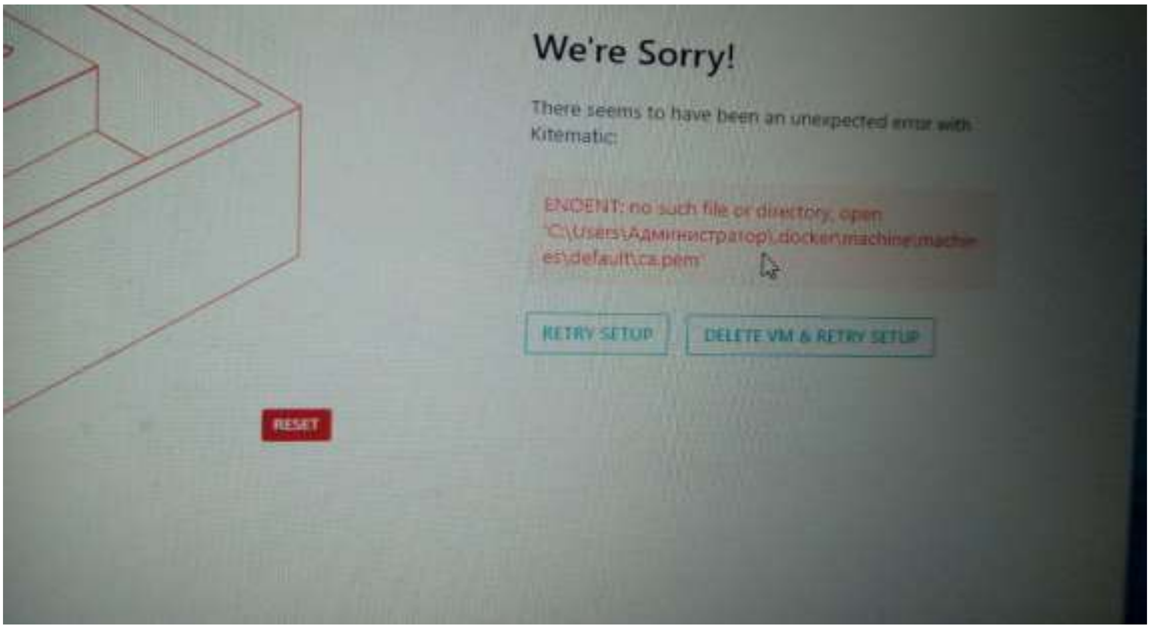


Figure F8c: Error while installing Kitematic

III. In the case of a successful installation, reboot the operating system .

IV. Installing an application (in case of the release of the updated version, start installing from this section).

1. Unpacks my archive with a software solution.
2. Starts the file with the administrator privilege : "/ bin / install . bat "(Fig. F9).

The process may, aynyaty while.

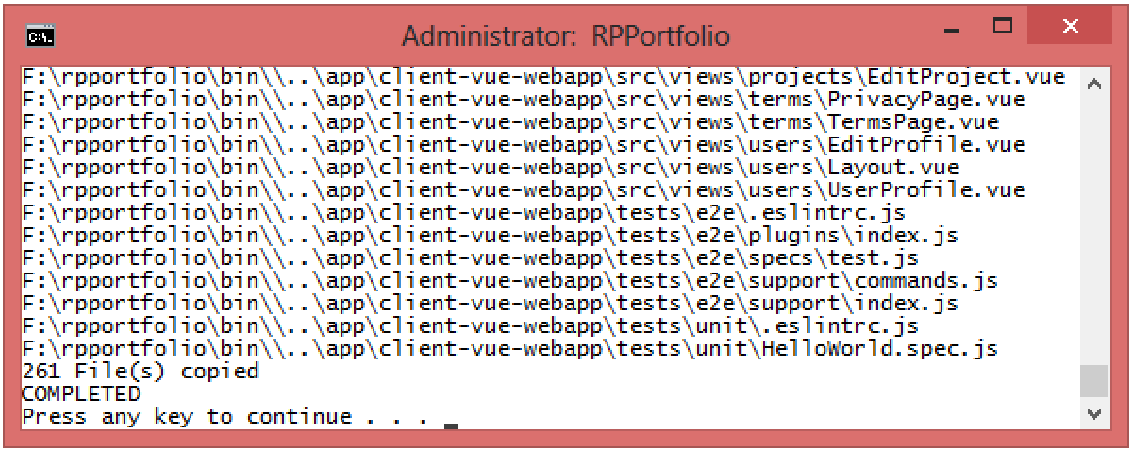


Figure F9.Install update

3. Presses «Enter».
4. Run Kitematic.

5. In idkryvaye mo CLI (Figure F10, lower left corner)

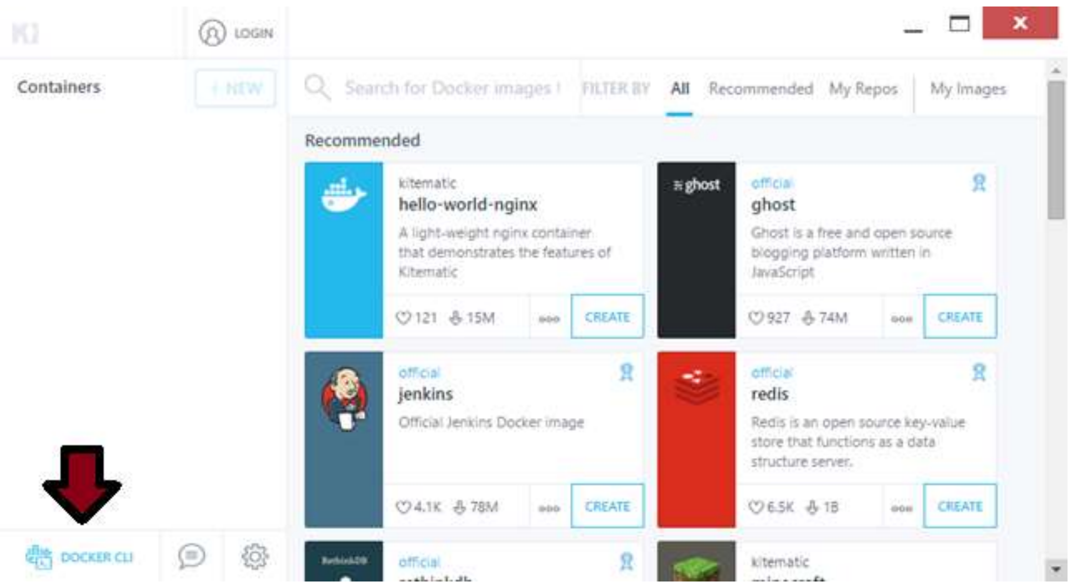


Figure F10.Opening of CLI

6. Copy the next line to the CLI (we *do not use the* shortcut *keys*). We use the commands (copy, paste) from the menu.

Line for Copy : cd C: \ servers \ rpportfolio; docker-compose build;

Press Enter.

7. The installation is complete. Installation may take some time. Example the installation process is shown in Fig.F11a.

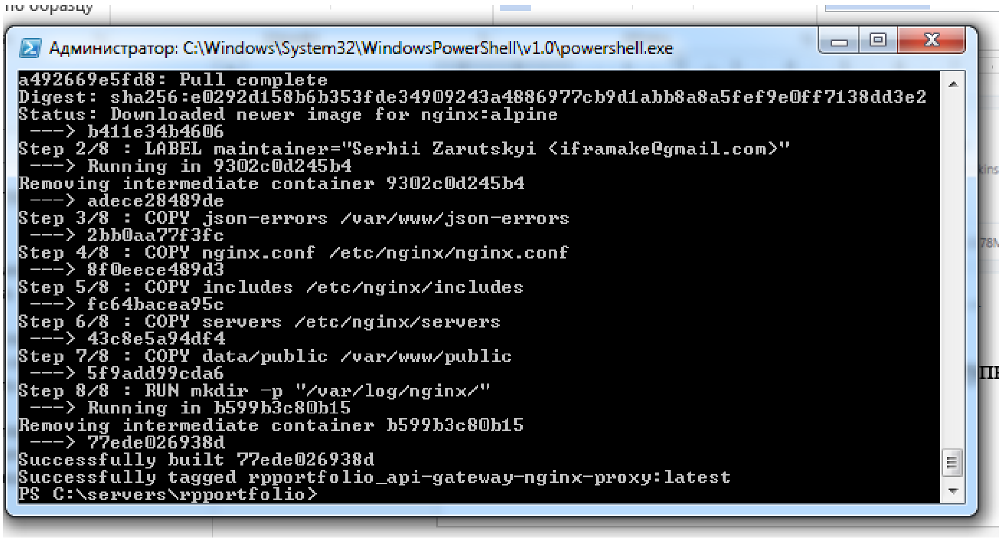


Figure F11a. The installation process

8. If you encounter difficulties with steps 6-7, the console will issue errors to the commands such as in Fig. F11b , then you need to install python 3.6 (https://www.python.org/download) and repeat command 6 if errors continue (remove installed components (Docker , Kitematic , Oracle VM) through the menu-control panel of the program, install the previous version of the Docker 17 Toolbox , repeating and all items since the beginning of the instruction.

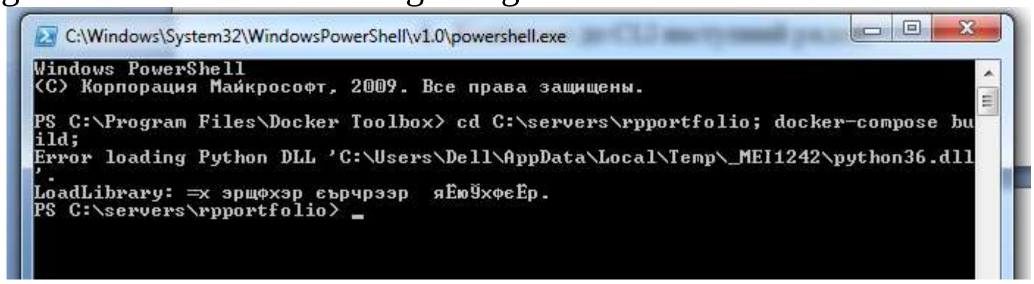


Figure F11 b Example of installation error

In case of difficulties, contact the developers of this software.

Since the launch of the software solution.

I. Launches my Kitematic . If necessary, click " UseVirtualBox ".
II. Opens my CLI (Fig. F12) .

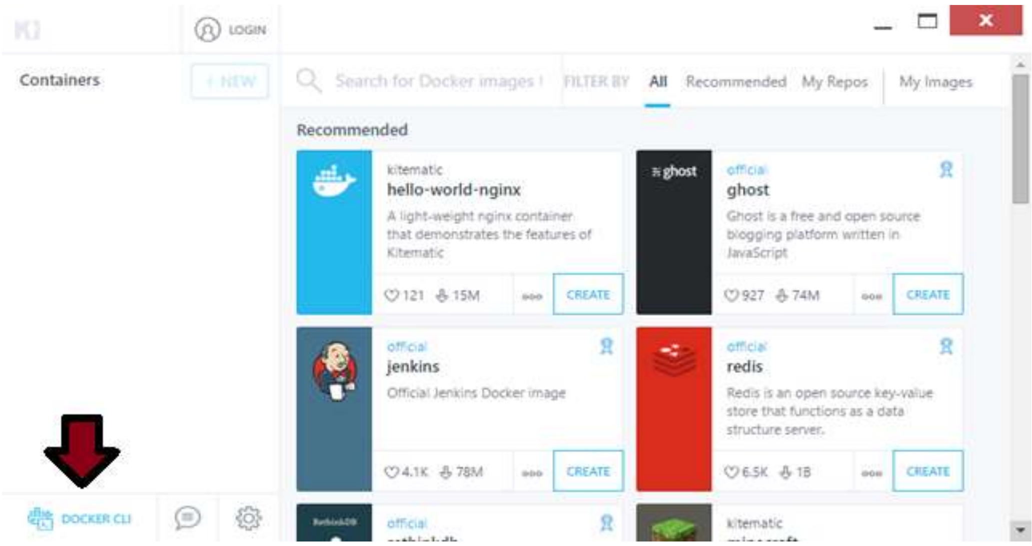


Figure F12. Starting the Docker

III. Copy to the CLI the following line (we *do not use wallet keys*):
cd c: \ servers \ rpportfolio; docker-compose up;
Presses my Enter.

IV. There is a wait until 20 seconds to stop the messages. (the process may take some time) rice. 13.

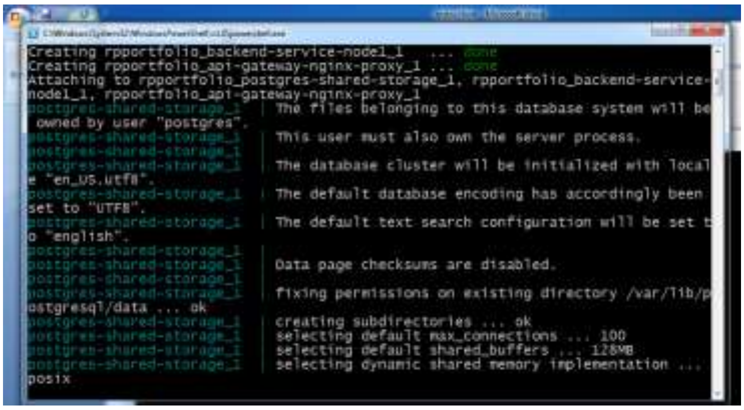


Figure F13.View of messages

V. Selects mo container that contains the name of the API (claim 1, Fig.F15), and click mo "in eopen in your default browser" (p.2) for open solutions address available in other browsers.

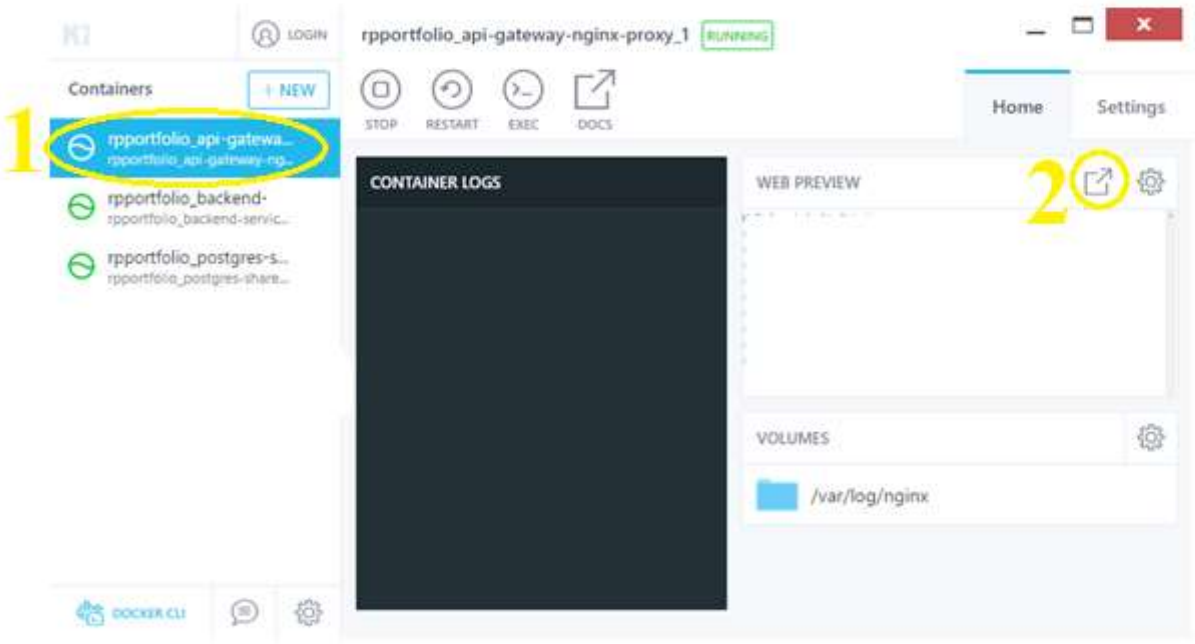


Figure F15a.Container selection

If the page in the browser does not automatically upload (it is desirable to use Google Chrome), you need to click on the image in the web window left mouse button preview "(Fig. F15b).

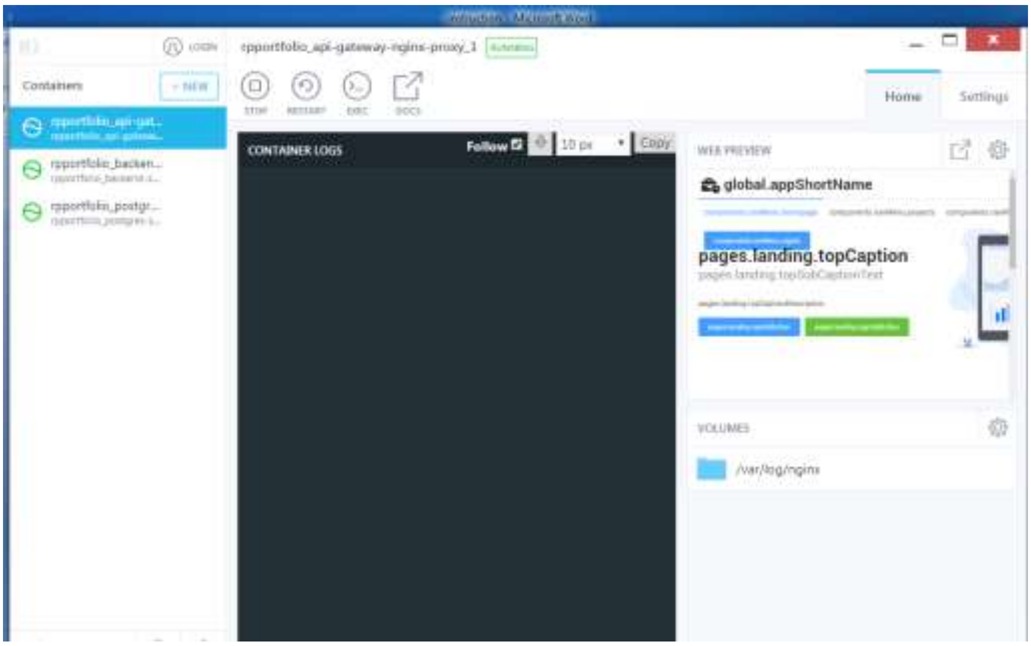


Figure F15b . Opening a software product

Registration in the program (more detailed information in the user's manual).

If the program is installed and the software solution is activated before the user in the browser opens the next page (Figure F16). It is suggested to sign up for the program (create an account if you work for the first time, or you need a new account). It is also suggested that you log in to the account you have already created (if you have not used the program for the first time).

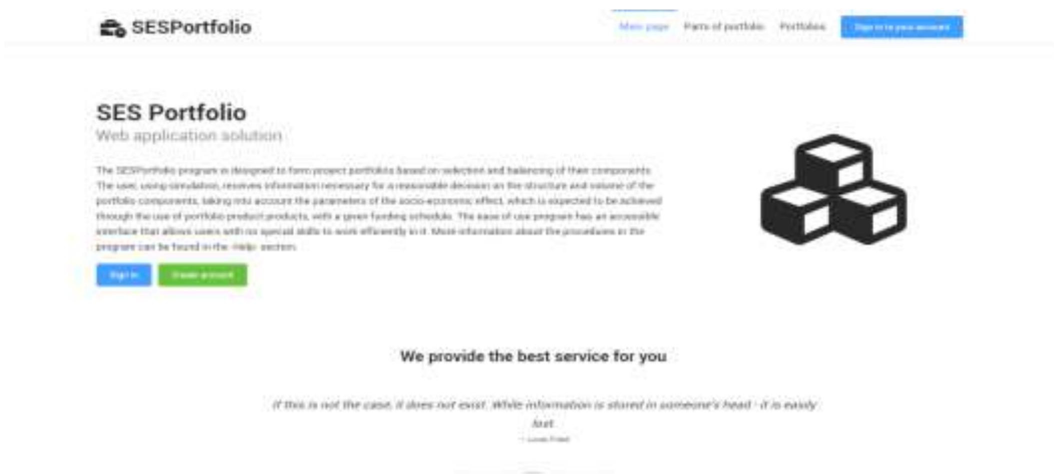


Figure F16. Program home page

If you are the first time you work with the program, you will be logged in , indicating the necessary data (username, email and password to be remembered). An example of registration is shown in Fig.F17

If necessary, the language of the interface (English, Ukrainian) can be changed using the menu in the lower right corner of the loaded page.

