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PROJECTS' PORTFOLIO FORMATION USING TWO-STEP PROCEDURE

Considered problems of organization and support management in organizations that implement their activities in the form of projects, as well as the main approaches to managing a portfolio of projects, proposed two-step procedure for drawing portfolio, taking into account both formal and informal aspects.

Keywords: portfolio, optimization, Pareto-optimal solutions, the method of analytic hierarchy.

Introduction. Justification of the urgency of the problem

The need for organizations to implement more than one project led to the emergence of a new type of objects that are associated with the management of the organization, such as was feasible election and formation of a group of projects in the portfolio of projects [6,7]. According to the standard OMP3 (PMI), there are three levels of maturity of the organization that implements the project approach: project management (PM3 = Project Management Maturity Model); management of programs and projects (P2M3 = Programme and Project Management Maturity Model); managing portfolios, programs and projects (P3M3 = Portfolio, Programme and Project Management Maturity Model). The company may move to new levels of maturity only after reaching the previous level.

Portfolio - a collection of projects or programs and other work, combined with the goal of effective management to achieve the strategic goal [6]. Project Portfolio Management is a task whose importance has increased markedly in recent years, due to several factors, such as [1,2]:

- increasing of innovative activity leads to the need to create tools for project selection that match the chosen strategy and contribute to the growth of competitiveness project-oriented companies;
- increasing of investment activity has high requirements for the selection of projects to be included in the portfolio of the investor;
- existing methodology for real projects portfolio management is not perfect, methodologically coherent, there are new ideas and approaches that require development and generalization.

Methods of forming portfolio developed taking into account the following:

- participation of experts and evaluation of their individual projects; this feature is very important because it is the experts determine the initial set of candidate projects for inclusion in the portfolio and prepare final decision;
- strategic orientation of the portfolio, which contributes to the implementation of strategy and policy to avoid «gaps»;
- ways of allocating resources among projects portfolio based on resource constraints;
- uncertainty parameters of projects; the degree of uncertainty decreases as we approach the end of the project period;
- interdependence of projects in the portfolio that reflects the real situation in the creation of new products and processes.

Aims of article

The main purpose of the work is a critical analysis of models of portfolio formation, determining the main directions of solving this problem and develop a procedure of portfolio subject to the restrictions on resources, which takes into account both quantitative and qualitative aspects.

Analysis of models and methods of forming portfolio

There are 2 types of portfolios of projects – independent, which is not imposed any restrictions on the sequence of, and dependent, which is given a sequence (chain) projects [6]. In our opinion, dependent projects in most cases should be considered as an aggregate of projects that are separate components of the portfolio, so that (except for a few cases) portfolio formation problem is reduced to the problem of portfolio formation independent projects (Fig. 1). In this example, two groups of technology-dependent projects (Pr 2 – Pr 6) and (Pr 7 – Pr 9) are considered as two aggregated projects Pr 2a and 7a, respectively.

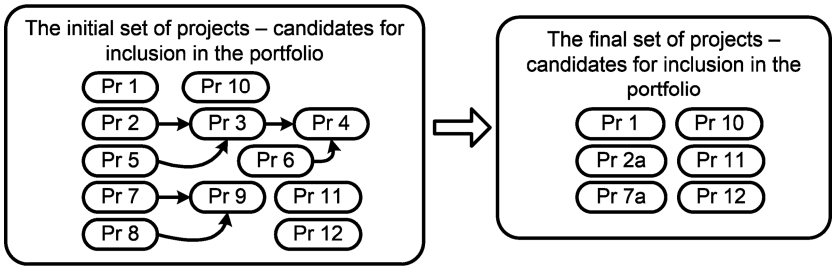

Fig. 1. Formation of set of independent projects – candidates for inclusion in the portfolio

The structure of inputs-outputs model of management project portfolio is presented in Fig. 2.

