PROJECT PORTFOLIO SELECTION METHOD CONSIDERING POSSIBILITIES AND INFLUENCE OF PROJECT STAKEHOLDERS

Igor Kononenko
National Technical University "Kharkiv Polytechnic Institute", Strategic Management Department, Kharkiv, Ukraine, e-mail: kiv@kpi.kharkov.ua

Karina Bukrieieva
National Technical University "Kharkiv Polytechnic Institute", Strategic Management Department, Kharkiv, Ukraine, e-mail: karina.bukrieieva@gmail.com

ABSTRACT

A project portfolio selection method has been suggested, which is focused to systemic accounting for factors affecting the efficiency of a set of projects. In solving the task, the focus was on studying the impact of the human factor and the subjective component. The key point of the method is acquisition and assessment of information on the market, the organisation's strategy, the projects, the organisation's potential to implement the projects, and the influence of stakeholders. The set of projects selected for the portfolio is validated for admissibility in regard to the profit gained, income, financial feasibility, and the company's resource load. A model for optimising the project portfolio with algorithmic constraints has been suggested. The method can be applied for large and medium businesses.

1. INTRODUCTION

The global economic downturn has aggravated the problem of project portfolio selection for many companies. Under normal economic conditions, prior to the downturn, large and medium-scale-operation companies had gained significant experience in selection of effective project portfolios. In so doing, this problem was often solved based on reviewing business plans and the company's potential to implement projects jointly with other projects in one portfolio. Experience and common sense, as applied to this problem, was most often the underpinning of success. Under the conditions of a downturn in many industries, the demand for products dropped dramatically. The strategy of activity diversification is a means for survival and opportunity build-up under current conditions. In so doing, the companies should consider the potentialities of implementing projects in areas where they lack experience in selecting projects. Due to this, the problem of selection of an optimal, or even a practical project portfolio, becomes involved and crucial. To solve the problem, one has to acquire additional information and use advanced methods. The objective of the study was developing a method for project portfolio formation, which would solve all the above problems.

2. LITERATURE REVIEW

The selection of a company's project portfolio can be effected in two ways. The first one presupposes reviewing project options, and selecting them for the portfolio based only on the opinions of experts and the company's top management. The second one is based on wide application of decision making support systems.

Over many decades, decision making support systems were being developed in many countries. These systems were based on optimisation methods (Moiseyev 1981, Burkov and Kvon 1982, and Matveyev and Novikov 2005). Experience in applying these methods has shown that the optimal solutions found with their help are rarely applied in practice. Moreover, such solutions can be very erroneous. The reason for this is that existing formalised models and methods fail to adequately reflect real-life conditions. If the decision is made by company managers, they account for many subjective factors, such as the opinion of sponsors, customers, managers, the local administration, the public, and the political situation in the country and the region. These subjective factors resist formalisation. Besides, there is a multitude of such factors. At any rate, there are dozens, and sometimes even hundreds of them.

Due to this, the most useful and suitable methods for decision making are those that account more for the subjective component when solving real-life problems, and which adequately characterise the market, the company, the project, and the influence of stakeholders. It can be claimed that a method is required, which can be actually used in the process of project portfolio selection. It would be beneficial if the method would also allow for an optimisation procedure for references, though everything mentioned above about the potentialities of such procedures remains valid for the time being.

When using optimisation methods, conventional models for project portfolio formation are classified depending on whether they account for unknown factors, and if they do, then how do they do this. In this connection, deterministic models, stochastic models and models with uncertainty elements are distinguished (Tsarev 2004).

In turn, deterministic models are classified as linear, nonlinear, dynamic and graphic ones. Stochastic models rely on achievements in stochastic programming. Decision making models, with the presence of uncertainty elements, include models based on the theory of games and simulation models. In our opinion, this classification should be amended with models for project portfolio formation that account for different kinds of fuzziness (Coffin and Taylor 1996). This classification should also account for single-criteria and multicriteria problem statements.

In considering multicriteria problems in project portfolio formation, the criteria suggested are profit, cost, investment requirement, as well as the behaviour of these indicators (Tsarev 2004).

The criteria of profitability and risk are widespread in statements of the problem of project portfolio optimisation. Such a problem was suggested for formation of an optimal securities portfolio (Markowitz 1952). Further, it was often used during formation of company's project portfolio (Radulescu 2001).