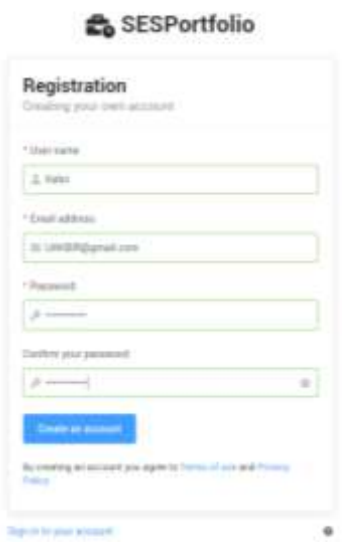


Figure F17. Using a new user

After entering the data, you will be able to log into your account (by entering the email box and password that was specified during registration) . Fig.F18

Figure F18. Entry to the program

After logging in to your account (Fig.F19), you will be able to specify project parameters and form portfolios from them in the future.

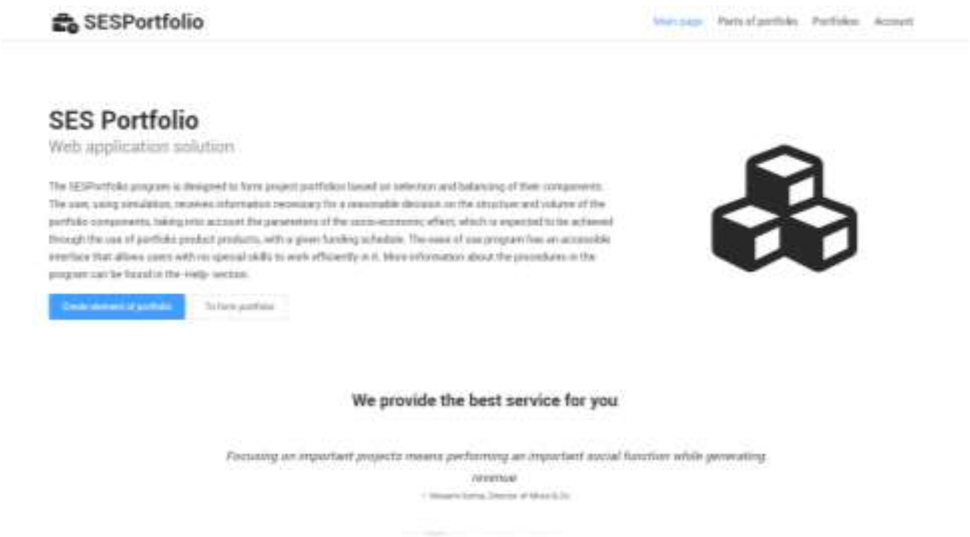


Figure F19.Functions of functions after the entrance

Close the program by closing the page in the browser.

Reboot the program

When you restart the program, start with the " **Start a software solution** " section. We carry out all actions according to the specified points.

If there are errors when executing commands in the CLI, you need to remove all three available containers from the left upper corner (fig. F20). To do this, hover over them (opposite the containers, activating additional functional buttons in the form of a heart and a cross - deleting-the cross "X"). Then, repeat all the items in the " **Starting a Software Solution** " section.

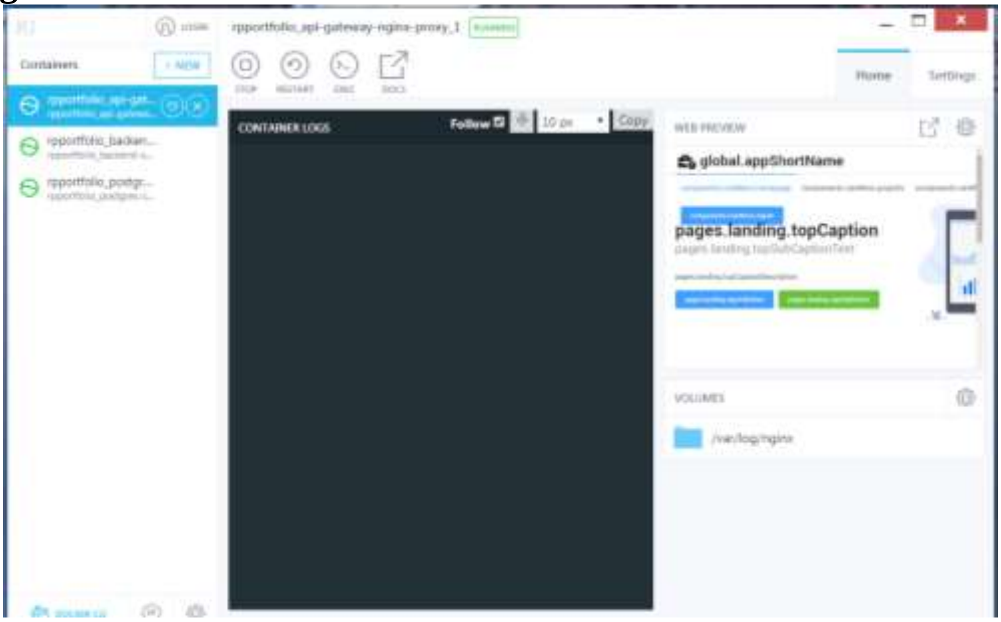


Figure F20. Re-launch and remove the program

Appendix G

User manual

Terms.

The SESPortfolio program is designed to form project portfolios based on selection and balancing of their components. The user, using simulation, receives information necessary for a reasonable decision on the structure and volume of the portfolio components, taking into account the parameters of the socio-economic effect, which is expected to be achieved through the use of portfolio product products, with a given funding schedule. The ease of use program has an accessible interface that allows users with no special skills to work efficiently in it.

Item 1. Getting to know the interface of the main page.

After starting the program before the user will download the main page of the program (Fig .G1) .

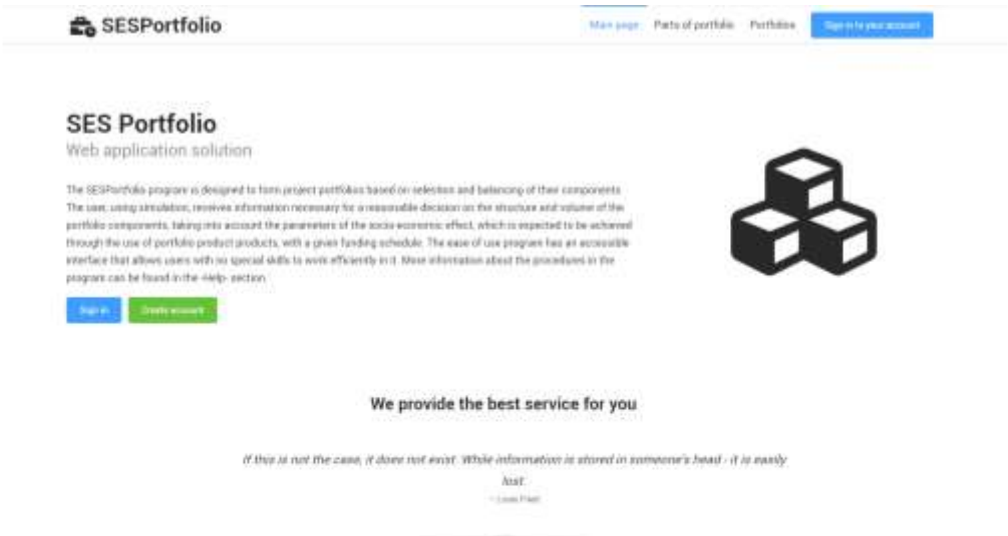


Figure G1 Interface of the main page of the program (general view)

The main page contains a general description of the program, with an explanation of its purpose, the main steps to create portfolios, are dynamically modeled "winged expressions" that emphasize the specificity of planning and project and portfolio management.

Explanation of the functional elements of the interface of the main page of the SES program Portfolio (Portfolio of socio-economic systems) is shown in Fig. G2.

In the upper right corner (label 1) is the main menu with sections "Home Page", "Portfolio components", "Portfolios", "Login to account".

Below is an additional menu for logging into the program with "Sign In" and "Create Account" sections (Tag 2).

At the bottom of the page is the menu of the choice of language - Ukrainian, English (mark 3) and menu of additional information: copyright - «© 2019 SESPortfolio », «Help», «Privacy», «Terms of Use» (mark 4).

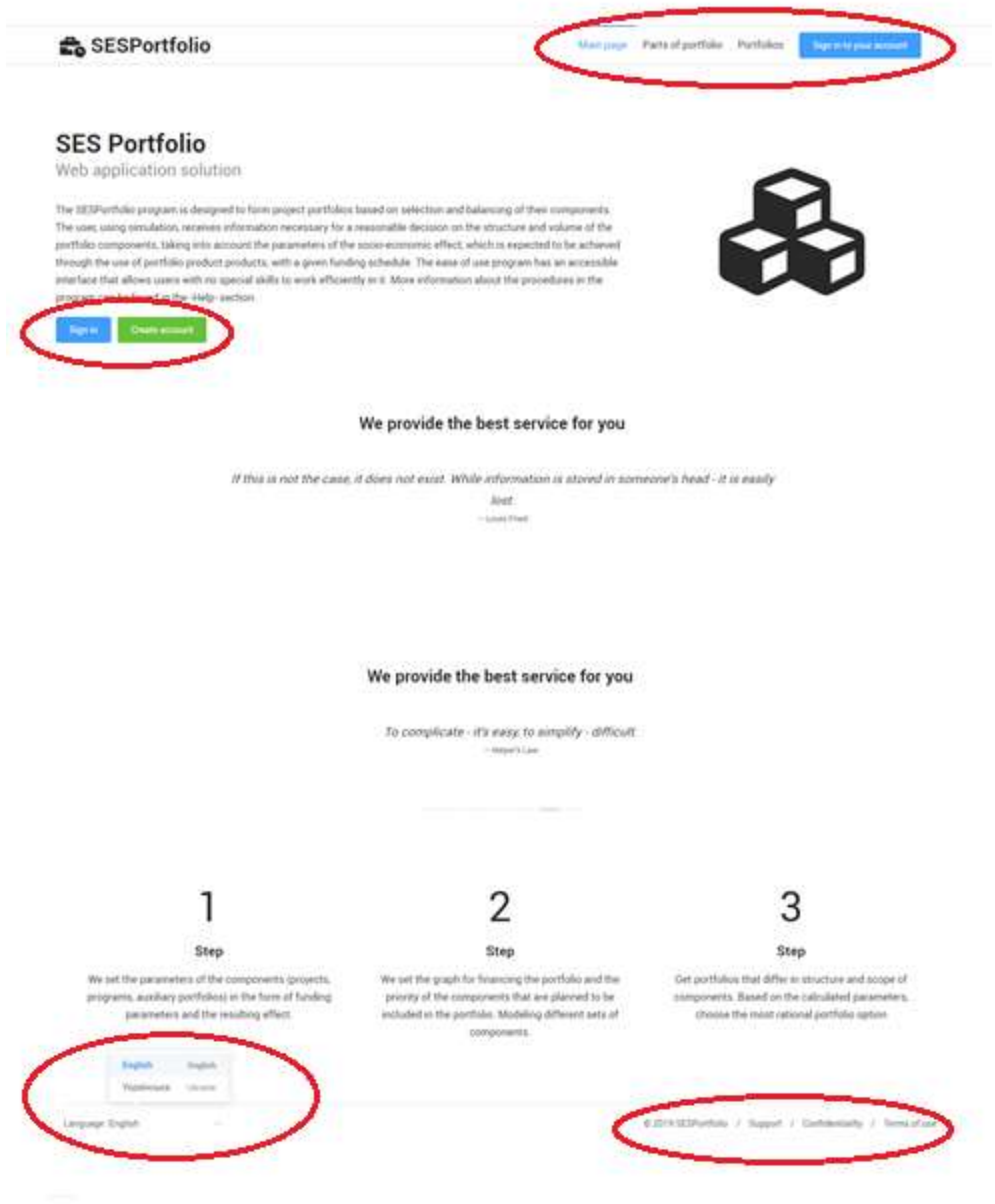


Figure G2 Interface of the main page of the program

Item 2. Creating an account.

The "Sign in" section (Figure G2, tag 2) is used by already registered users who have an account created. If you work for the first time, then you must register first - that is, create an account (click on the "Create account" section).

After that you need to fill in the corresponding registration form (fig. 3.1) with the username (login), email address, password (at least 8 characters). Entering data must be remembered.

If all the fields are filled correctly, the program will allow you to create an account for which the user needs to click on the corresponding link "Create account" (Fig. G3.2).

Figure G3.1. Registration form   vG3.2. Create an account

Item 3. Log in to the account.

After registration, the user returns to the main page (fig. G2, tag 1) and can log into the program using the corresponding link - "Login" (fig. G2, tag 2).

In this case, the program will require the input of the identification: the email address and password (fig. G4.1). If you are not the first time you log in to your account, depending on the device you use to work with the program, its operating system settings and the browser (password management function), the program will offer you a list of already saved addresses and passwords.

To log in, you must confirm the entry by clicking on the "Sign in" link (Figure 4.1).

After logging in to the main page, you'll see the link "Create a portfolio component", "Create a portfolio" (fig. G4.2, tag 1).

Figure G4.1. Log in to your account

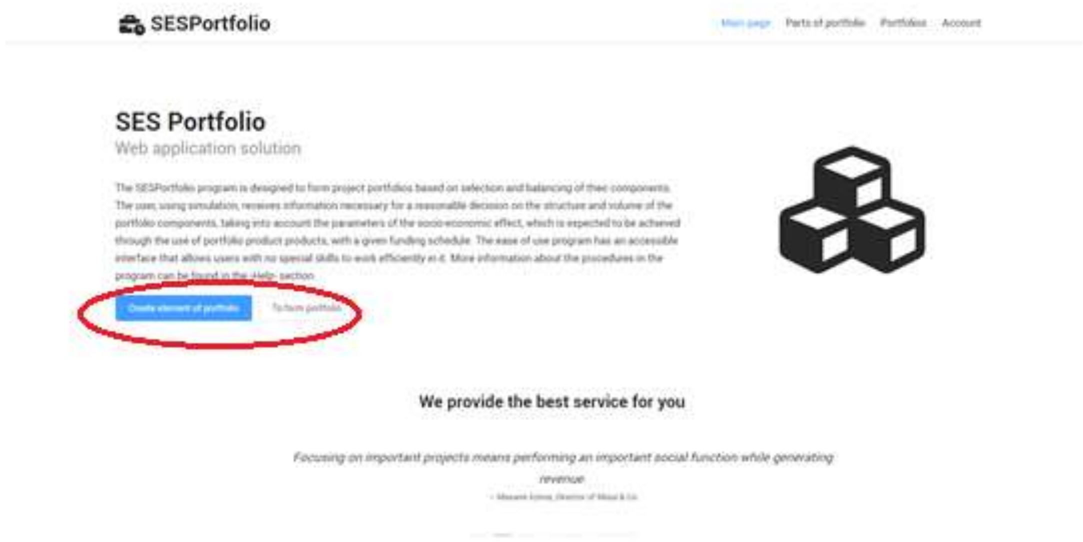


Figure G4.2. Program home page after identification (login to your own account)

In the first event in the sections of the main menu "Portfolio components" and "Portfolios" they do not have information (Fig. G5.1-5.2). The "Account" section already contains information about the user who was entered when creating the account and which can be supplemented or changed if necessary (Figures G5.3-5.4).

Figure G5.1. Information in the main menu section "Parts of portfolio"

Figure G5.2. Information in the section of the main menu "Portfolios"

Figure G5.3. Information in the main menu section "Account"

Figure G5.4. Editing information in the main section of the "Account" section.

Item 4. Creating the components of the portfolio .

When entering the section of the main menu "Portfolio components" it is possible to specify the parameters of a new project, program or support portfolio for this just go to the link "Create a new component" (Fig. G6). The user is invited to fill in the corresponding template (Fig.G7).

Parameters of the new portfolio component are given by the following items: basic information (name - can be specified by the user or the program automatically, short description - given only by the user, but not obligatory); risks (annual risk financing, annual risk of effect - set by the user in the range of values from 0 to 1); financing (user-specified key points for duration-cost parameters), while automatically creating a data table and component cost schedule; effect (the initial, initial moment of obtaining the effect from the product product or intermediate product configurations and the key points of the duration-effect parameters is given), while automatically creating the data table and the effect component graph; A common graph which combines information on financing a portfolio component and obtaining an effect from its implementation is also built automatically (Fig. G8).

New data is entered separately for each key point in the appropriate forms, with the following values can not be less than the previous (accumulated, cumulative data).To correct already entered data presented in a tabular form over the data input forms for key moments, the functions of their removal are provided. and changes.

After entering the necessary data for the component, the user can save it (using the corresponding "Save Portfolio Component" link). When the data is saved successfully, the program displays a message (Fig. G9) that informs the user about the creation of a new component and invites them to go to the list of already saved components or use the data as a template to create other new portfolio components.