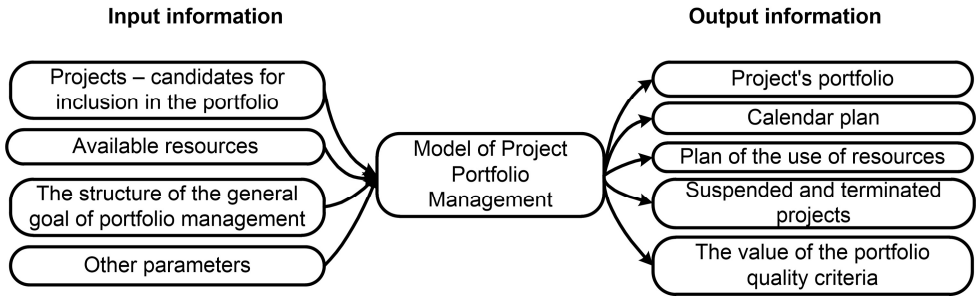

Fig. 2. Inputs and outputs of model of project portfolio management

It is believed that with the help of portfolio management models should be formed in a sense, optimal portfolio, which can be further adjusted the head with a wide involvement of visualization. Manage portfolio includes the following processes:

1. Selection of projects in a portfolio (the formation and revision of portfolio).
2. Calendar planning.
3. Resource planning and «alignment» intensity of resource consumption.

These processes can be performed: series of iterations of this sequence; 1st and 2nd in parallel, and the next stage of the 3rd, all three processes simultaneously. The most commonly used sequential implementation, much less – 2nd option, 3rd is because of computational difficulties rather speculative.

The main problems faced by companies developing new products based on project portfolio management are as follows [9]:

- too many projects overcome barriers to inclusion in the list of projects to be performed, so that early is difficult to assess which design is better and which is worse;
- requirements of resources for projects far exceed supply;
- lack of information in the decision to terminate, suspend and extension project;

- too many small projects in the portfolio and the absence of major.

Since at each stage management portfolio optimization problems arise, which in most cases are single criteria there is a problem the main criterion for selection or formation of several global criterion, the resolution of any difficulties arise [3]. Portfolio optimization problem is much more complicated when there are heterogeneous constraints – for resources: financial, material and labor; on the implementation of the portfolio and its individual projects.

Risk is a very important characteristic of the portfolio, so that in the end it is the implementation of risk factors determining its effectiveness because a significant percentage of projects not being implemented successfully, especially for innovative companies which deliberately assumed that a large proportion of the projects will lead to negative results [5]. To help assess the risk of the successful completion of each new project allows the accumulated statistics on failed projects. The quality of accounting risk strongly depends on the type of project portfolio. In addition, this method is used for simulation, the advantage of which is universal and Disadvantages – significant time and depending on the input provided by the experimenter.

To form the portfolio using a range of models and methods.

Model «stage-gate» (Stage-Gate™) is designed to improve the management of a portfolio of innovative projects and actively used in a large number of companies (60% in the U.S.). [9] The project to create a new product is divided into stages, from research to commercial realization. Before each stage are «gates» through which to pass the project. In goal decisions are made about the future of the project. This model is available in two versions – with a priority of «gate» and the priority view portfolio.

The first of these «gateway» manage middle managers and work on each project individually. Initially, the project analyzed against the selected criteria using the portfolio tool that allows you to make a decision to terminate or continue the project (Go/Kill decision). Then, if the project continues, set its priority and allocated resources.

The second is that each project must compete with each other. Solutions Go/Kill adopted when viewing portfolio 2-4 times a year, and thus provides greater dynamic portfolio. This option is often used by companies to develop software and electronics.

Badri-Davis's Model of selection projects has been developed for selection of projects of information systems in healthcare [8]. Optimality criterion takes into account the benefits, the cost of the project, hardware and software. We consider time constraints on performance during training, additional personnel, mutual relations projects. The feature of this model is the introduction of cost as a component of an aggregate quality criterion, which therefore becomes meaningful interpretation.

In the model of K. and M. Radulesku set of candidate projects for inclusion in the portfolio is divided into subsets – equivalence classes. Projects in these subsets may be varying degrees of completion, cost, and with different resource requirements. Portfolio is constructed by choosing one project from each class so as to satisfy the resource constraints, to maximize useful results and minimize risk. However, the portfolio risk is defined as the variation points, offered by experts and two-criterion optimization problem is transformed into single-criterion, leading to a single solution, while for multicriterion problems complete solution is the set of portfolios Pareto optimal.