In (Ghasemzadeh, Archer and Iyogun 1999) linear Boolean programming model is proposed for selecting and scheduling an optimal project portfolio, based

on the organization’s objectives and constraints such as resource limitations and interdependence among projects.

The study (Matveyev, Novikov, and Tsvetkov 2005) explores the problem of multicriteria optimisation of a project portfolio with constraints imposed on expending resources of several kinds, and with fuzzy data about the project implementation effect.

Known studies in project portfolio optimisation focus mainly on optimisation models and methods, and insufficiently consider the criteria for evaluating the market, the company, the project, and the influence of stakeholders.

It is suggested to apply formalized estimate of the impact of stakeholders on projects with the cognitive map method. The term “cognitive map” was introduced for a scheme, simplified description of individualistic world picture, more precisely, its fragment, related to some problem situation (Tolman 1948). Cognitive maps have been studied in various fields, such as psychology, education, archaeology, planning, geography and management.

Historically, the first cognitive model was the signed graph (Roberts, 1986). The cognitive approach to decision making support is focused to activating the subject's intellectual processes, and help the subject fix his/her representation of the challenge as a formal model. The model used is the so-called cognitive situation map. It presents the subject with known basic laws and regularities of the situation perceived in the form of an oriented signed graph, wherein the graph nodes are factors (attributes and situation characteristics), and the edges between the factors are the cause-and-effect relationships between the factors.

B. Kosko (1986) introduced fuzzy cognitive maps. In contrast to simple cognitive maps, a fuzzy cognitive map is a fuzzy oriented graph whose nodes are fuzzy sets. Oriented graph edges not only reflect the cause-and-effect relationships between concepts, but also determine the degree of impact (weight) of linked concepts. Active usage of fuzzy cognitive maps as a system modelling tool stems from the possibility of visual representation of the system analysed, and ease of interpretation of cause-and-effect relationships between concepts.

3. RESEARCH PROJECT

3.1 Project description and objectives

The objective of the study was developing a method for a company's project portfolio selection, which could be actually applied in large and medium businesses. Such a method has to account for all the factors that have a significant impact on the potential of implementing projects and their efficiency. As compared to current approaches, the method should focus more on the human factor and subjective components during decision making.

3.2 Research methodology

A project portfolio selection method has been developed for application in companies who not only manage projects prior to commissioning facilities, but also operate the facilities that emerge by implementing the projects. One might say that project management in such companies is a means for development of

facilities, and as a rule, operation of these facilities generates the basic income of these companies.

The method accounts for criteria that characterise the company's experience in project management and the company's goals. It also characterises the projects that will make up the project portfolio. The projects are assessed based on both their feasibility in the company and project implementation results.

The method comprises four sections:

1. The mission, values, vision, and goals of the company.
2. An assessment of project results for company development and achievement of its strategic goals.
3. Project management assessment (a valuation of project complexity and its feasibility for a specific company).
4. An assessment of the impact of stakeholders (project environment) with cognitive maps.

Each section has a group of criteria.
The project attractiveness criteria and projects' compatibility with company capacities is evaluated on a 0 to 10-point scale.
10 points means that a criterion yields maximum advantage when selecting the project
8 points: the criterion yields a significant advantage
6 points: the criterion yields a certain advantage
4 points: the criterion yields an insignificant advantage
2 points: the criterion is insignificant
0 points: there is no criterion
Criteria with 1, 3, 5, 7, and 9 points are used for expressing intermediate advantage values.

In the following is a list of questions to be answered by experts.

1. Mission, values, vision, and goals of the company:
   a. Company mission
   b. Company values
   c. Company vision
   d. Company goals
   e. Sales plan for every year of planning period
   f. Net income plan for every year of planning period
   g. Availability of own investment funds for each year, irrespective of the profit gained by implementing the projects considered
   h. The sum of credit that can be attracted for financing the projects

2. Assessment of project results for company development and achieving the strategic goals

Project assessment criteria with account of project results:

a. Market analysis
- mid-term market attractiveness
- long-term market attractiveness

(Evaluate by 0 to 10 points)

b. Marketing strategy
- assumed market share (compare with other portfolio projects).

The normalised value of the company's assumed market share for a *k*-th project is calculated by the formula

$$y_k^{norm} = 10 \cdot \frac{y_k - y_{\min}}{y_{\max} - y_{\min}} \quad (1)$$

y_k is the indicator for the *k*-th project, $k=\overline{1,K}$, and *K* is the number of projects considered, and
$y_{\max}$ and $y_{\min}$ are the maximum and minimum indicators for the considered *k*-projects.