Figure G6 Go to creating a new portfolio component

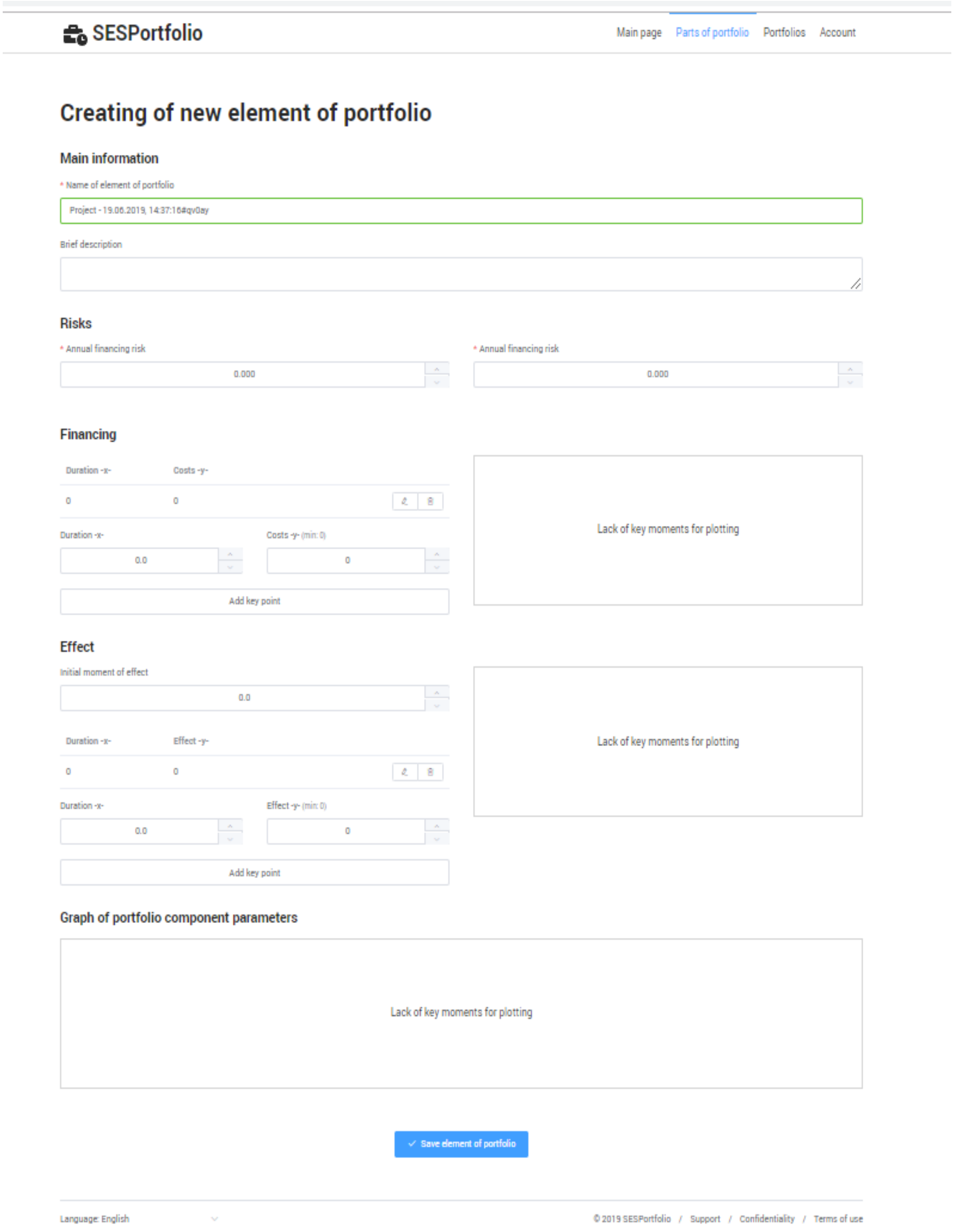


Figure G7. Data entry form when creating a new portfolio component

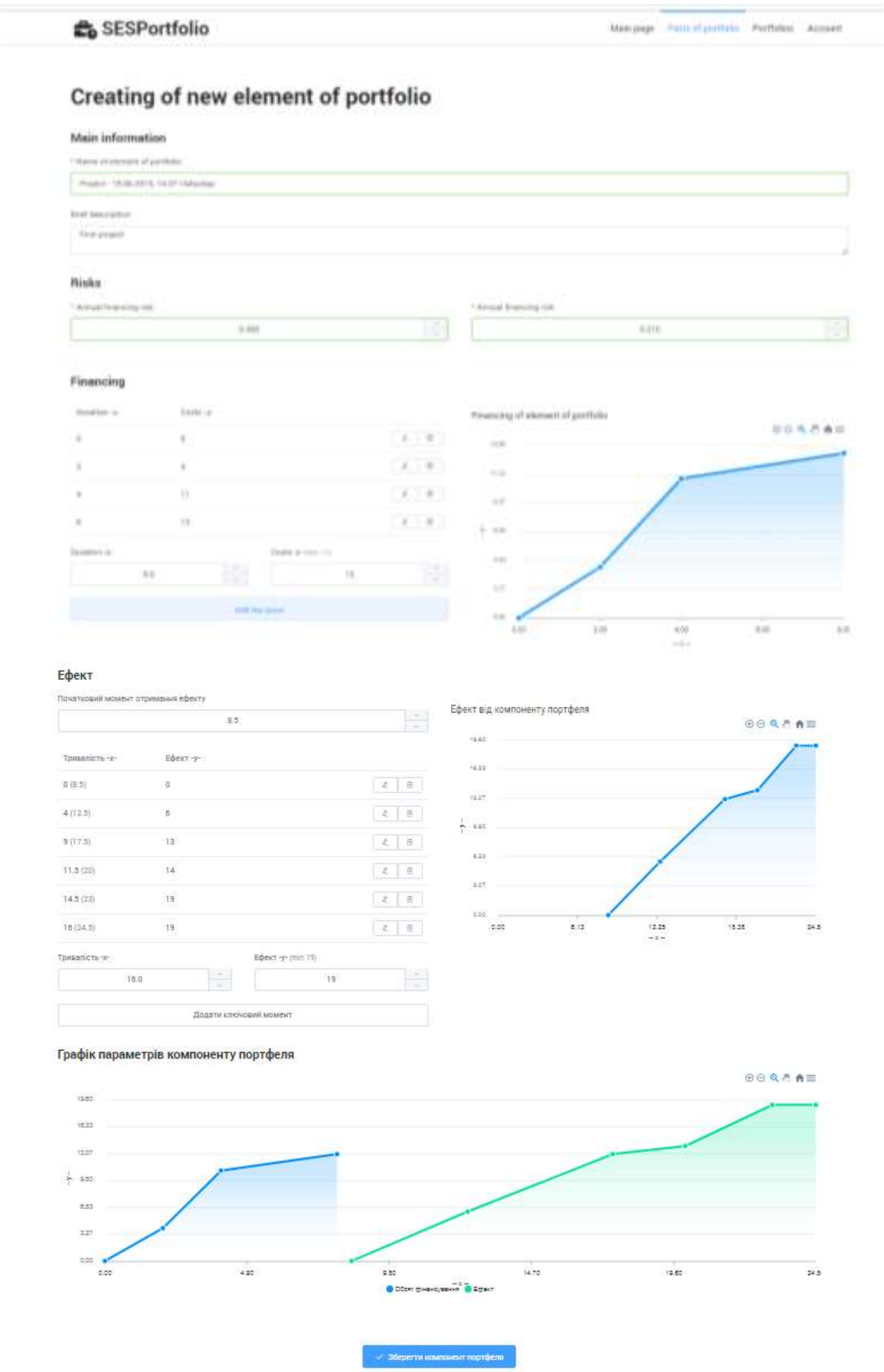


Figure G8 Fill in the form of data for the new portfolio component

To work with schedules, the program provides the appropriate menu respectively: increase, decrease, return to original size, save in SVG and PNG format .

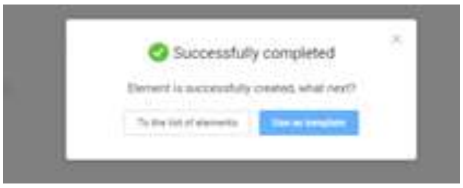


Figure G9. Message about successful data storage for the new portfolio ***component***

When switching to the "List of Components" (Fig. G9), which was previously created and stored in the database of the program, the user can see their parameters in the "expanded" and "compact" view (Fig. G10.1-10.2) for what to use relevant links.

Figure G10.1 Compact view of the parameters of the saved portfolio components

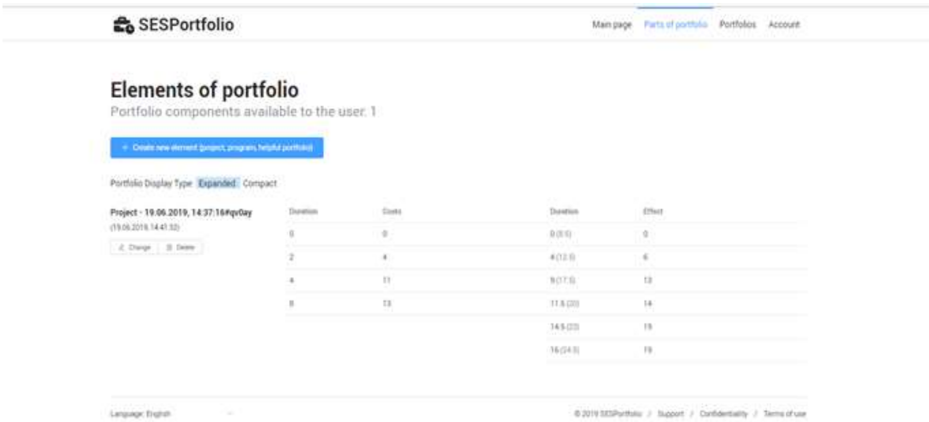


Figure G10.2 Detailed view of the parameters of the saved portfolio components

If the user selects the transition to the component template, using the "Use as Template" link (Fig. G9), he will return to the menu for creating a new portfolio component, which will be able to adjust the parameters of the previously created component, which already contains the template. To correct the data, the functions of their removal are provided and changes, the removal action must be confirmed (fig. G11.1). Saving the data of the new component is confirmed by the corresponding message (Figure G11.2).

An example of the adjusted portfolio component parameters previously presented in Fig.G8 is shown in Fig. G11.3 (an additional key point with the data for the parameters "financing" and "effect" is entered).

All components created are available in the "Portfolio Components" main menu, as previously noted in the "expanded" or "compact" view (Fig. G12).

The content of paragraph 4 corresponds to step 1 shown in Fig. G1 and Fig. G2, which must be performed to obtain the results of modeling the structure of the portfolio.

Fig.G11.1. Confirm deletion

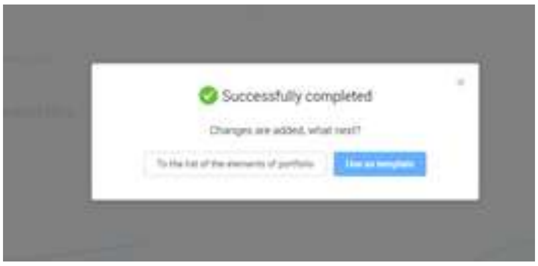
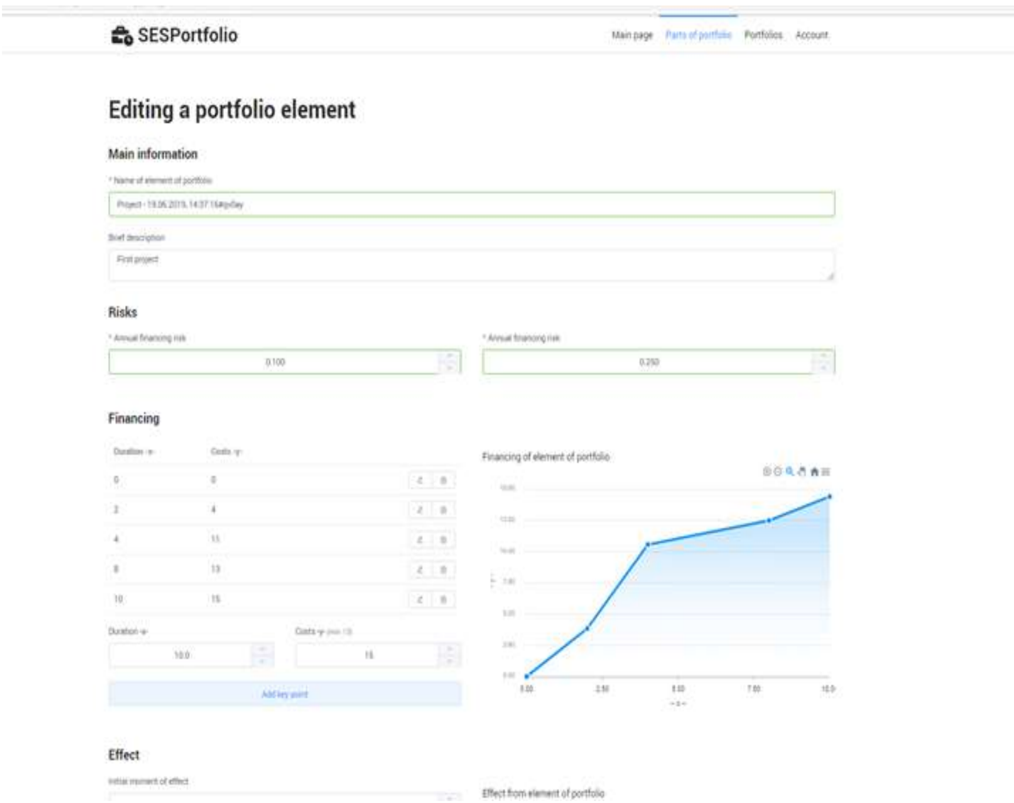


Figure G11.2. Message about successful operation



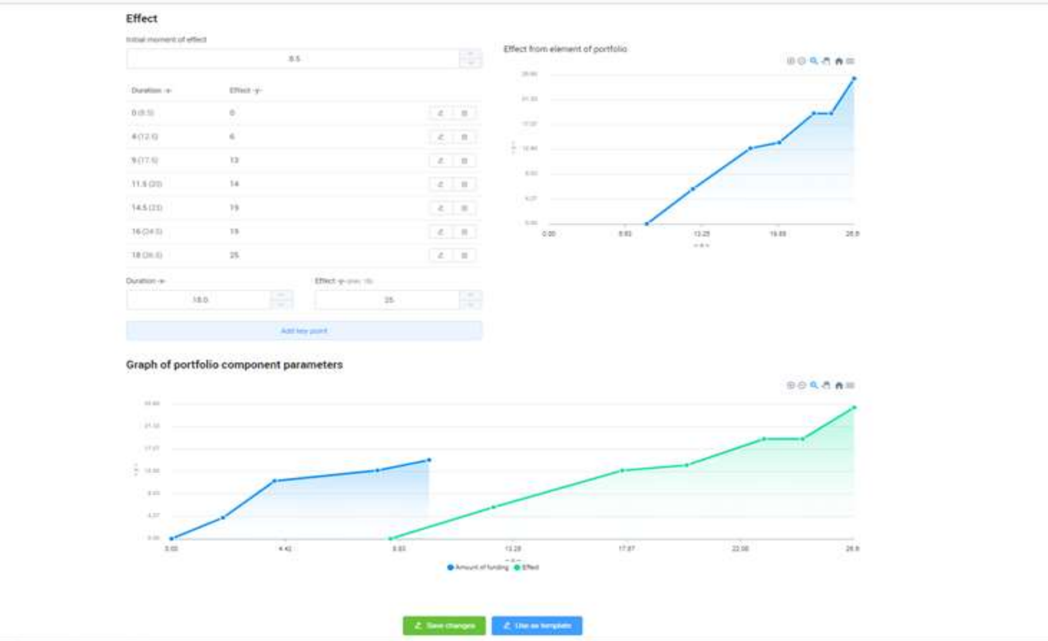


Figure G11.3. Change the data in the template of the previously created *component*

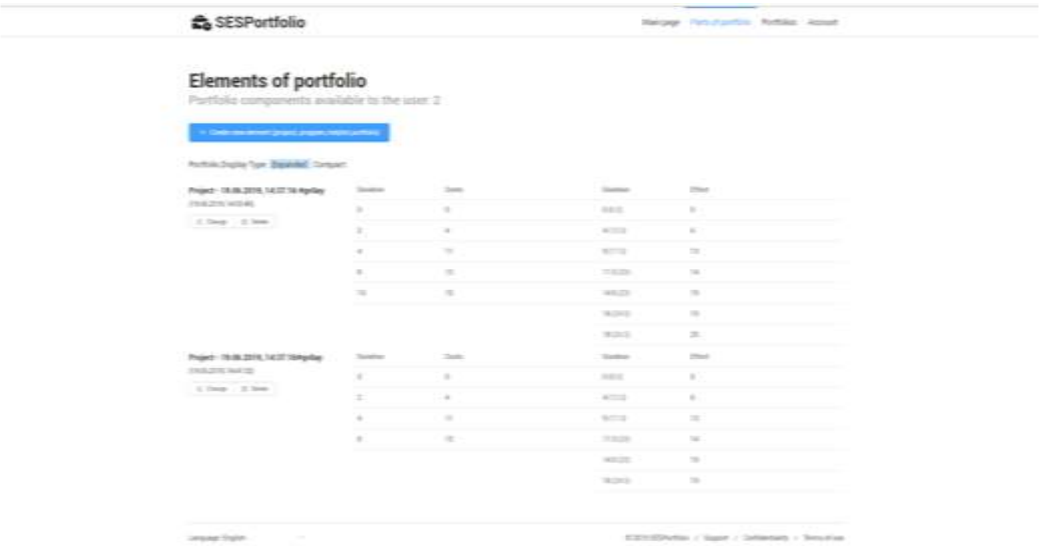


Figure G12. List of components available to the user
(for the next modeling of portfolio composition)

Item 5 Creating a portfolio .

To create a new portfolio, the user needs to return to the main page of the program and use the corresponding "Create a portfolio" link (Figure G13) or go to the section of the main menu "Portfolios" (Fig. G14) and also use the corresponding "Create a portfolio" link.

When performing the transition, the user is requested to fill out the appropriate data form for the portfolio (Fig. G15).

Parameters of the new portfolio are given by the following items: basic information (project name, short description, number of breakdowns); Financing stages (key moments are given in terms of duration-volume of funding), while the portfolio financing schedule is automatically built, for which the correct construction is required, a minimum of 2 points need to be allocated, the amount of funding to be the same (Fig. G16).

Procedures for entering, modifying, or removing portfolio data are similar to those described for the portfolio components (paragraph 4).

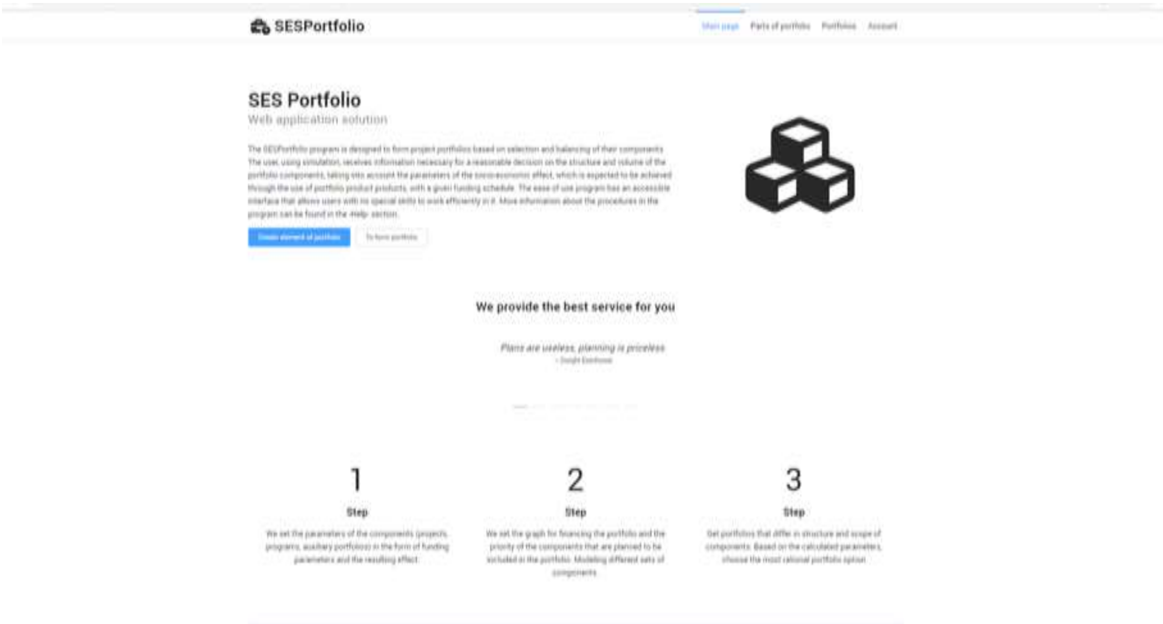


Figure G13. Go to creating a project portfolio from the main page of the program

Figure G14. Go to creating a portfolio of projects from the section of the main menu "Portfolios"

To form a portfolio you need to choose from the database of saved components those that are pretending to include the portfolio. The corresponding list of components is given in the "Priority Projects" position. You must use the link to select components . After that it will be possible to specify the priority of the component, for example by using the appropriate menu. With the arrows you can increase or decrease priorities from 1-maximum, most priority to other values > 1 . If the total cost of the selected components exceeds the amount of financing of the portfolio, the program will notify it (fig. G17), removing the extra component from the portfolio is possible through because of an increase in the priority of <1, in this case the linked component is reactivated again .

If the priorities are not specified by the user, the program will consider all selected components that apply for the portfolio as priorities. The user can also specify levels for several components, and for others it is not. The program automatically redraws selected components with priorities taking into account the importance of reducing their importance (in case of equality of priorities, the program will take into account the cost of each component and the effect value of the component).