In the model of Dickinson, Thornton and Grave account the mutual dependency between the projects portfolio in a matrix, each element of which reflects the degree of dependence of one project from another and is determined by interviewing experts. This value varies in the range [0, 1] (0 – independent projects, 1 – rigid sensitive, intermediate values correspond to intermediate strength dependence). Depending on the degree of dependence is dependent on the distribution of resources between projects. The criterion of quality is the net present value of the project portfolio if budget constraints and balanced portfolio. The model takes into account the project is given a specific discrete (year) as well as the main characteristics presented in the form of matrices and columns which correspond to discrete points in time. The advantage of this model is the consideration of mutual dependence project portfolio balancing in accordance with the strategic objectives of the company, taking into account uncertainties by asking the probability of success. Disadvantages too obvious – is not considered a change in the duration of the project depending on the amount of allocated resources, projects are indivisible – if you work on the project began, they will be

funded to the estimated time of completion, difficulties obtaining expert information about the probabilities of success factors and their mutual dependence.

Therefore the existing models do not allow to fully take into account the available information concerning the candidate projects for inclusion in the portfolio quality criteria boil down to one, are not included qualitative criteria, there are difficulties in obtaining reliable information from experts on the parameters that are used in some models are not considered alternatives portfolio – usually sought another option that is modified in the future.

Two-step procedure of forming portfolio

Almost all the procedure of portfolio formation based on having one option portfolio. At the same time it would be highly desirable to obtain some variants portfolios and compare them with each other for the main parameters. The procedure that is proposed consists of two main stages – a multiple Pareto optimal portfolio choices and final selection and portfolio formation, which was adopted to implement.

Consider the following problem of finding the optimal portfolio:

$$Q_k = \sum_{j=1}^{n} c_j x_j,\ k = \overline{1,l};\ \sum_{j=1}^{n} a_{ij} x_j \le b_i,\ i = \overline{1,n};\ \sum_{j=1}^{n} x_j \le P, \quad (1)$$

where $Q_1,...,Q_l$ – quality criteria of the portfolio, b_i – amount of resources available R_i, a_{ij}, – volume of the *i*-th resource, required to perform the *j*-th project, P – maximum number of projects in the portfolio. If $x_i = 1$, the project belongs to the portfolio, and if $x_i = 0$ – not. If there are dependent projects, the dependence taken into account by introducing additional constraints $\sum_{i \in A_j} x_i \ge card(A_j) \times x_j$, where A_j – set of projects that affect the project *j*, $card(A_j)$ – power of set A_j.

Step 1. Finding Pareto-optimal portfolios of projects. Determine the main 2-3 criteria by which we solve problem (1). As at the stage of project portfolio problem is of Boolean programming, but given, possible limitations and other criteria than linear (although the first stage in most cases, this model is sufficient) for its solution scheme should be used and the method of limits branching Of course, if there is an effective algorithm for solving, it is advisable to consider it. As a result of solving this problem, obtain the set of Pareto-optimal portfolios for major projects selected criteria. The final selection and modification of the portfolio is the next step.

Step 2. Election of the final portfolio. At this stage, for the election of the final portfolio from the set of Pareto-optimal advisable to use a variant of the analytic hierarchy process (AHP), which allows to evaluate the options portfolio in terms of the general goal of the project-oriented organization. In Fig. 3 shows a diagram of the election AHP option depending on the conditions of formation of the portfolio.

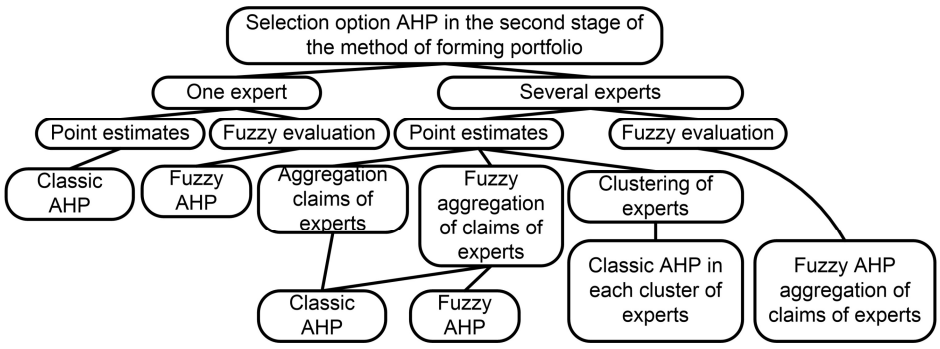

Fig. 3. The scheme of selection option AHP

After that the expert survey and evaluation of quantitative criteria values for each option portfolio and formed the matrix of pairwise comparisons for the hierarchy tree of objectives and alternatives.