- selected market segment profile (Point evaluation: world market, 10; country market, 7; regional market, 4; city and city district market, 1).
- describe the kind of products and/or services.

c. Organisational plan
- type of organisational structure (is the planned organisational structure for the project in line with the company's organisational structure?). Evaluate compliance by 0 to 10 points. Assign 10 points if the organisational structure for the project completely complies with the company's one.
- experience of key managers (evaluation in points: 10-years' experience, 10; 5 to 10 years, 5; less than 5 years, 1).

d. Production plan
- production capacity (evaluation: 10 points, the production capacity is available and meets the requirements; 0 means there is no capacity).
- for each project, define the work load of available production capacities. The valuation is 10 points if the production capacities work load is full.
- sales plan annually.

e. Company's experience in similar projects
Evaluate by 0 to 10 points: assign 10 points if the company has implemented 15+ projects.

f. Finance plan
- NPV
- IRR
- PI
- discounted project payback period

Normalise each financial criterion for all projects.
The normalised values of NPV, IRR, and PI for the *k*-th project are calculated by (1).

The normalised value of the discounted payback period of the *k*-th project is found as

$$y_k^{norm} = 10 \cdot \frac{y^{DBP}{}_{\max} - y^{DBP}{}_k}{y^{DBP}{}_{\max} - y^{DBP}{}_{\min}} \quad (2)$$

y_k^{DBP} is discounted payback period for the *k*-th project;

$y_{\max}^{DBP}$ is maximum value of the discounted payback period for all the projects considered;

$y_{\min}^{DBP}$ is minimum value of the discounted payback period for all the projects considered.

- required annual investments for each project.

g. Risk estimate

Estimate risks using the EMV decision tree diagram (PMBOK). Calculate the normalised EMV value by a formula similar to (1).

h. Project's compliance with the company's mission, values, goals and vision. Evaluate by 0 to 10 points.

3. Project management assessment

a. Hierarchical structure of tasks
- total number of tasks.
- time required for execution of tasks.

b. Assessing the tightness of the schedule for executing the key phases of project tasks. A very tight task execution schedule means 0 points. Assign 10 points if time is not a critical resource.

c. Project execution complexity. A very involved project means 0 points; assign 10 points for a not complicated one.

d. Project management team experience in management of similar projects; assign 10 points for a considerable one.

4. Estimating the impact of stakeholders (project environment) with cognitive maps

The project environment is defined, which affects its outcome and determines how involved each project will be. A formalised estimate of the impact of stakeholders on the project is made depending on the level of concernment (negative of positive) with project results, and the degree of impact on the project, using the formula

$$I_k = \sum_{r=1}^{R} f_{kr} \cdot v_{kr} \qquad (3)$$

I_k is estimate of the impact of stakeholders on the *k*-th project;

v_{kr} is level of concernment of *r*-th stakeholder in the outcome of the *k*–th project (evaluated by points (-1;1); point -1 means maximum possible disinterest in project results, and conversely, 1 means maximum interest);

f_{kr} is degree of impact of the *r*-th stakeholder on the *k*–th project by a 10-point system;

R is number of stakeholders considered.

Selection of projects with account of constraints

The above information on the market, company, projects and stakeholders characterises the situation completely and in detail. It allows the decision makers to make a correct choice and find a really effective solution. There is yet another problem that should be addressed. It is necessary to validate whether the projects selected and their mix will allow the company to meet its planned profit

and income; will investment resources and potential credits be sufficient for project implementation, and will the load on other company resources exceed the admissible level.

These conditions can be validated as follows.

1. Profit constraint

$$P_\tau \le \sum_{k=1}^{K} \sum_{t=1}^{\tau} p_{kt\tau} \cdot x_{kt} \,,\ \tau = \overline{1,T} \qquad (4)$$

P_τ is planned project implementation profit in year τ;

$p_{kt\tau}$ is planned profit gained by implementing the *k*-th project in year τ, if the project initiated in year t;

$x_{kt} \in \{0,1\}$, x_{kt} =1, if the *k*–th project is included in the portfolio and initiated in year t;

$x_{kt} = 0$, if the *k*-th project initiated in year t is not included in the portfolio;

T is planning period.