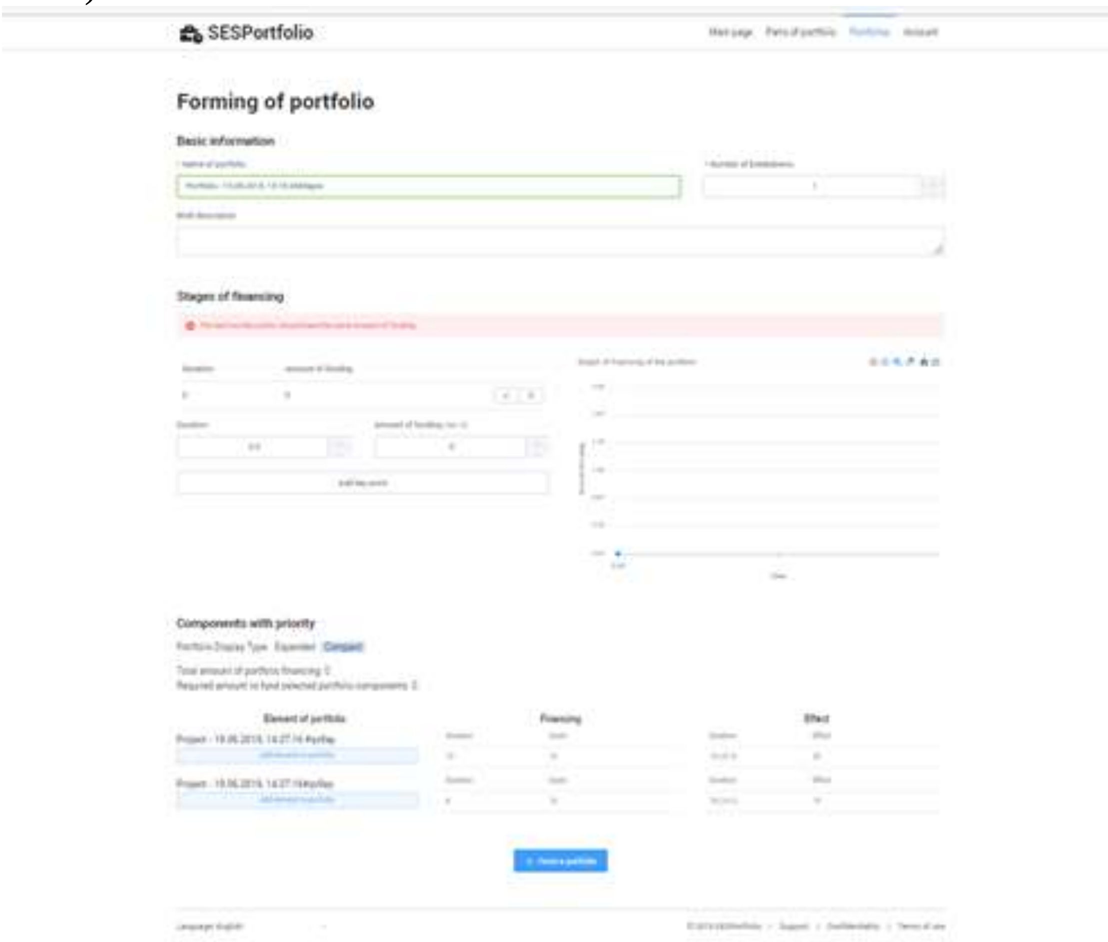


Figure G15. Portfolio data form

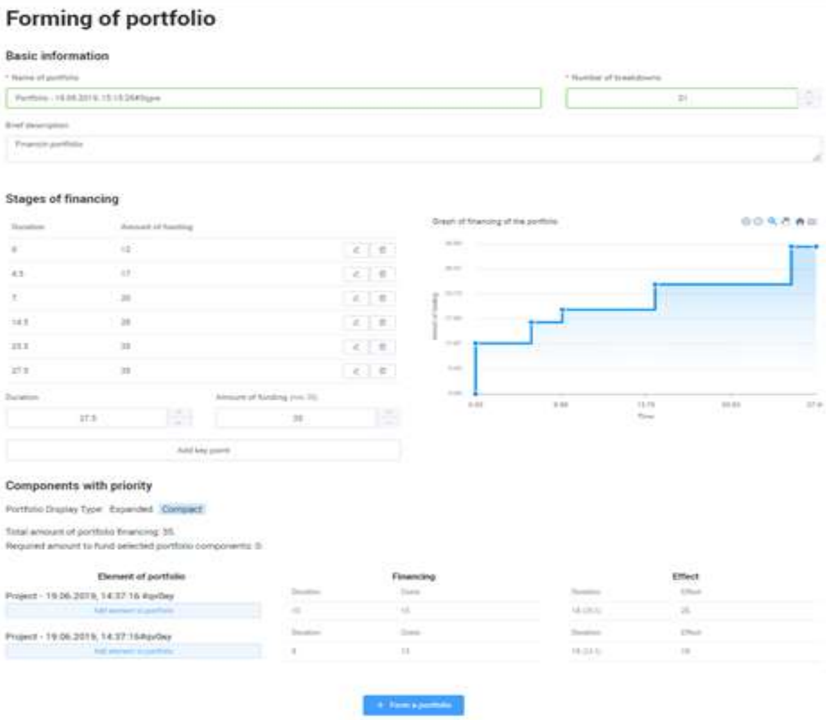


Figure 16. A completed portfolio data form

After entering the necessary data for the portfolio, the user can save it (using the corresponding link) Figure G16 "Form a portfolio". When the data is saved successfully, the program issues a message (Fig. G18) that informs the user about creating a new portfolio and invites him to go to the list of already saved portfolios or use the data as a template to create other new portfolios.

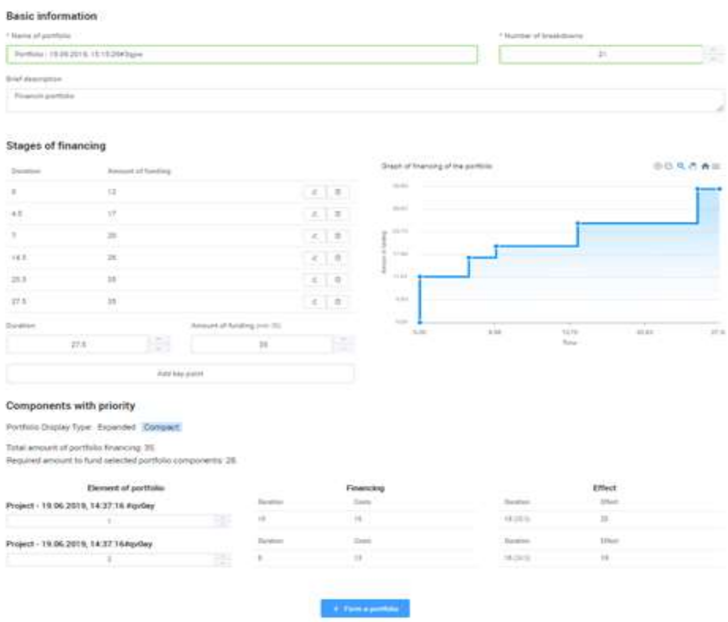


Figure 17. The required amount of component financing exceeds the amount of financing of the portfolio

Figure 18. Confirmation of portfolio formation

If the user selects the link "To the list of portfolios" (Fig. G18), the program will go to the section "List of available portfolios" (Fig. G19).

Figure 19. List of available (formed) portfolios

When you switch to the list of project portfolios (previously created and stored in the program database), the user can familiarize himself with the results of the program calculations or use the stored data as a template for new portfolios or to delete an unnecessary portfolio. (Fig. G19) for which it is necessary to use the corresponding references. Also, from the page of the list of available portfolios it is possible to go to the page for the formation of a new portfolio. The program provides the ability to search for formed portfolios using a filter by their name .

If the user selects the "Use as a template" link (Fig. G18), the program will move to the section "Creating a new portfolio based on existing" (Fig. G20). In this case, it is possible to adjust the existing data in the portfolio and form a new portfolio on their basis. If necessary, the user may reject the changes .

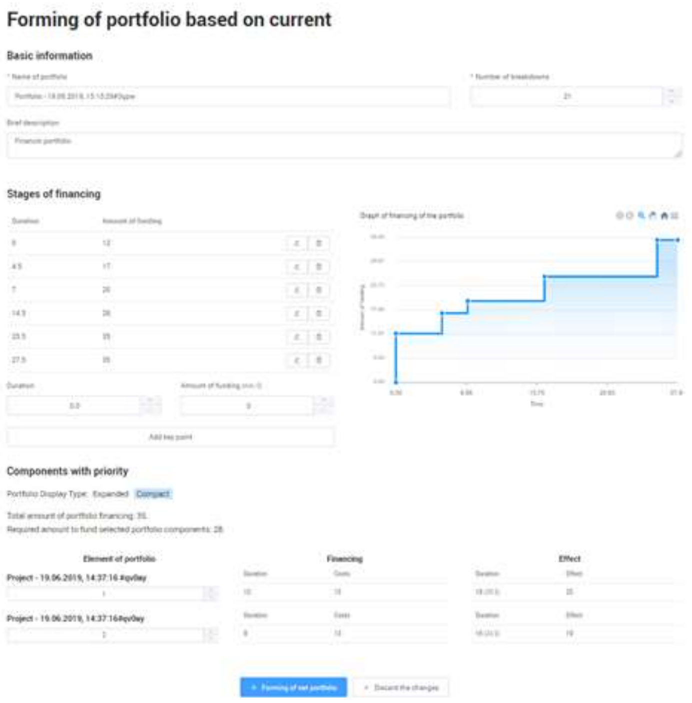


Figure G20 Formation of a new portfolio based on the existing template

When forming a new portfolio, the database available for review and analysis of portfolios increases, an example in Fig.G21

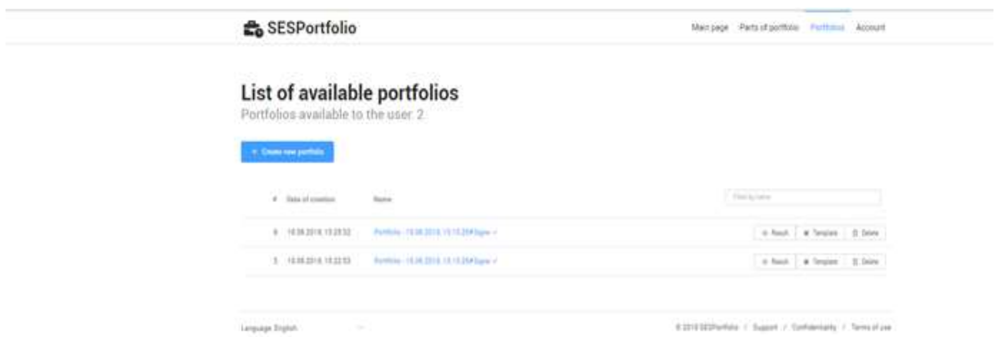


Figure G20.1. The database of available project portfolios

The content of paragraph 5 corresponds to step 2 shown in Fig. 1 and Fig. 2, which must be performed to obtain the results of modeling the structure of the portfolio.

Item 6. Receiving results .

When moving to the "result" of the formed portfolio (Fig. G20), the user is available graphs with information on the financing of the portfolio, the cost and effects of selected components of the portfolio. Information in charts may or may not appear depending on how the cursor is placed on the associated affiliation names that are arranged below the charts. Details of the components included in the portfolio are presented in tabular form. The final values of the parameters for the portfolio are given separately (Fig. G21). On the basis of comparison of the results of calculations with different components of the portfolio, the most rational portfolio structure is determined.

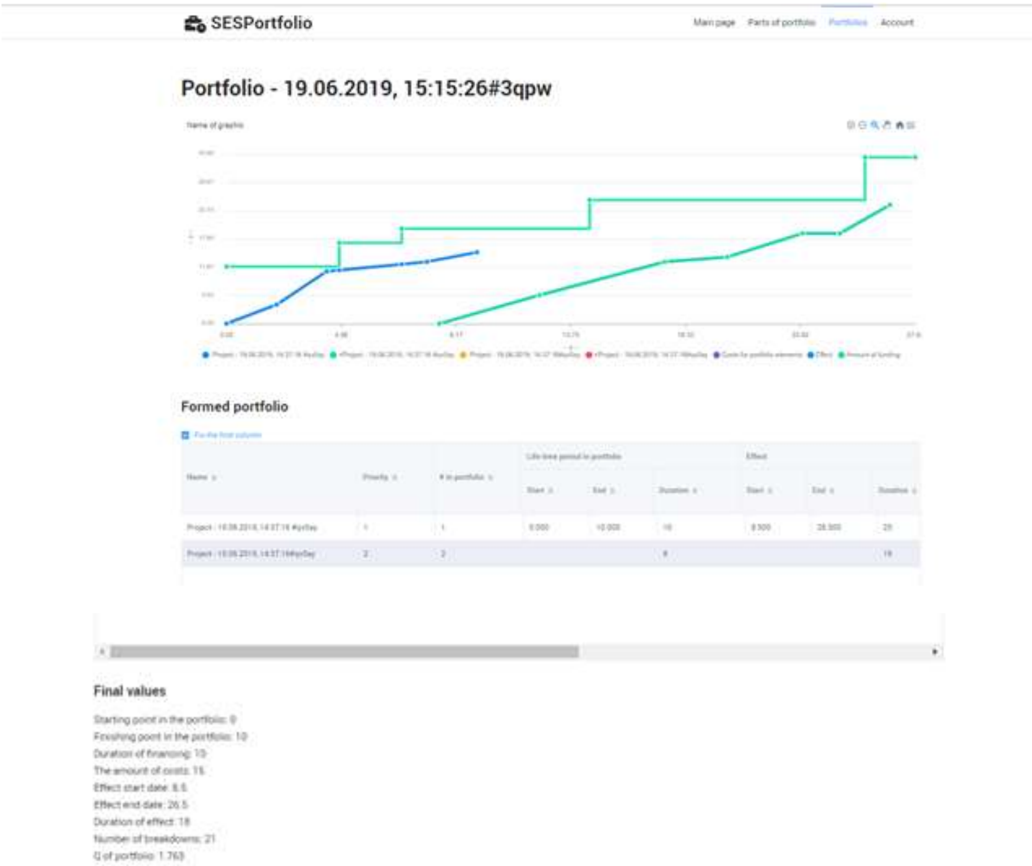


Figure 21. Results on the formed portfolio

Accordingly, the meaning of paragraph 6 corresponds to step 3 given in Fig. G1 and Fig. G2, which must be performed to obtain the results of modeling the structure of the portfolio.

The user can use any portfolio from the list of available portfolios in the form of a template or remove it (Fig. G20).

It should also be noted that work in the program requires a permanent connection with the Internet, in case of its temporary absence, or if the user did not perform any actions in the program for 5 minutes, the program at activation of work needs to be re-authenticated (Fig. G22) .

Figure G22. Back to account

Item 7. Closing the program

Close the program by closing the page in the browser in which it was launched.

Appendix H

Applied project portfolio configuration aspects

(Testing robots method based adequacy hypotheses on calculations obtained in SESPortfolio program)

H.1.1 hypothesis testing

Initial data

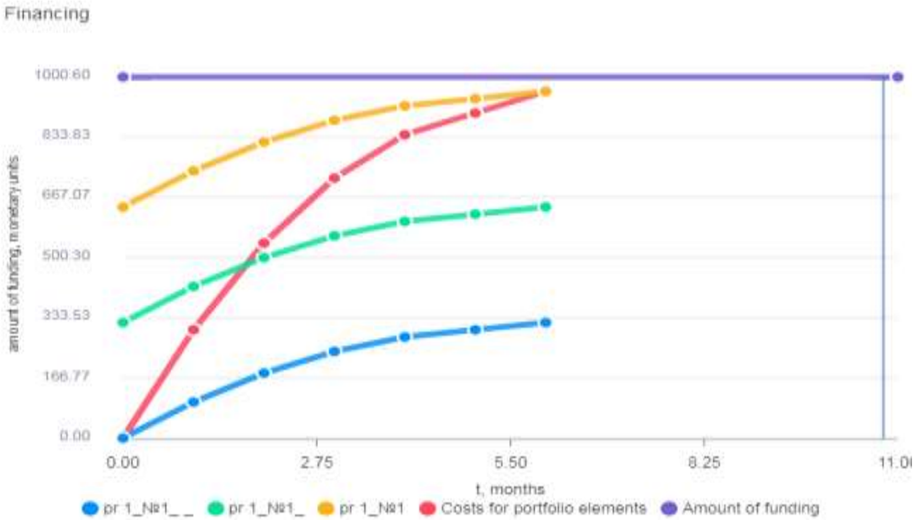
Project 1 (pr_1№1)			Project 2 (pr_1№1_)			Project 3 (pr_1№1_ _)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3
0	0	0	0	0	0	0	0	0
1	100		1	100		1	100	
2	180		2	180		2	180	
3	240		3	240		3	240	
4	280		4	280		4	280	
5	300		5	300		5	300	
6	320	1	6	320	1	6	320	1

Tables with calculation results (Portfolio Portf3 Same)

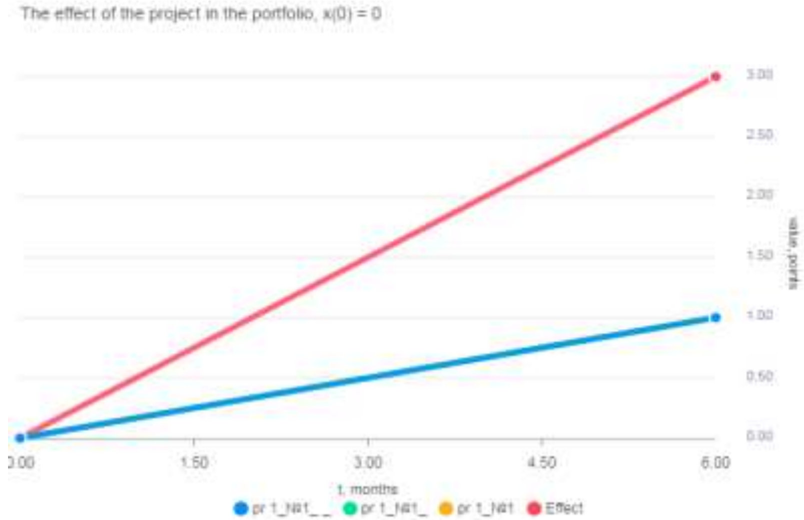
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_№1_ _	1	1	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1	1	3	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82

The total portfolio performance

The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 960,000
Effect start date: 0,000
Effect end date: 6,000
Duration of effect: 6,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,922
Portfolio attractiveness coefficient W: 0,820



Cost curves schedule for projects and total costs for portfolio with the project financing priority in portfolio Portf3 Same (H.1.1 hypothesis testing)



Effect curves graph for projects (combined in one line) and overall effect in Portf3 Same portfolio (H.1.1 hypothesis testing)

H.1.2 hypothesis testing

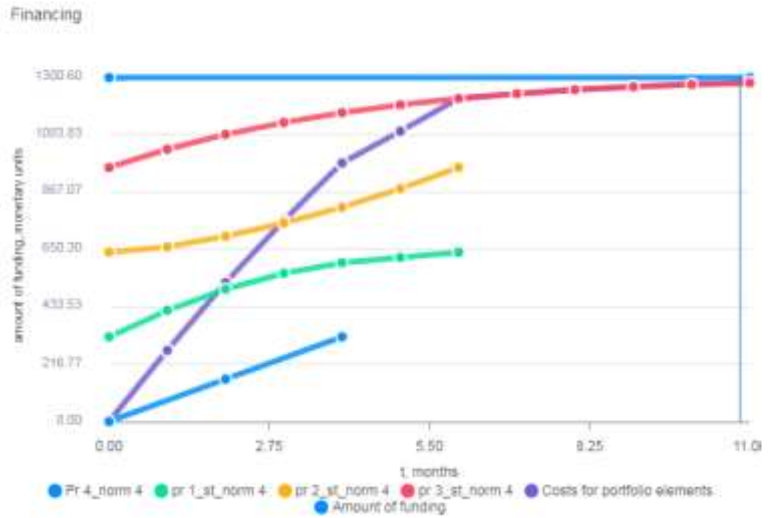
Initial data

Project 1 (pr 1_st_norm 4)			Project 2 (pr 2_st_norm 4)			Project 3 (pr 2_st_norm 4)			Project 4 (pr4_norm 4)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0			${}^{\sigma}d^4$ =0,48; ${}^{r}d^4$ =0,3; δ^4 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3	${}^{s}\tau^4$	S^4	R^4
0	0	0	0	0	0	0	0	0	0	0	0
1	100		1	20		1	69		1		
2	180		2	60		2	125		2	160	
3	240		3	110		3	170		3		
4	280		4	170		4	207		4	320	
5	300		5	240		5	237		5		
6	320	5	6	320	5	6	261	5	6		5
						7	279				
						8	294				
						9	305				
						10	314				
						11	320	5			