Moving on alternatives to the root of the tree, set the value of global priorities and carry out the election of the final portfolio. Selected option portfolio is analyzed in terms of the value of unused resources and modified using visualization tools.

Example of portfolio formation

Quality criteria are: $Q_1(x) \Rightarrow \max$ – expected total profit of the projects portfolio (measured in monetary units); $Q_2(x) \Rightarrow \max$ – prestige projects owned portfolio (measured in scale, a similar scale AHP, obtained by interviewing experts in basic shades are not prestigious – 1, moderately prestigious – 3, substantially prestigious – 5, much more prestigious – 7, project is very high prestige – 9, with the possibility of evaluating also intermediate values).

6 projects are candidates for inclusion in the portfolio, among whom must choose those that do not violate constraints and maximize the value criteria. Available 2 types of resource constraints on which are respectively 12 and 11. Thus the optimization problem is as follows:

$$\begin{array}{lccccccc} Q_1 = & 7x_1 & +x_2 & +6x_3 & & +6x_5 & +x_6 & \Rightarrow \max \\ Q_2 = & x_1 & +3x_2 & +2x_3 & +4x_4 & +x_5 & +6x_6 & \Rightarrow \max \\ R_1 & x_1 & +4x_2 & +x_3 & +5x_4 & +2x_5 & +3x_6 & \le 12 \\ R_2 & 4x_1 & +x_2 & +5x_3 & +2x_4 & +3x_5 & +2x_6 & \le 11 \end{array}$$

Need to find a set of Pareto-optimal portfolios and choose one of them for the final implementation. Fig. 4 shows the process of solving the test case using the method of limits and ramifications of the search strategy «at once – inside».

Features portfolios belonging to the set of Pareto-optimal portfolios are following (Table 1)

Table 1.

Characteristics of Pareto-optimal portfolio of projects

N	Portfolio	$Q_1(x)$	$Q_2(x)$	Remains R_1	Remains R_2
1	(1,1,0,0,1,1)	15	11	2	1
2	(1,0,0,1,1,1)	14	12	1	0
3	(0,1,1,0,1,1)	14	12	2	0
4	(0,1,0,1,0,1)	2	13	0	6

Tree of objectives and alternatives for the 2nd stage is shown in Fig. 5, and the results of interviews with experts in the form of matrices of pairwise comparisons, the value of local priorities hierarchy and global priorities of alternative portfolios of projects in terms of general purpose – in Fig. 6 and 7.

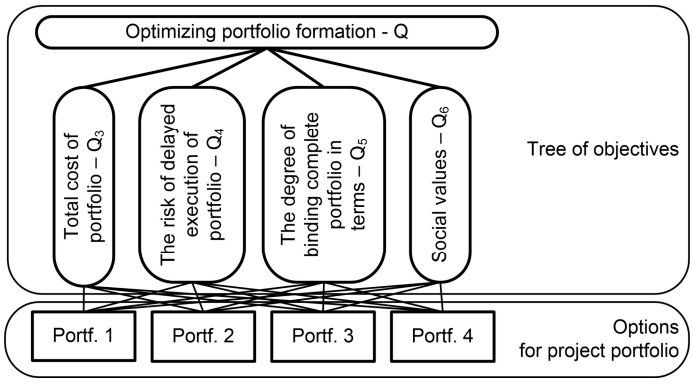

Fig. 5. Tree of objectives and Pareto-optimal portfolio of projects

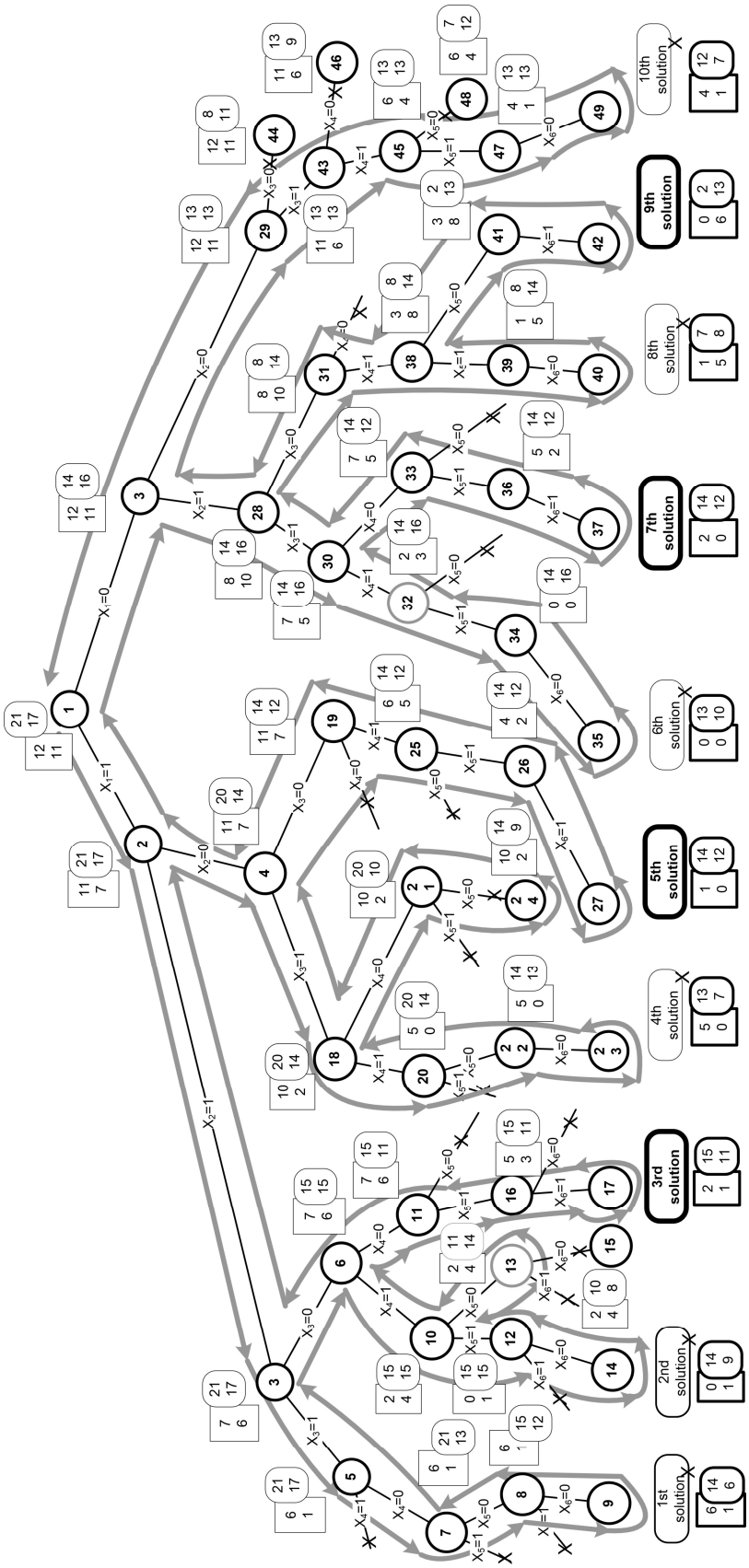

Fig. 4. Tree branches and Pareto-optimal portfolio of projects (3,5,7 and 9)

To determine the final portfolio from the set of Pareto-optimal we use analytical hierarchy method [4].