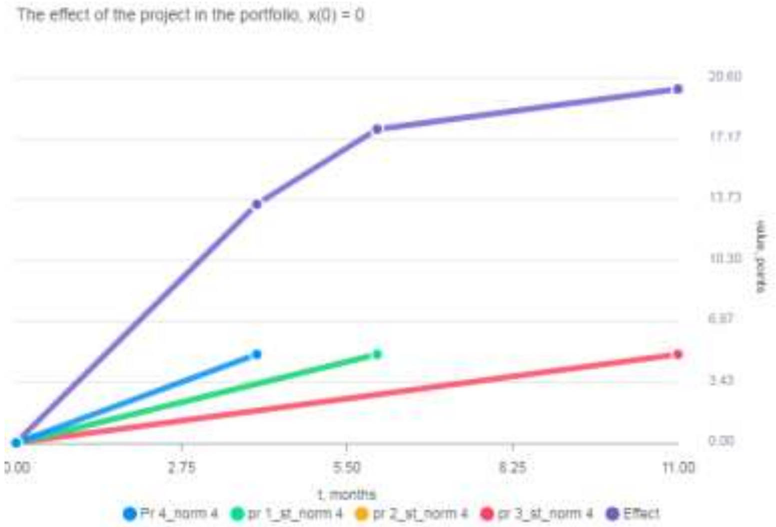
Tables with calculation results (Portfolio Portf2 pr4 norm4)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Pr 4_norm 4	1	1	0,852	0	4	4	27	0,48	0	4	4	0	0,925	1	0,925	0,925	1	0,925
pr 1_st_norm 4	1	2	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
pr 2_st_norm 4	1	3	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	0,868	0,868	1	0,868
pr 3_st_norm 4	1	4	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	0,795	0,795	1	0,795

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 11,000
Duration of financing: 11,000
The amount of expenses for financing the portfolio: 1280,000
Effect start date: 0,000
Effect end date: 11,000
Duration of effect: 11,000
Portfolio realizability coefficient: 0,798
Portfolio effect reachability coefficient: 1,000
Portfolio attractiveness coefficient W: 0,798



Cost curves schedule for projects and total costs for portfolio with projects financing sequence in portfolio Portf2 pr4 norm4 (H.1.2 hypothesis)



Effect curves graph for projects and overall effect in Portf2 pr4 norm4 portfolio (H.1.2 hypothesis testing)

H.1.3 hypothesis testing

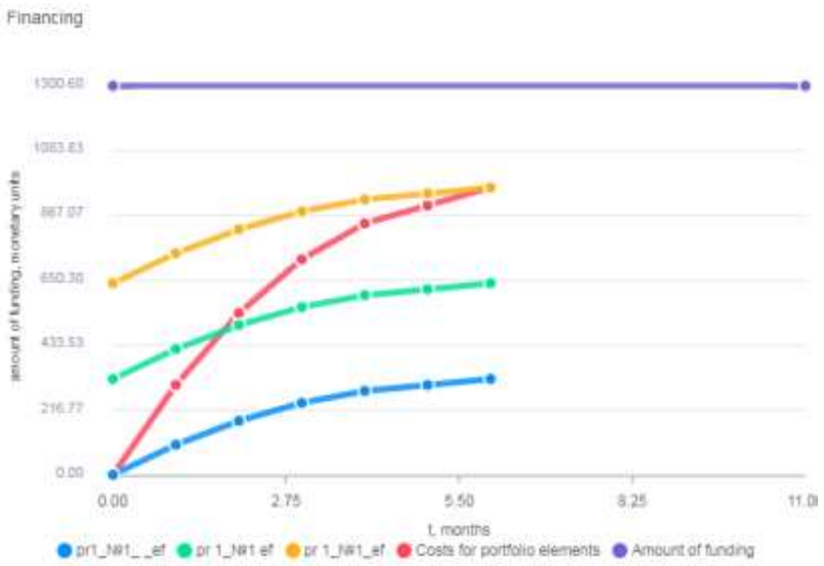
Initial data

Project 1 (pr 1_№1 ef)			Project 2 (pr 1_№1_ef)			Project 3 (pr 1_№1_ _ef)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3
0	0	0	0	0	0	0	0	0
1	100	1,5	1	100	0,8	1	100	1
2	180	2,5	2	180	1	2	180	2
3	240	3,2	3	240	1,3	3	240	3
4	280	3,8	4	280	1,8	4	280	4
5	300	4	5	300	2,1	5	300	5
6	320	4,3	6	320	3	6	320	
7		4,8	7		4			
8		5	8		5			

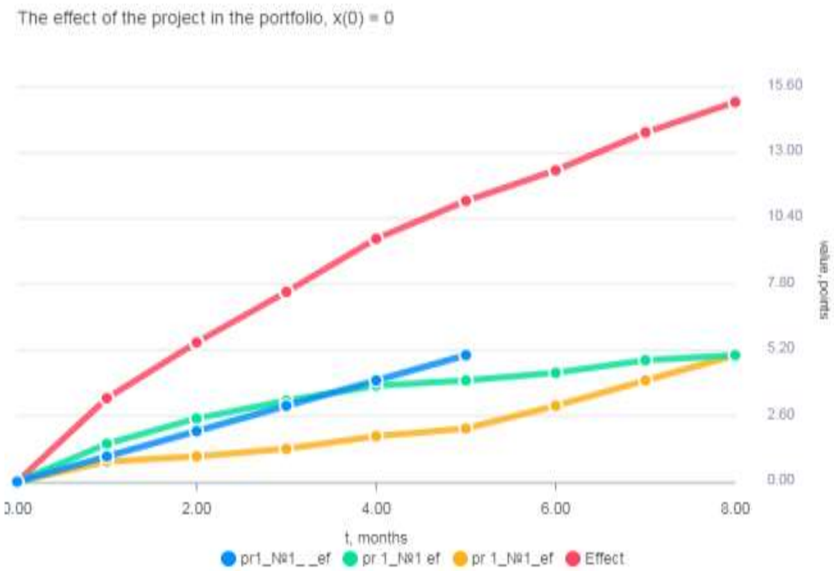
Tables with calculation results (Portfolio Port_ef_)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr1_№1_ _ef	1	1	0,667	0	6	6	18	0,48	0	5	5	0,3	0,89	0,937	0,833	0,89	0,937	0,833
pr 1_№1 ef	1	2	0,667	0	6	6	18	0,48	0	8	8	0,3	0,89	0,903	0,804	0,89	0,903	0,804
pr 1_№1_ef	1	3	0,667	0	6	6	18	0,48	0	8	8	0,3	0,89	0,889	0,791	0,89	0,889	0,791

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 960,000
Effect start date: 0,000
Effect end date: 8,000
Duration of effect: 8,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,898
Portfolio attractiveness coefficient W: 0,799



Cost curves graph for projects and total costs for Port_ef_ portfolio (H.1.3 hypothesis testing)



Effect curves graph for projects and overall effect in Port_ef_ portfolio (H.1.3 hypothesis testing)

H.1.4 hypothesis testing

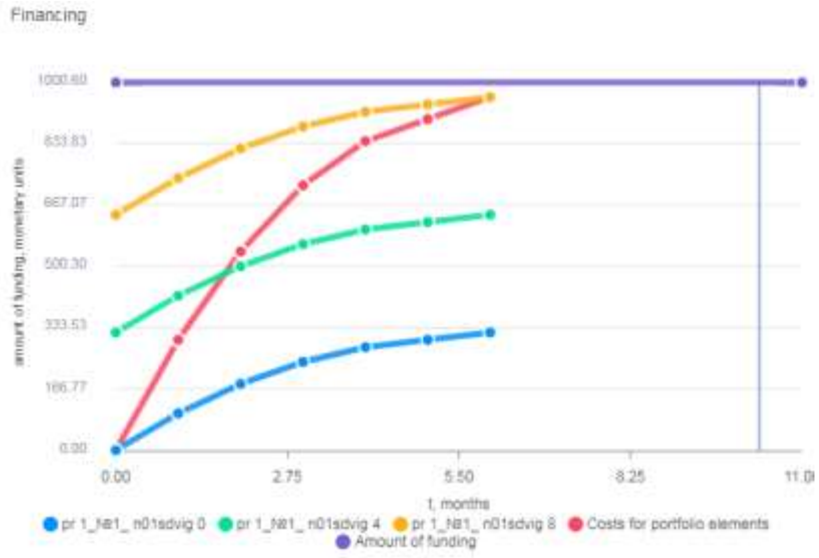
Initial data

Project 1 (pr_1№1_n01sdvig0)			Project 2 (pr_1№1_ n01sdvig4)			Project 3 (pr_1№1_ n01sdvig8)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =4			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =8		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3
0	0	0	0	0	0	0	0	0
1	100		1	100		1	100	
2	180		2	180		2	180	
3	240		3	240		3	240	
4	280		4	280		4	280	
5	300		5	300		5	300	
6	320	5	6	320	5	6	320	5

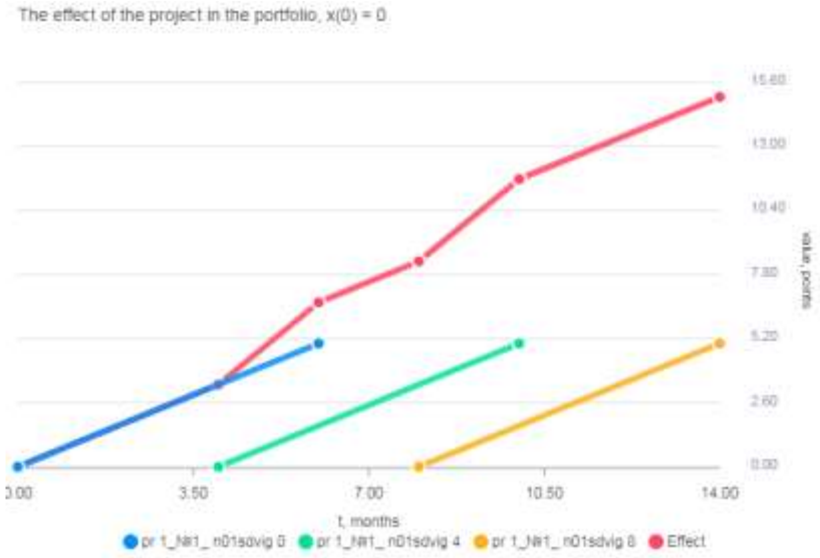
Tables with calculation results (Portfolio Portf sdvig eff)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_№1_ n01sdvig 0	1	1	0,667	0	6	6	18	0,48	0	6	6	0,1	0,89	0,973	0,865	0,89	0,973	0,865
pr 1_№1_ n01sdvig 4	1	2	0,667	0	6	6	18	0,48	4	10	6	0,1	0,89	0,941	0,837	0,89	0,941	0,837
pr 1_№1_ n01sdvig 8	1	3	0,667	0	6	6	18	0,48	8	14	6	0,1	0,89	0,91	0,81	0,89	0,91	0,81

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 960,000
Effect start date: 0,000
Effect end date: 14,000
Duration of effect: 14,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,930
Portfolio attractiveness coefficient W: 0,827



Cost curves graph for projects and total costs for Portf sdvig eff portfolio (H.1.4 hypothesis testing)



Effect curves graph for projects and overall effect in Portf sdvig eff portfolio (H.1.4 hypothesis testing)

H.1.5 hypothesis testing

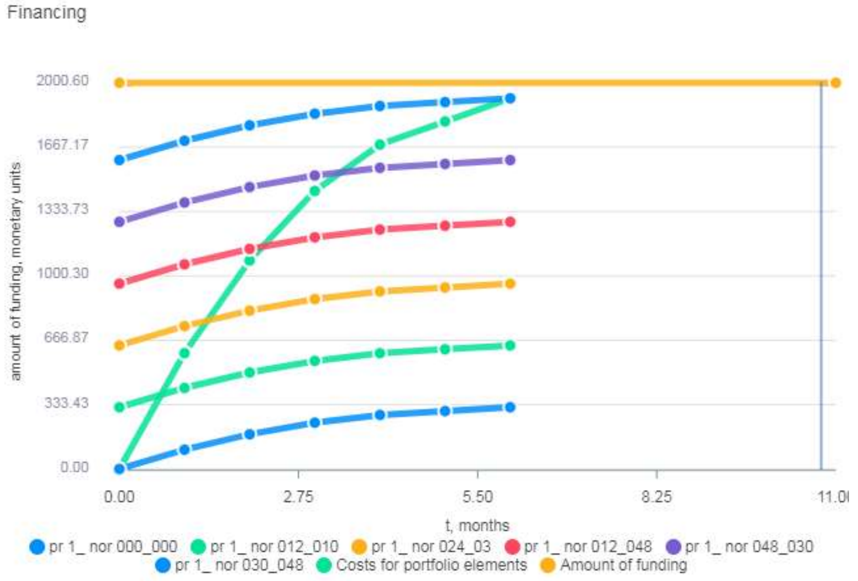
Initial data

Project 1 (pr 1_ nor 000_000)			Project 2 (pr 1_ nor 012_010)			Project 3 (pr 1_ nor 024_03)			Project 4 (pr 1_ nor 012_048)			Project 5 (pr 1_ nor 048_030)			Project 6 (pr 1_ nor 030_048)		
${}^{\sigma}d^1$ =0; ${}^{r}d^1$ =0; δ^1 =0			${}^{\sigma}d^2$ =0,12; ${}^{r}d^2$ =0,1; δ^2 =0			${}^{\sigma}d^3$ =0,24; ${}^{r}d^3$ =0,3; δ^3 =0			${}^{\sigma}d^4$ =0,12; ${}^{r}d^4$ =0,48; δ^4 =0			${}^{\sigma}d^5$ =0,48; ${}^{r}d^5$ =0,3; δ^5 =0			${}^{\sigma}d^6$ =0,3; ${}^{r}d^6$ =0,48; δ^6 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3	${}^{s}\tau^4$	S^4	R^4	${}^{s}\tau^5$	S^5	R^5	${}^{s}\tau^6$	S^6	R^6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	100		1	100		1	100		1	100		1	100		1	100	
2	180		2	180		2	180		2	180		2	180		2	180	
3	240		3	240		3	240		3	240		3	240		3	240	
4	280		4	280		4	280		4	280		4	280		4	280	
5	300		5	300		5	300		5	300		5	300		5	300	
6	320	5	6	320	5	6	320	5	6	320	5	6	320	5	6	320	5

Tables with calculation results (Portfolio Portf raz norm 6pr)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_ nor 000_000	1	1	0,833	0	6	6	36	0	0	6	6	0	1	1	1	1	1	1
pr 1_ nor 012_010	1	2	0,833	0	6	6	36	0,12	0	6	6	0,1	0,97	0,973	0,944	0,97	0,973	0,944
pr 1_ nor 024_03	1	3	0,833	0	6	6	36	0,24	0	6	6	0,3	0,942	0,922	0,868	0,942	0,922	0,868
pr 1_ nor 012_048	1	4	0,833	0	6	6	36	0,12	0	6	6	0,48	0,97	0,879	0,853	0,97	0,879	0,853
pr 1_ nor 048_030	1	5	0,833	0	6	6	36	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_ nor 030_048	1	6	0,833	0	6	6	36	0,3	0	6	6	0,48	0,929	0,879	0,816	0,929	0,879	0,816

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 1920,000
Effect start date: 0,000
Effect end date: 6,000
Duration of effect: 6,000
Portfolio realizability coefficient: 0,949
Portfolio effect reachability coefficient: 0,927
Portfolio attractiveness coefficient W: 0,880



Cost curves graph for projects and total costs for Portf raz norm 6pr portfolio (H.1.5 hypothesis testing)

Effect curves graph for projects and overall effect in portfolio Portf raz norm 6pr (H.1.5 hypothesis testing)

H.1.6 hypothesis testing

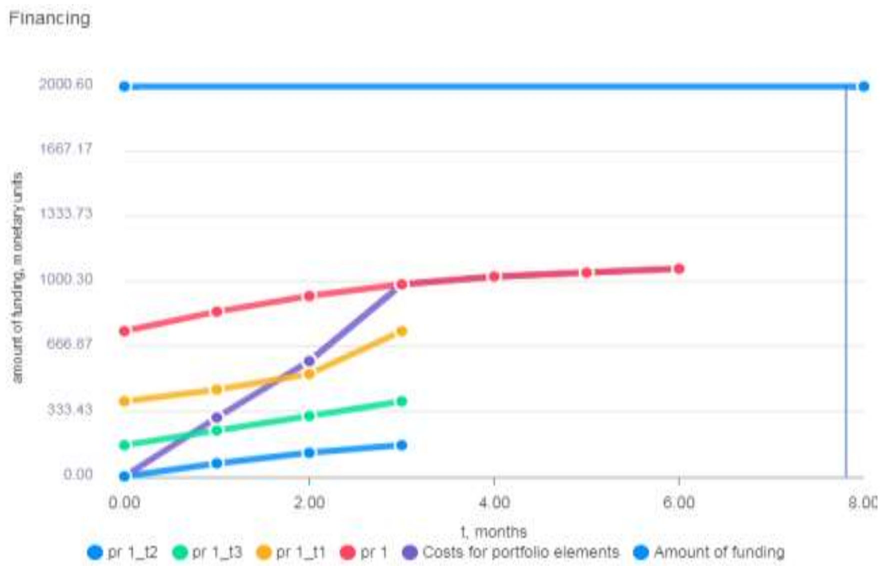
Initial data

Project 1 (pr 1)			Project 2 (pr 1_t1)			Project 3 (pr 1_t2)			Project 4 (pr1_t3)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0			${}^{\sigma}d^4$ =0,48; ${}^{r}d^4$ =0,3; δ^4 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3	${}^{s}\tau^4$	S^4	R^4
0	0	0	0	0	0	0	0	0	0	0	0
1	100		1	133		1	67		1	75	
2	180		2	240		2	121		2	150	
3	240		3	320		3	160		3	225	
4	280		4			4			4		
5	300		5			5			5		
6	320	1	6		1	6		1	6		1

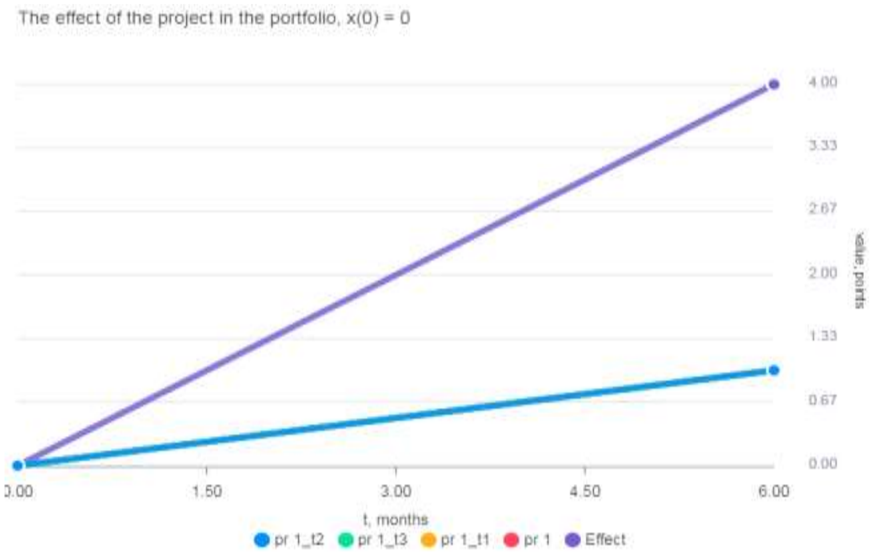
Tables with calculation results (Portfolio portf_t)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_t2	1	1	0,8	0	3	3	15	0,48	0	6	6	0,3	0,952	0,922	0,877	0,952	0,922	0,877
pr 1_t3	1	2	0,8	0	3	3	15	0,48	0	6	6	0,3	0,949	0,922	0,875	0,949	0,922	0,875
pr 1_t1	1	3	0,8	0	3	3	15	0,48	0	6	6	0,3	0,942	0,922	0,868	0,942	0,922	0,868
pr 1	1	4	0,6	0	6	6	15	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 1065,000
Effect start date: 0,000
Effect end date: 6,000
Duration of effect: 6,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,922
Portfolio attractiveness coefficient W: 0,820



Cost curves graph for projects and total costs for portfolio portf_t (H.1.6 hypothesis testing)