$$\begin{bmatrix} Q & Q_3 & Q_4 & Q_5 & Q_6 \\ Q_3 & 1 & 2 & 1 & 3 \\ Q_4 & 1/2 & 1 & 1/3 & 2 \\ Q_5 & 1 & 3 & 1 & 4 \\ Q_6 & 1/3 & 1/2 & 1/4 & 1 \end{bmatrix} \quad \begin{bmatrix} Q_3 & \Pi_1 & \Pi_2 & \Pi_3 & \Pi_4 \\ \Pi_1 & 1 & 3 & 2 & 4 \\ \Pi_2 & 1/3 & 1 & 1/3 & 1 \\ \Pi_3 & 1/2 & 3 & 1 & 2 \\ \Pi_4 & 1/4 & 1 & 1/2 & 1 \end{bmatrix} \quad \begin{bmatrix} Q_4 & \Pi_1 & \Pi_2 & \Pi_3 & \Pi_4 \\ \Pi_1 & 1 & 1/2 & 3 & 1/4 \\ \Pi_2 & 2 & 1 & 2 & 1/2 \\ \Pi_3 & 1/3 & 1/2 & 1 & 1/3 \\ \Pi_4 & 4 & 2 & 3 & 1 \end{bmatrix}$$

$$\begin{bmatrix} Q_5 & \Pi_1 & \Pi_2 & \Pi_3 & \Pi_4 \\ \Pi_1 & 1 & 5 & 8 & 9 \\ \Pi_2 & 1/5 & 1 & 3 & 6 \\ \Pi_3 & 1/8 & 1/3 & 1 & 2 \\ \Pi_4 & 1/9 & 1/6 & 1/2 & 1 \end{bmatrix} \quad \begin{bmatrix} Q_6 & \Pi_1 & \Pi_2 & \Pi_3 & \Pi_4 \\ \Pi_1 & 1 & 3 & 2 & 7 \\ \Pi_2 & 1/3 & 1 & 1/2 & 4 \\ \Pi_3 & 1/2 & 2 & 1 & 4 \\ \Pi_4 & 1/7 & 1/4 & 1/4 & 1 \end{bmatrix}$$

Fig. 6. Matrix of pairwise comparisons

$$\begin{bmatrix} Q & \lambda \\ Q_3 & 0,34 \\ Q_4 & 0,16 \\ Q_5 & 0,40 \\ Q_6 & 0,10 \end{bmatrix} \begin{bmatrix} Q_3 & \lambda \\ \Pi_1 & 0,47 \\ \Pi_2 & 0,12 \\ \Pi_3 & 0,28 \\ \Pi_4 & 0,12 \end{bmatrix} \begin{bmatrix} Q_4 & \lambda \\ \Pi_1 & 0,12 \\ \Pi_2 & 0,19 \\ \Pi_3 & 0,34 \\ \Pi_4 & 0,35 \end{bmatrix} \begin{bmatrix} Q_5 & \lambda \\ \Pi_1 & 0,48 \\ \Pi_2 & 0,15 \\ \Pi_3 & 0,06 \\ \Pi_4 & 0,31 \end{bmatrix} \begin{bmatrix} Q_6 & \lambda \\ \Pi_1 & 0,31 \\ \Pi_2 & 0,11 \\ \Pi_3 & 0,17 \\ \Pi_4 & 0,41 \end{bmatrix} \Rightarrow \begin{bmatrix} \Pi_1 & 0,427 \\ \Pi_2 & 0,195 \\ \Pi_3 & 0,159 \\ \Pi_4 & 0,129 \end{bmatrix}$$

Fig. 7. Local and global priorities options of portfolios projects

So as a result chosen portfolio 1, which has a significant advantage over others. Portfolios 2 and 3, which were identical to the first stage, differ significantly from the final priority.

Conclusions

The main tasks of the current projects portfolio management are: determining the structure of the portfolio of projects - types and characteristics of projects that should be included in the portfolio to achieve organizational goals, a portfolio of projects - selection projects to be included in the portfolio, scheduling process of portfolio allocation of resources between projects portfolio, efficient portfolio management projects. Problem forming portfolio belongs to the poorly structured, making it difficult to develop effective methods for its solution. Existing methods used to form the portfolio, built on the use of single-criterion optimization models – even in cases where several criteria are considered, they are brought to a single criterion by introducing a global criterion and switch to some other limitations. The information you receive from experts is offered in many cases is quite extensive, which makes excessive demands on experts, and it eventually diminish its authenticity.

The proposed procedure consists of two main stages – a multiple Pareto optimal portfolio choices and final selection and portfolio formation, which was adopted to implement that can handle multiple projects and portfolios of options to consider both quantitative and qualitative aspects.

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