Effect curves graph for projects and overall effect in portfolio portf_t (H.1.6 hypothesis testing)

H.1.7 hypothesis testing

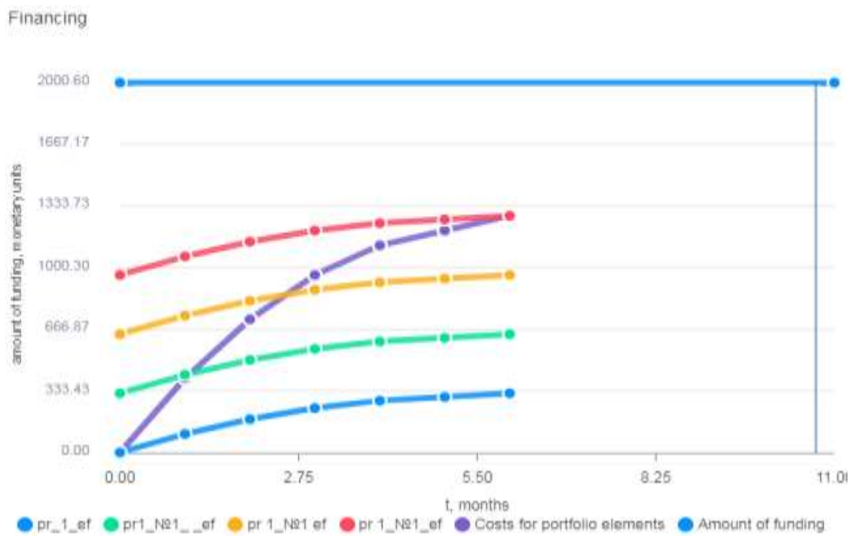
Initial data

Project 1 (pr 1_№1 ef)			Project 2 (pr 1_№1_ef)			Project 3 (pr 1_№1_ _ef)			Project 4 (pr_1_ef)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0			${}^{\sigma}d^4$ =0,48; ${}^{r}d^4$ =0,3; δ^4 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3	${}^{s}\tau^4$	S^4	R^4
0	0	0	0	0	0	0	0	0	0	0	0
1	100	1,5	1	100	0,8	1	100	1	1	100	0,9
2	180	2,5	2	180	1	2	180	2	2	180	1,5
3	240	3,2	3	240	1,3	3	240	3	3	240	2
4	280	3,8	4	280	1,8	4	280	4	4	280	
5	300	4	5	300	2,1	5	300	5	5	300	
6	320	4,3	6	320	3	6	320		6	320	
7		4,8	7		4						
8		5	8		5						

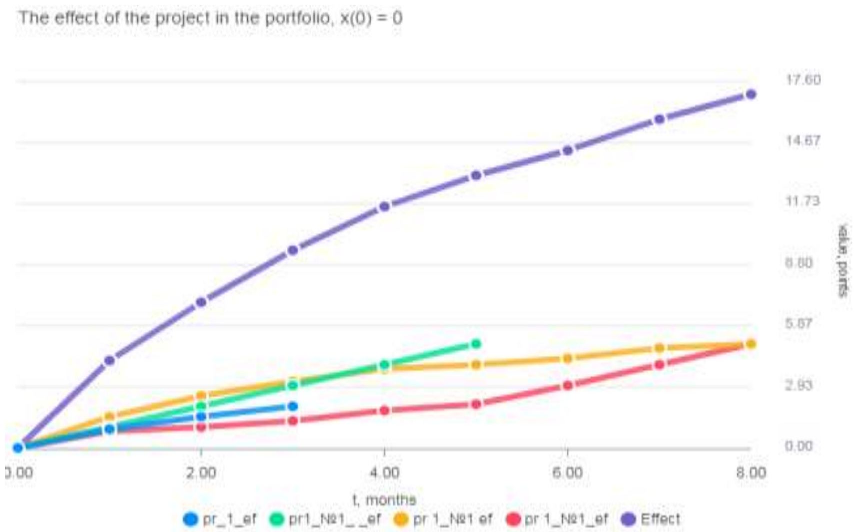
Tables with calculation results (Portfolio Portfolio_ef_var)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr_1_ef	1	1	0,75	0	6	6	24	0,48	0	3	3	0,3	0,89	0,97	0,863	0,89	0,97	0,863
pr1_№1_ _ef	1	2	0,75	0	6	6	24	0,48	0	5	5	0,3	0,89	0,937	0,833	0,89	0,937	0,833
pr 1_№1 ef	1	3	0,75	0	6	6	24	0,48	0	8	8	0,3	0,89	0,903	0,804	0,89	0,903	0,804
pr 1_№1_ef	1	4	0,75	0	6	6	24	0,48	0	8	8	0,3	0,89	0,889	0,791	0,89	0,889	0,791

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 1280,000
Effect start date: 0,000
Effect end date: 8,000
Duration of effect: 8,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,900
Portfolio attractiveness coefficient W: 0,801



Cost curves graph for projects and total costs for Portfolio_ef_var portfolio (H.1.7 hypothesis testing)



Effect curves graph for projects and overall effect in Portfolio_ef_var portfolio (H.1.7 hypothesis testing)

H.1.8 hypothesis testing

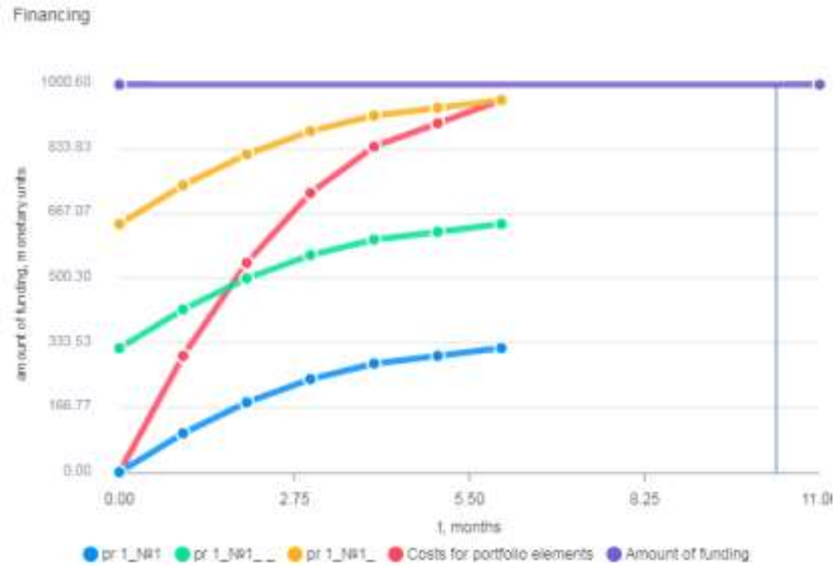
Project itial data are similar to H1.1 with change in project priorities ranks

Project 1 (pr_1№1)			Project 2 (pr_1№1_)			Project 3 (pr_1№1_ _)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0; *RP*=1			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0; *RP*=3			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0; *RP*=2		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3
0	0	0	0	0	0	0	0	0
1	100		1	100		1	100	
2	180		2	180		2	180	
3	240		3	240		3	240	
4	280		4	280		4	280	
5	300		5	300		5	300	
6	320	1	6	320	1	6	320	1

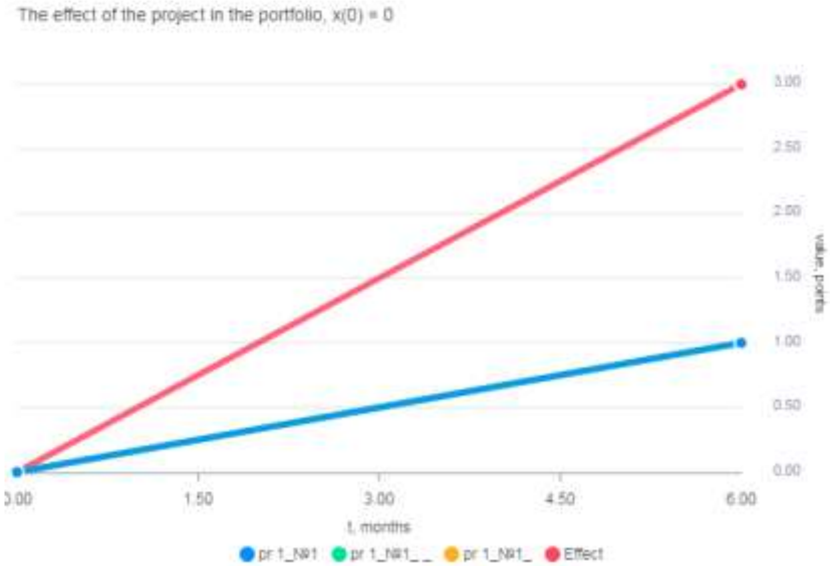
Tables with calculation results (Portfolio portf 3same_rang)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_№1	**1**	**1**	1	0	6	6	6	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	**0,82**
pr 1_№1_ _	**2**	**2**	0,5	0	6	6	12	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	**0,82**
pr 1_№1_	**2**	**3**	0,5	0	6	6	12	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	**0,82**

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 960,000
Effect start date: 0,000
Effect end date: 6,000
Duration of effect: 6,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,922
Portfolio attractiveness coefficient W: 0,820



Cost curves graph for projects and total costs for portfolio portf 3same_rang (H.1.8 hypothesis testing)

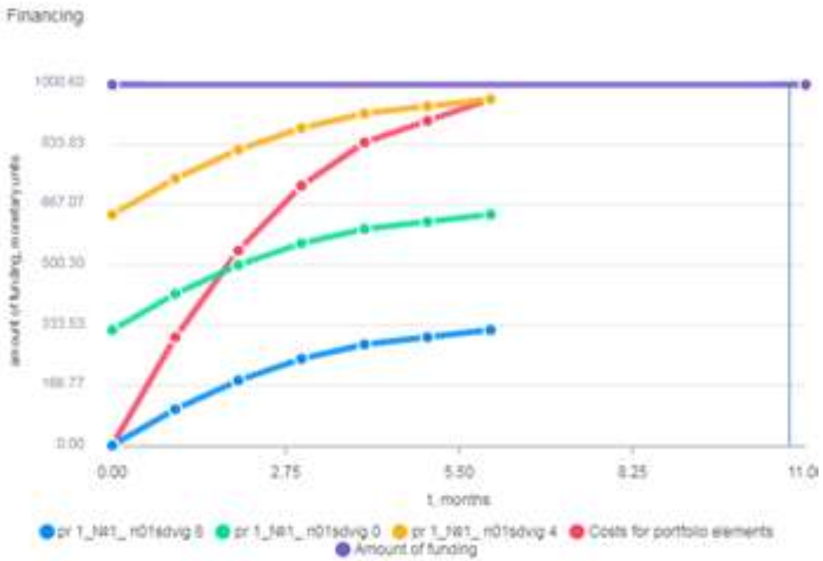


Effect curves graph for projects and overall effect in portfolio portf 3same_rang (H.1.8 hypothesis testing)

Tables with project portfolio calculation results of Portf sdvig eff rang similar data H.1.4, with changing ranks)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_№1_ n01sdvig 8	**1**	**1**	1	0	6	6	6	0,48	8	14	6	0,1	0,89	0,91	0,81	0,89	0,91	**0,81**
pr 1_№1_ n01sdvig 0	**2**	**2**	0,5	0	6	6	12	0,48	0	6	6	0,1	0,89	0,973	0,865	0,89	0,973	**0,865**
pr 1_№1_ n01sdvig 4	**2**	**3**	0,5	0	6	6	12	0,48	4	10	6	0,1	0,89	0,941	0,837	0,89	0,941	**0,837**

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 960,000
Effect start date: 0,000
Effect end date: 14,000
Duration of effect: 14,000
Portfolio realizability coefficient: 0,890
Portfolio effect reachability coefficient: 0,930
Portfolio attractiveness coefficient W: 0,827

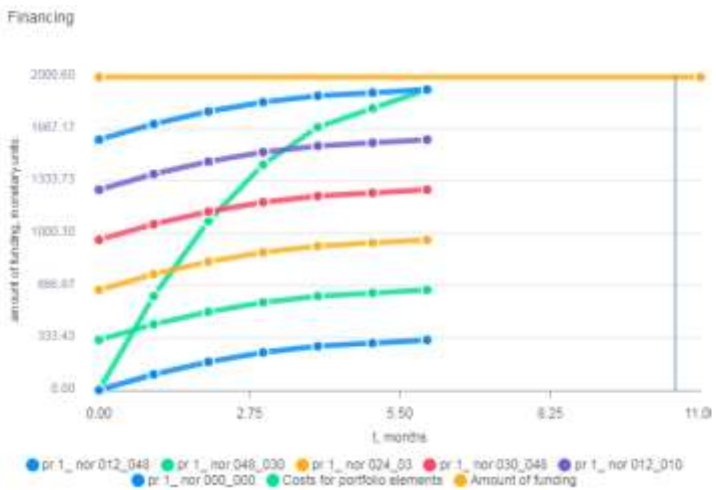


Project cost curves graph and total portfolio costs
Portf sdvig eff rang

Tables with projects portfolio calculation results of Portf raz norm 6pr rang (data H.1.5, with changing ranks)

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
pr 1_ nor 012_048	**1**	**1**	0,5	0	6	6	12	0,12	0	6	6	0,48	0,97	0,879	0,853	0,97	0,879	**0,853**
pr 1_ nor 048_030	**1**	**2**	0,5	0	6	6	12	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	**0,82**
pr 1_ nor 024_03	**2**	**3**	0,5	0	6	6	12	0,24	0	6	6	0,3	0,942	0,922	0,868	0,942	0,922	**0,868**
pr 1_ nor 030_048	**2**	**4**	0,5	0	6	6	12	0,3	0	6	6	0,48	0,929	0,879	0,816	0,929	0,879	**0,816**
pr 1_ nor 012_010	**3**	**5**	1	0	6	6	6	0,12	0	6	6	0,1	0,97	0,973	0,944	0,97	0,973	**0,944**
pr 1_ nor 000_000	**4**	**6**	1	0	6	6	6	0	0	6	6	0	1	1	1	1	1	**1**

The total portfolio performance
The start date of the portfolio: 0,000
The finish end date of the portfolio: 6,000
Duration of financing: 6,000
The amount of expenses for financing the portfolio: 1920,000
Effect start date: 0,000
Effect end date: 6,000
Duration of effect: 6,000
Portfolio realizability coefficient: 0,949
Portfolio effect reachability coefficient: 0,927
Portfolio attractiveness coefficient W: 0,880



Project cost curves graph and total portfolio costs Portf raz norm 6pr rang

2 stage. H2.1 hypothesis

Initial data

Project 1 (pr_1№1)			Project 2 (pr_1№1_)			Project 3 (pr_1№1_ _)		
${}^{\sigma}d^{1}$ =0,48; ${}^{r}d^{1}$ =0,3; δ^{1} =0			${}^{\sigma}d^{2}$ =0,48; ${}^{r}d^{2}$ =0,3; δ^{2} =0			${}^{\sigma}d^{3}$ =0,48; ${}^{r}d^{3}$ =0,3; δ^{3} =0		
${}^{s}\tau^{1}$	S^{1}	R^{1}	${}^{s}\tau^{2}$	S^{2}	R^{2}	${}^{s}\tau^{3}$	S^{3}	R^{3}
0	0	0	0	0	0	0	0	0
1	100		1	100		1	100	
2	180		2	180		2	180	
3	240		3	240		3	240	
4	280		4	280		4	280	
5	300		5	300		5	300	
6	320	1	6	320	1	6	320	1

Initial data of project portfolio financing schedule

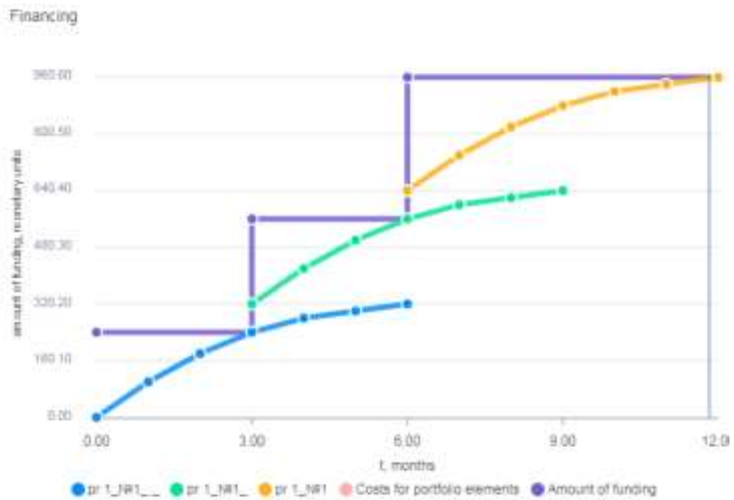
Portf3 Same		Portf 3 same_3		Portf 3 same_1	
moment	financing	moment	financing	moment	financing
0	1000	0	240	0	280
11	1000	3	560	2	820
		6	960	8	960
		12	960	12	960

Calculation results

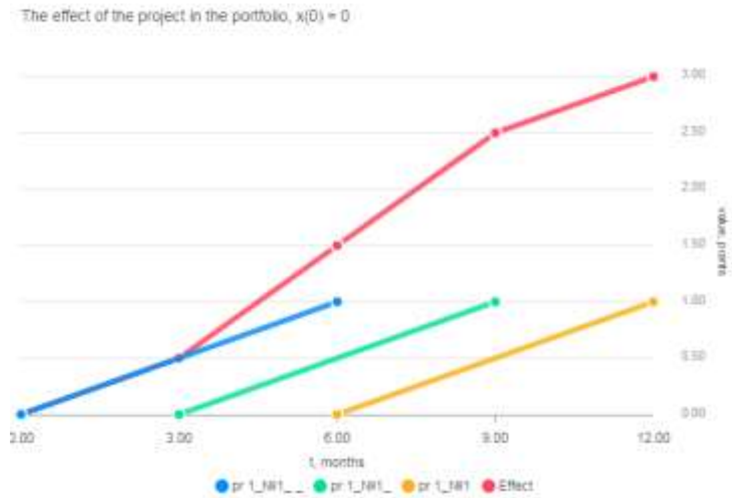
The total portfolio performance	Portf3 Same	Portf 3 same_3	Portf 3 same_1
The start date of the portfolio	0,000	0,000	0,000
The finish end date of the portfolio	6,000	12,000	12,000
Duration of financing:	6,000	12,000	12,000
The amount of expenses for financing the portfolio	960	960	960
Effect start date	0,000	0,000	0,000
Effect end date	6,000	12,000	12,000
Duration of effect	6,000	12,000	12,000
Portfolio realizability coefficient	**0,89**	**0,758**	**0,769**
Portfolio effect reachability coefficient	**0,922**	**0,832**	**0,839**
Portfolio attractiveness coefficient W	**0,82**	**0,630**	**0,645**

Calculation results

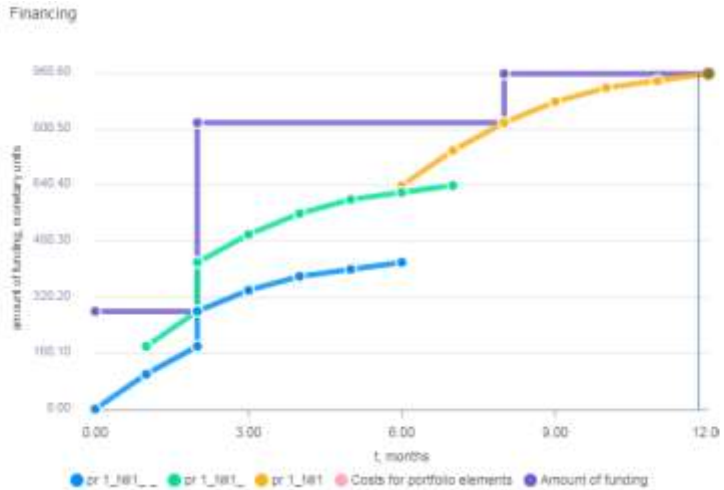
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf3 Same																		
pr 1_№1_ _	1	1	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1	1	3	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
Portf 3 same_3																		
pr 1_№1__	1	1	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	3	9	6	18	0,48	3	9	6	0,3	0,89	0,922	0,82	0,791	0,856	0,677
pr 1_№1	1	3	0,667	6	12	6	18	0,48	6	12	6	0,3	0,89	0,922	0,82	0,703	0,795	0,559
Portf 3 same_1																		
pr 1_№1_	1	1	0,667	0	6	6	18	0,48	0	6	6	0,3	0,89	0,922	0,82	0,89	0,922	0,82
pr 1_№1_	1	2	0,667	1	7	6	18	0,48	1	7	6	0,3	0,89	0,922	0,82	0,855	0,899	0,769
pr 1_№1	1	3	0,667	6	12	6	18	0,48	6	12	6	0,3	0,89	0,922	0,82	0,703	0,795	0,559



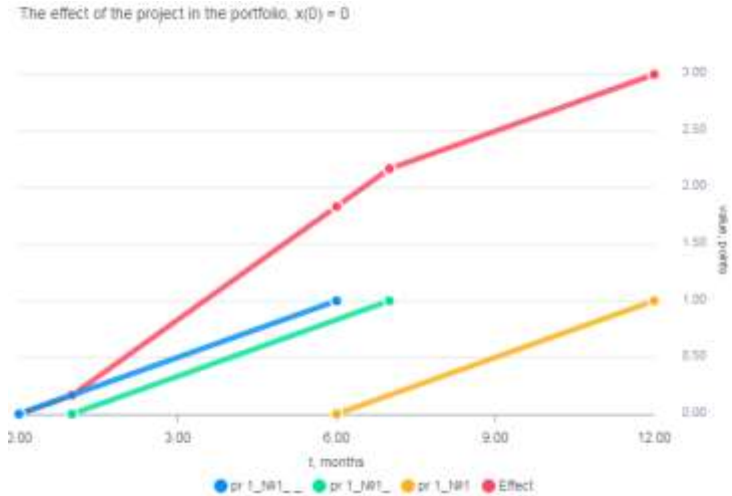
Cost curves graph for projects and total costs for Portf 3 same_3 portfolio (H2.1 hypothesis)



Effect curves graph for projects and overall effect in portfolio



Cost curves graph for projects and total costs for Portf same_1 portfolio (H2.1 hypothesis)



Effect curves graph for projects and overall effect in portfolio

H2.2 hypothesis

Initial data

Project 1 (pr 1_st_norm 4)			Project 2 (pr 2_st_norm 4)			Project 3 (pr 2_st_norm 4)			Project 4 (pr4_norm 4)		
${}^{\sigma}d^{1}$ =0,48; ${}^{r}d^{1}$ =0,3; δ^{1} =0			${}^{\sigma}d^{2}$ =0,48; ${}^{r}d^{2}$ =0,3; δ^{2} =0			${}^{\sigma}d^{3}$ =0,48; ${}^{r}d^{3}$ =0,3; δ^{3} =0			${}^{\sigma}d^{4}$ =0,48; ${}^{r}d^{4}$ =0,3; δ^{4} =0		
${}^{s}\tau^{1}$	S^{1}	R^{1}	${}^{s}\tau^{2}$	S^{2}	R^{2}	${}^{s}\tau^{3}$	S^{3}	R^{3}	${}^{s}\tau^{4}$	S^{4}	R^{4}
0	0	0	0	0	0	0	0	0	0	0	0
1	100		1	20		1	69		1		
2	180		2	60		2	125		2	160	
3	240		3	110		3	170		3		
4	280		4	170		4	207		4	320	
5	300		5	240		5	237		5		
6	320	5	6	320	5	6	261	5	6		5
						7	279				
						8	294				
						9	305				
						10	314				
						11	320	5			

Initial data of project portfolio financing schedule

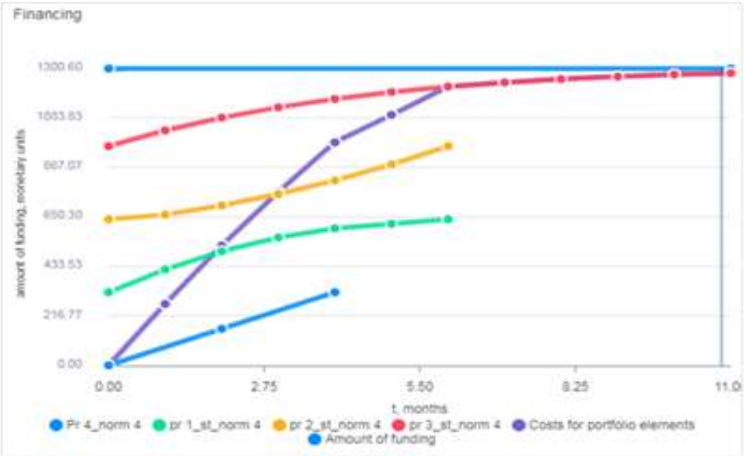
Portf2 pr4 norm4		Portf pr step 2		Portf pr step3		Portf pr step4	
moment	financing	moment	financing	moment	financing	moment	financing
0	1300	0	600	0	500	0	400
11	1300	4	1300	4	800	4	800
		15	1300	8	1300	6	1000
				21	1300	8	1300
						20	1300

Summary calculation results

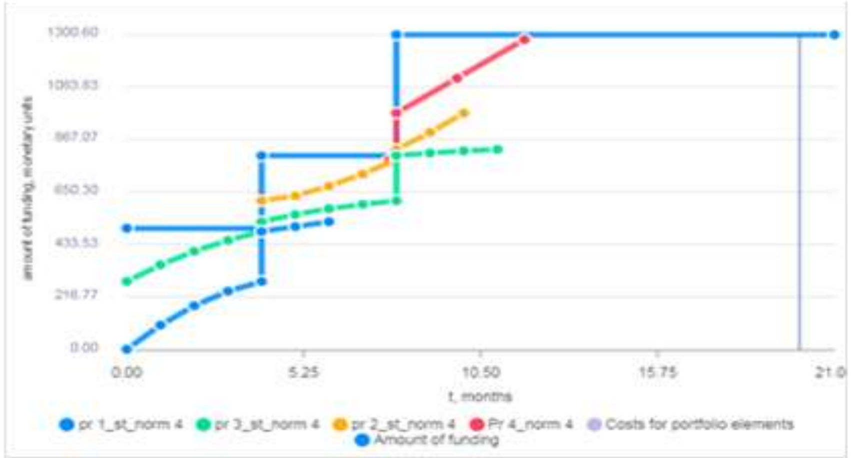
The total portfolio performance	The start date of the portfolio	The finish end date of the portfolio:	Duration of financing	The amount of expenses for financing the portfolio	Effect start date	Effect end date:	Duration of effect:	Portfolio realizability coefficient:	Portfolio effect reachability coefficient:	Portfolio attractiveness coefficient W:
Portf2 pr4 norm4	0,000	**11,000**	11,000	1280,000	0,000	11,000	11,000	0,798	1,000	**0,798**
Portf pr step2	0,000	**11,000**	11,000	1280,000	0,000	11,000	11,000	0,782	1,000	**0,782**
Portf pr step3	0,000	**11,8**	11,8	1280,000	0,000	11,8	11,8	0,780	1,000	**0,780**
Portf pr step4	0,000	**11,000**	11,000	1280,000	0,000	11,000	11,000	0,770	1,000	**0,770**

Summary calculation results

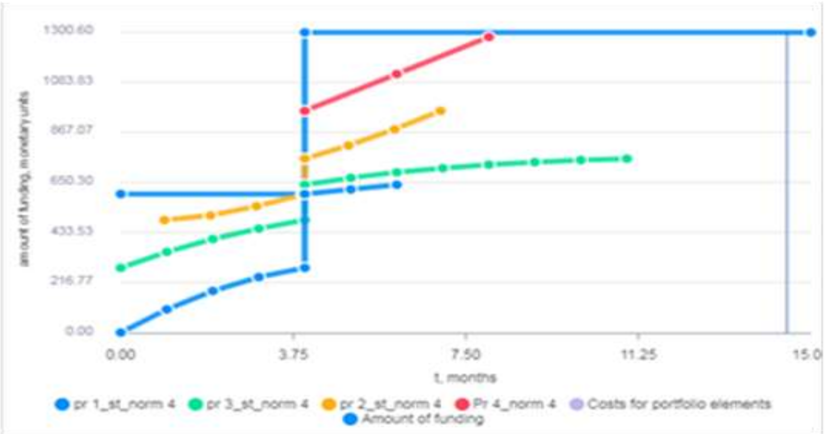
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractivenes s W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf2 pr4 norm4																		
pr 4_norm 4	1	**1**	0,852	0	4	4	27	0,48	0	4	4	0	0,925	1	**0,925**	0,925	1	**0,925**
pr 1_st_norm 4	1	**2**	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	**0,89**	0,89	1	**0,89**
pr 2_st_norm 4	1	**3**	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	**0,868**	0,868	1	**0,868**
pr 3_st_norm 4	1	**4**	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	**0,795**	0,795	1	**0,795**
Portf pr step 2																		
pr 1_st_norm 4	1	**1**	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	**0,89**	0,89	1	**0,89**
pr 3_st_norm 4	1	**2**	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	**0,795**	0,795	1	**0,795**
pr 2_st_norm 4	1	**3**	0,778	0,95	6,95	6	27	0,48	0,95	6,95	6	0	0,868	1	**0,868**	0,859	1	**0,859**
Pr 4_norm 4	1	**4**	0,852	4	8	4	27	0,48	4	8	4	0	0,925	1	**0,925**	0,791	1	**0,791**
Portf pr step3																		
pr 1_st_norm 4	1	**1**	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	**0,89**	0,89	1	**0,89**
pr 3_st_norm 4	1	**2**	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	**0,795**	0,795	1	**0,795**
pr 2_st_norm 4	1	**3**	0,778	4	10	6	27	0,48	4	10	6	0	0,868	1	**0,868**	0,742	1	**0,742**
Pr 4_norm 4	1	**4**	0,852	7,8	11,8	4	27	0,48	7,8	11,8	4	0	0,925	1	**0,925**	0,697	1	**0,697**
Portf pr step4																		
pr 2_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	**0,868**	0,868	1	**0,868**
pr 3_st_norm 4	1	2	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	**0,795**	0,795	1	**0,795**
pr 1_st_norm 4	1	3	0,778	3,77	9,77	6	27	0,48	3,77	9,77	6	0	0,89	1	**0,89**	0,781	1	**0,781**
pr 4_norm 4	1	4	0,852	6,73	10,73	4	27	0,48	6,73	10,73	4	0	0,925	1	**0,925**	0,725	1	**0,725**



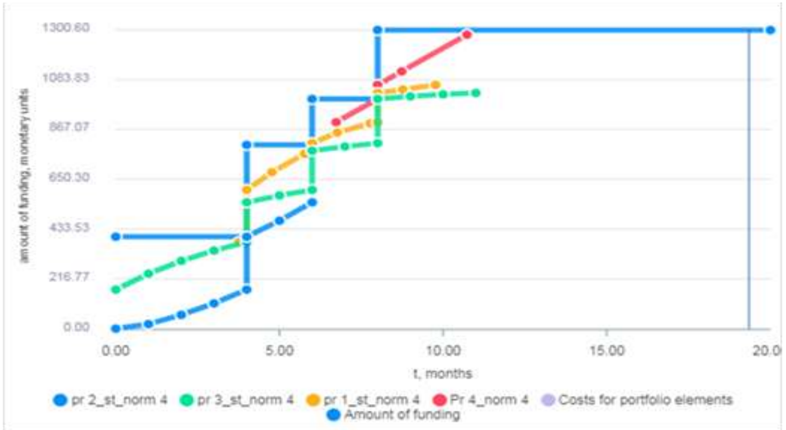
Cost curves graph for projects and total costs for Portf2 pr4 norm4 portfolio (H2.2 hypothesis)



Cost curves graph for projects and total costs for Portf pr step3 portfolio (H2.2 hypothesis)



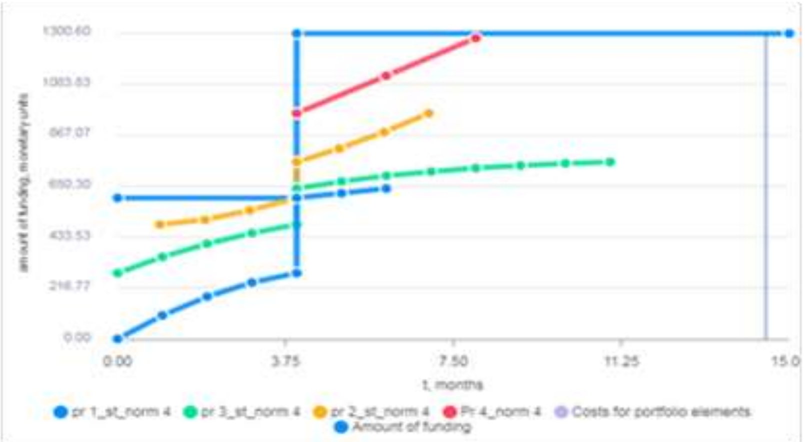
Cost curves graph for projects and total costs for Portf pr step 2 portfolio (H2.2 hypothesis)



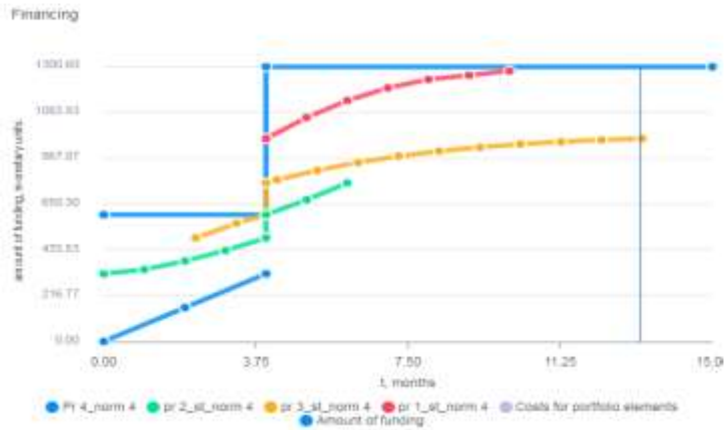
Cost curves graph for projects and total costs for Portf pr step4 portfolio (H2.2 hypothesis)

H2.2.1 hypothesis, ranking

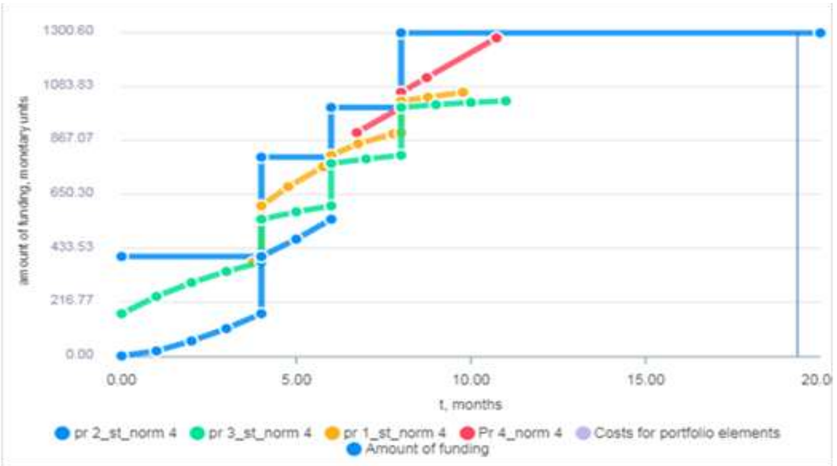
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf pr step 2																		
pr 1_st_norm 4	**1**	**1**	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	**0,89**
pr 3_st_norm 4	**1**	**2**	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	0,795	0,795	1	**0,795**
pr 2_st_norm 4	**1**	**3**	0,778	0,95	6,95	6	27	0,48	0,95	6,95	6	0	0,868	1	0,868	0,859	1	**0,859**
Pr 4_norm 4	**1**	**4**	0,852	4	8	4	27	0,48	4	8	4	0	0,925	1	0,925	0,791	1	**0,791**
Portf pr step 2 rang																		
Pr 4_norm 4	**1**	**1**	1	0	4	4	4	0,48	0	4	4	0	0,925	1	0,925	0,925	1	**0,925**
pr 2_st_norm 4	**2**	**2**	1	0	6	6	6	0,48	0	6	6	0	0,868	1	0,868	0,868	1	**0,868**
pr 3_st_norm 4	**3**	**3**	0,353	2,27	13,27	11	17	0,48	2,27	13,27	11	0	0,795	1	0,795	0,732	1	**0,732**
pr 1_st_norm 4	**3**	**4**	0,647	4	10	6	17	0,48	4	10	6	0	0,89	1	0,89	0,761	1	**0,761**
Portf pr step4																		
pr 2_st_norm 4	**1**	**1**	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	0,868	0,868	1	**0,868**
pr 3_st_norm 4	**1**	**2**	0,593	0	11	11	27	0,48	0	11	11	0	0,795	1	0,795	0,795	1	**0,795**
pr 1_st_norm 4	**1**	**3**	0,778	3,77	9,77	6	27	0,48	3,77	9,77	6	0	0,89	1	0,89	0,781	1	**0,781**
pr 4_norm 4	**1**	**4**	0,852	6,73	10,73	4	27	0,48	6,73	10,73	4	0	0,925	1	0,925	0,725	1	**0,725**
Portf pr step4 rang																		
Pr 4_norm 4	**1**	**1**	1	0	4	4	4	0,48	0	4	4	0	0,925	1	0,925	0,925	1	**0,925**
pr 1_st_norm 4	**2**	**2**	1	3,2	9,2	6	6	0,48	3,2	9,2	6	0	0,89	1	0,89	0,789	1	**0,789**
pr 2_st_norm 4	**3**	**3**	0,647	4	10	6	17	0,48	4	10	6	0	0,868	1	0,868	0,742	1	**0,742**
pr 3_st_norm 4	**3**	**4**	0,353	4	15	11	17	0,48	4	15	11	0	0,795	1	0,795	0,679	1	**0,679**



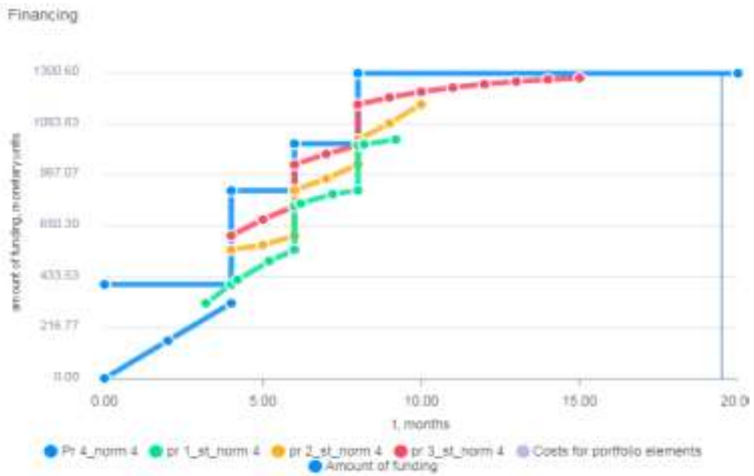
Project cost curves graph and total portfolio costs Portf pr step 2



Project cost curves graph and total portfolio costs Portf pr step 2 rang



Project cost curves graph and total portfolio costs Portf pr step4



Project cost curves graph and total portfolio costs Portf pr step4 rang

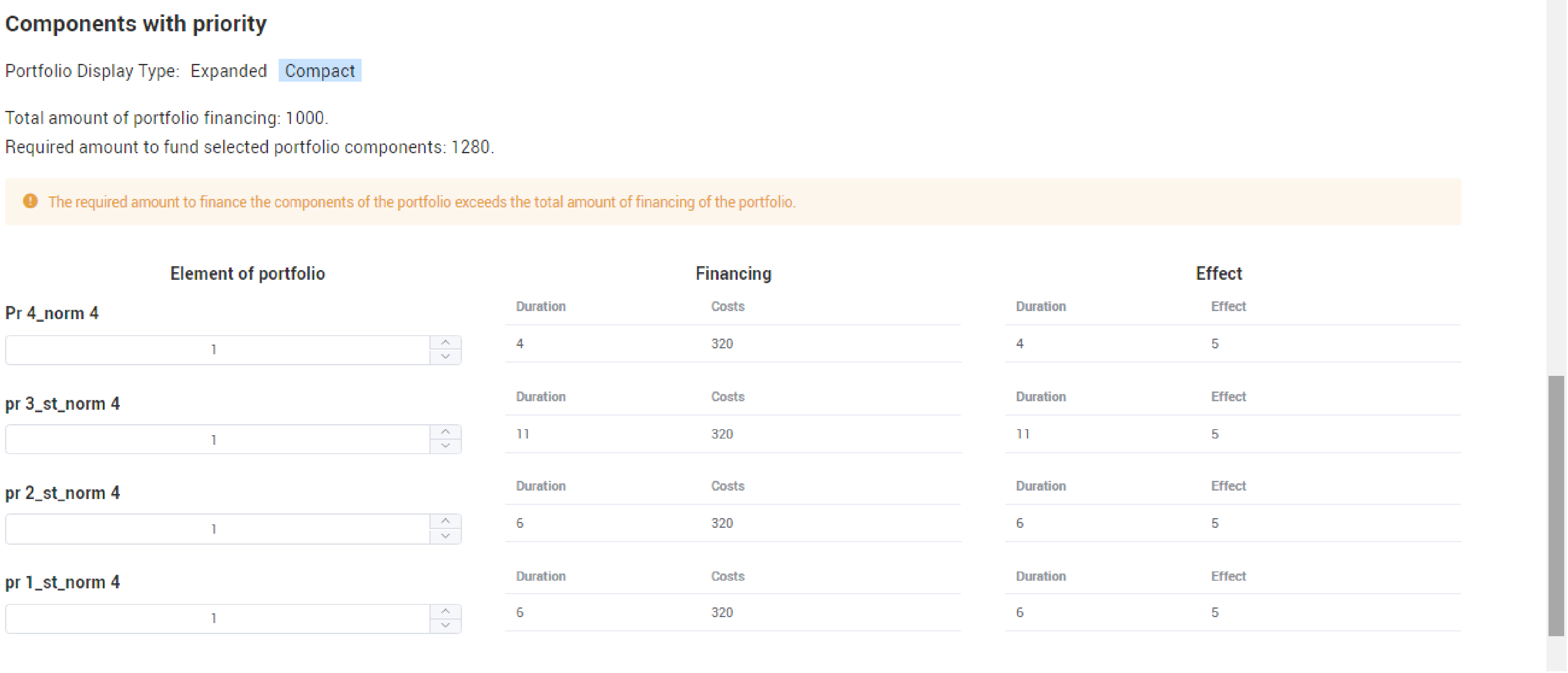
Working ability verification of project portfolio configuration method in insufficient funding face for contemplated project-candidate

Initial data

Project 1 (pr 1_st_norm 4)			Project 2 (pr 2_st_norm 4)			Project 3 (pr 2_st_norm 4)			Project 4 (pr4_norm 4)		
${}^{\sigma}d^1$ =0,48; ${}^{r}d^1$ =0,3; δ^1 =0			${}^{\sigma}d^2$ =0,48; ${}^{r}d^2$ =0,3; δ^2 =0			${}^{\sigma}d^3$ =0,48; ${}^{r}d^3$ =0,3; δ^3 =0			${}^{\sigma}d^4$ =0,48; ${}^{r}d^4$ =0,3; δ^4 =0		
${}^{s}\tau^1$	S^1	R^1	${}^{s}\tau^2$	S^2	R^2	${}^{s}\tau^3$	S^3	R^3	${}^{s}\tau^4$	S^4	R^4
0	0	0	0	0	0	0	0	0	0	0	0
1	100		1	20		1	69		1		
2	180		2	60		2	125		2	160	
3	240		3	110		3	170		3		
4	280		4	170		4	207		4	320	
5	300		5	240		5	237		5		
6	320	5	6	320	5	6	261	5	6		5
						7	279				
						8	294				
						9	305				
						10	314				
						11	320	5			

Initial data of project portfolio financing schedule

Portf2 pr4 norm4i		Portf pr step 2i		Portf pr step3i		Portf pr step4i	
moment	financing	moment	financing	moment	financing	moment	financing
0	**1000**	0	600	0	500	0	400
11	**1000**	4	**1000**	4	800	4	800
		15	**1000**	8	**1000**	6	**1000**
				21	**1000**	8	**1000**
						20	**1000**

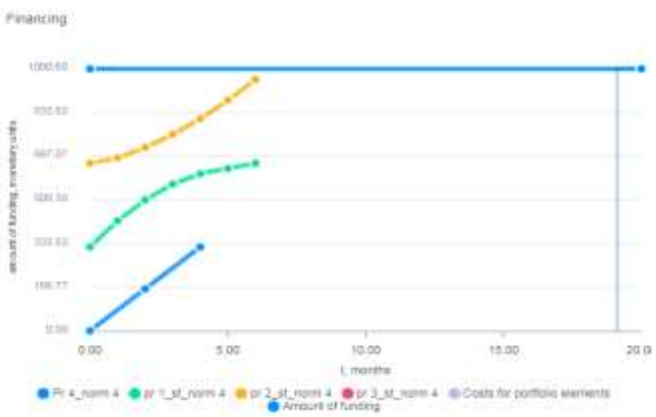


Program interface fragment with message about insufficient funding

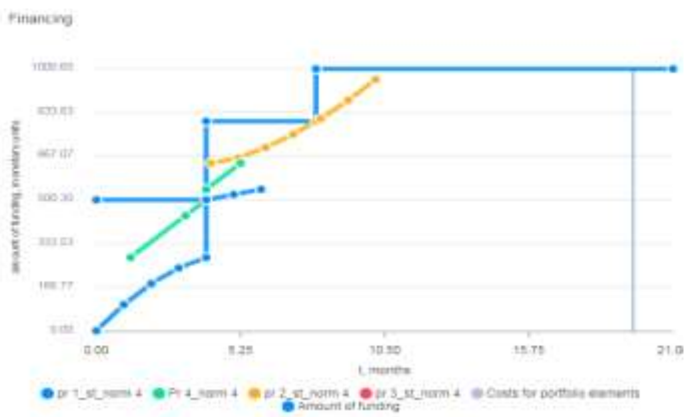
Summary calculation results

The total portfolio performance	The start date of the portfolio	The finish end date of the portfolio:	Duration of financing	The amount of expenses for financing the portfolio	Effect start date	Effect end date:	Duration of effect:	Portfolio realizability coefficient:	Portfolio effect reachability coefficient:	Portfolio attractiveness coefficient W:
Portf2 pr4 norm4i	0,000	6,000	6,000	960,000	0,000	6,000	6,000	0,883	1,000	0,883
Portf pr step2i	0,000	6,125	6,125	960,000	0,000	6,125	6,125	0,875	1,000	0,875
Portf pr step3i	0,000	10,167	10,167	960,000	0,000	10,167	10,167	0,801	1,000	0,801
Portf pr step4i	0,000	8,000	8,000	960,000	0,000	8,000	8,000	0,831	1,000	0,831

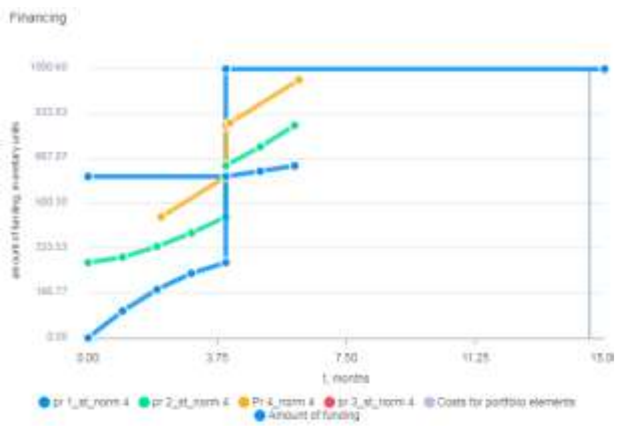
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the project	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractiveness W in the portfolio
				Start	End	Duration of project product creation			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf2 pr4 norm4i																		
Pr 4_norm 4	1	1	0,852	0	4	4	27	0,48	0	4	4	0	0,925	1	0,925	0,925	1	0,925
pr 1_st_norm 4	1	2	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
pr 2_st_norm 4	1	3	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	0,868	0,868	1	0,868
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0
Portf pr step 2i																		
pr 1_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
pr 2_st_norm 4	1	2	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	0,868	0,868	1	0,868
Pr 4_norm 4	1	3	0,852	2,13	6,13	4	27	0,48	2,13	6,13	4	0	0,925	1	0,925	0,855	1	0,855
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0
Portf pr step3i																		
pr 1_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
Pr 4_norm 4	1	2	0,852	1,25	5,25	4	27	0,48	1,25	5,25	4	0	0,925	1	0,925	0,888	1	0,888
pr 2_st_norm 4	1	3	0,778	4,17	10,17	6	27	0,48	4,17	10,17	6	0	0,868	1	0,868	0,741	1	0,741
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0
Portf pr step4i																		
pr 1_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
pr 2_st_norm 4	1	2	0,778	0,833	6,833	6	27	0,48	0,833	6,833	6	0	0,868	1	0,868	0,861	1	0,861
Pr 4_norm 4	1	3	0,852	4	8	4	27	0,48	4	8	4	0	0,925	1	0,925	0,791	1	0,791
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0



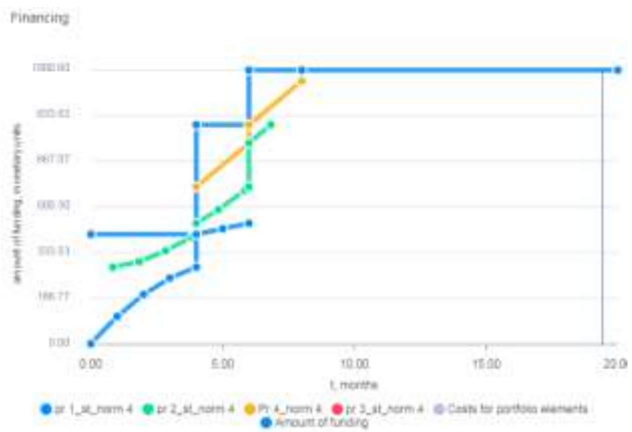
Project cost curves graph and total portfolio costs Portf2 pr4 norm4i



Project cost curves graph and total portfolio costs Portf pr step3i



Project cost curves graph and total portfolio costs Portf pr step 2i



Project cost curves graph and total portfolio costs Portf pr step4i

Calculation results show that, in comparison with results obtained in H.2.2 hypothesis testing framework (with sufficient funding level), projects financing procedure has changed. The longest project excluded from portfolio structure that affected overall portfolios configuration under consideration.

Decrease in financing. Initial data of project portfolio financing schedule.

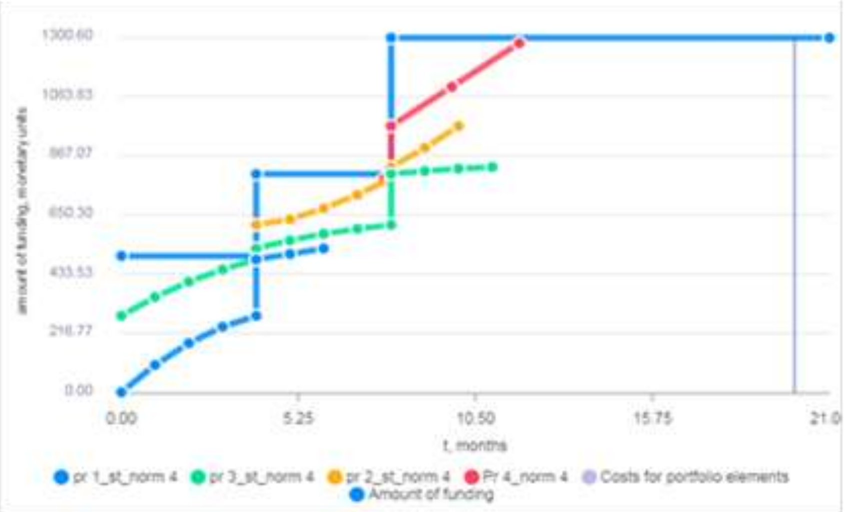
Portf pr step3i		Portf pr step3i2	
moment of time	financing	moment of time	financing
0	500	0	500
4	800	4	800
8	**1000**	8	**900**
21	**1000**	21	**900**

Calculation results

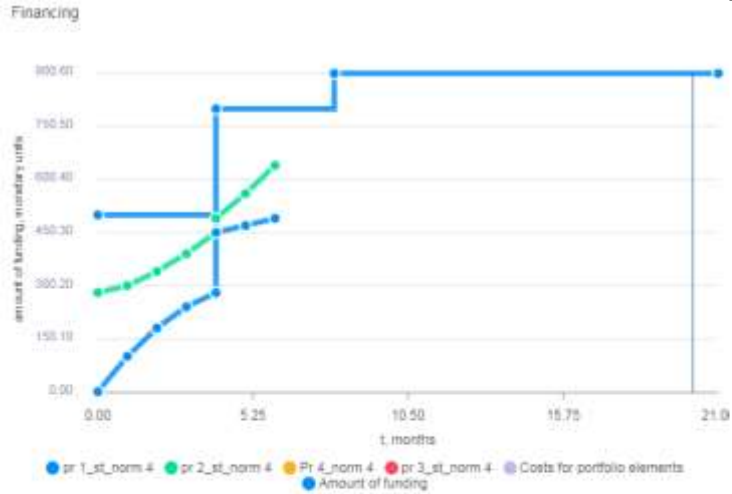
Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of projects of one priority	The annual rate of unrealizability of the project	Project effect in the portfolio, points			The annual rate of unattractiveness of the	The attractiveness coefficient components of the W project		Coefficient of project attractiveness W	Components of the coefficient of attractiveness of the W project in the portfolio		Coefficient of project attractivenes s W in the portfolio
				Start	End	Duration of project product			Start	End	Duration of project effect		Coefficient of realizability of the project	Coefficient of project effect reach		The project's coefficient of realization in the portfolio	Project effect reachability coefficient in the portfolio	
Portf pr step3i																		
pr 1_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
Pr 4_norm 4	1	2	0,852	1,25	5,25	4	27	0,48	1,25	5,25	4	0	0,925	1	0,925	0,888	1	0,888
pr 2_st_norm 4	1	3	0,778	4,17	10,17	6	27	0,48	4,17	10,17	6	0	0,868	1	0,868	0,741	1	0,741
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0
Portf pr step3i2																		
pr 1_st_norm 4	1	1	0,778	0	6	6	27	0,48	0	6	6	0	0,89	1	0,89	0,89	1	0,89
pr 2_st_norm 4	1	2	0,778	0	6	6	27	0,48	0	6	6	0	0,868	1	0,868	0,868	1	0,868
Pr 4_norm 4	1	3	0,852	-	-	4	27	0,48	-	-	4	0	0,925	1	0,925	0	0	0
pr 3_st_norm 4	1	4	0,593	-	-	11	27	0,48	-	-	11	0	0,795	1	0,795	0	0	0

Portfolio summary data

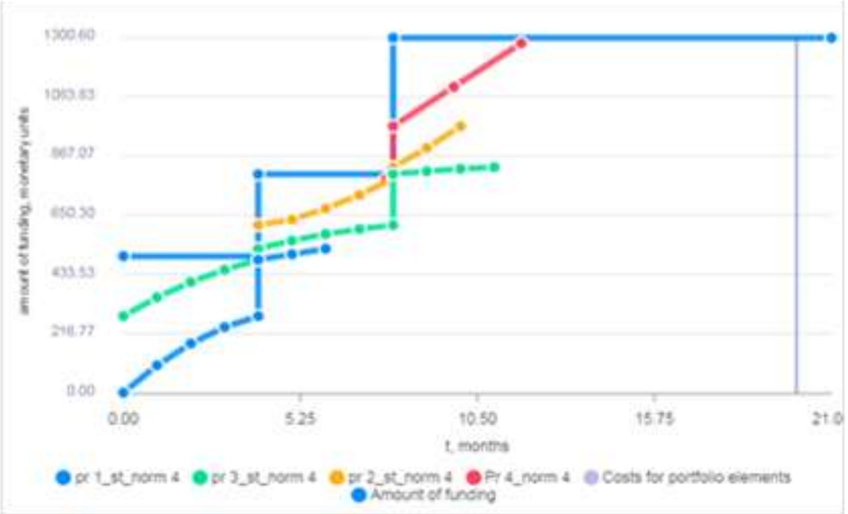
The total portfolio performance	The start date of the portfolio	The finish end date of the portfolio:	Duration of financing	The amount of expenses for financing the portfolio	Effect start date	Effect end date:	Duration of effect:	Portfolio realizability coefficient:	Portfolio effect reachability coefficient:	Portfolio attractiveness coefficient W:
Portf pr step3i	0,000	10,167	10,167	960,000	0,000	10,167	10,167	0,801	1,000	0,801
Portf pr step3i2	0,000	6,000	6,000	640,000	0,000	6,000	6,000	0,881	1,000	0,881



Project cost curves graph and total portfolio costs Portf pr step3i

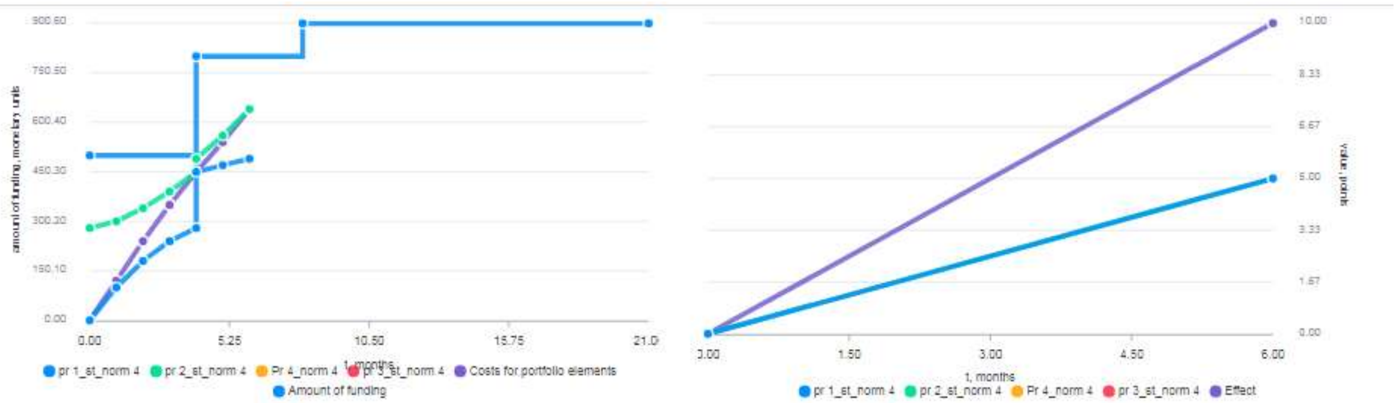


Project cost curves graph and total portfolio costs Portf pr step3i2



Cost curves graph for projects and total costs for Portf pr step3 portfolio (H2.2 hypothesis)

Calculation results comparison shows that decrease in funding (by reducing only the last stage) leads to a change in project portfolios structure (Portf pr step3i; Portf pr step3i2). Both projects list recommended for inclusion in portfolio and procedure for financing them change comparison with portfolio configuration (Portf pr step3) obtained with an excessive financing level.



Formed portfolio

Fix the first column

Name	Priority	# in portfolio	The coefficient of time attractiveness of the project	Project life cycle in portfolio, monetary units			Total duration of one priority
				Start	End	Duration of project product creation	
pr 1_st_norm 4	1	1	0.778	0.000	6.000	6.000	27.000
pr 2_st_norm 4	1	2	0.778	0.000	6.000	6.000	27.000
Pr 4_norm 4	1	3	0.852	-	-	4.000	27.000
pr 3_st_norm 4	1	4	0.593	-	-	11.000	27.000

Program interface fragment with results of Portf pr portfolio calculations step3i2 (by filling, projects that are not recommended for inclusion in projects portfolio for a given financing schedule are highlighted)