2. Income constraint

$$D_\tau \le \sum_{k=1}^{K} \sum_{t=1}^{\tau} d_{kt\tau} \cdot x_{kt} \,,\ \tau = \overline{1,T} \qquad (5)$$

D_τ is planned project implementation income in year τ;

$d_{kt\tau}$ is planned income gained by implementing the *k*-th project in year τ, if the project initiated in year t.

3. Investment funds constraints

$$S_\tau \ge \sum_{k=1}^{K} \sum_{t=1}^{\tau} s_{kt\tau} \cdot x_{kt} \,,\ \tau = \overline{1,T} \qquad (6)$$

S_τ is own investment funds and company's liable credit resources in year τ;

$s_{kt\tau}$ is resources required for implementing the *k*-th project in year τ, if the project initiated in year t.

4. Constraints on resources load during project management

Each project is characterised by a Gantt chart with indication of the times of commencement and completion of works, and requirements to expenditure of different resources. Analysis of the load on a specific resource in the project selected yields a time schedule of loading the given resource (PMBOK). Similarly, for the project portfolio being tested, the resources loading schedule can be defined. To evaluate the loads on resources, convenient software tools are MS Project and others. Hence, we arrive at a problem, in which the constraints related to the load on available resources are tested with an algorithm, the constraints being algorithmic, rather than analytical ones.

It is assumed that, after the resources for implementing the project portfolio have been allocated, their load is optimised.

Admissible load level of the l -th resource during project portfolio management is

$$T_l \geq \varphi_l(\{x_{kt}\}),\ l = \overline{1,L} \tag{7}$$

$\varphi_l(\{x_{kt}\})$ is maximum load level of l -th resource during project management, defined using project management software;
L is number of resources considerate.

If desired, the persons who prepare the decision can try to select the "optimum" prject portfolio with reducing all enumerated criteria to the generalized one. Each k -th project assigned a generalized estimate according to the formula

$$E_k = \sum_{i=1}^{n} \lambda_i \cdot e_{ki},\ k = \overline{1,K} \tag{8}$$

e_{ki} is estimate of the *k*-th project per *i*-th criterion;
λ_i is weight factor of the *i*-th criterion;
n is total number of criteria considered.
Experts shall assign a weight factor λ_i value within 1 to 0.
The projects are selected for the portfolio according to the generalised criteria obtained. The availability of financial resources in the company and compliance of project results with the company's profit-making and sales goals are considered as constraints during portfolio formation. In addition, another constraint is the company's capacity to implement the project using available resources (production capacities).

During the project portfolio selection, the target function is the sum of generalised criteria for projects included in the portfolio, namely:

$$F = \sum_{k=1}^{K} \sum_{t=1}^{T} E_k \cdot x_{kt} \rightarrow \max_{x_{kt}} \tag{9}$$

It is assumed that the project initiated during the planning period not more that once.

$$\sum_{t=1}^{T} x_{kt} \leq 1,\ \forall k = \overline{1,K} \tag{10}$$

Task (4)-(10) is the task of Boolean programming with an analytical target function, and algorithmic and analytical constraints. With the number of projects that are usually considered in practice, it can be solved by exhausting all the combinations of projects in the portfolio. For problem solving an implicit enumeration procedure could be suggested (Kononenko 2006). If fuzzy numbers are used for estimating criteria values, the problem will be solved in the fuzzy statement.

During problem formalisation, we assumed that the target function and the constraints are additive. This implies that portfolio assessment by a certain criterion is achieved by adding the assessments of all projects involved. Actually, a systemic effect is often observed, and the set of projects yields results other than the sum of outcomes of individual projects. This also pertains to the resources used.

Besides, we assumed that the projects are independent of each other, and no requirements to the sequence of their implementation exist.

To account for the systemic effect, profit, income, and required financial resources should be assessed for a body of projects, rather than by summing them individually. The interdependence of projects and the requirements to the sequence of implementation of projects can be accounted for by special constraints (Kononenko 2006).

If the target function and/or constraints have no additive properties, the problem is solved by complete enumeration of all project combinations in the portfolio.

4. RESEARCH RESULTS AND INDUSTRIAL IMPACT

4.1 Results

The studies conducted have generated a project portfolio selection method in situations when the company is interested not only in project management, but also in the efficiency of facilities that shall emerge after the projects have been implemented. In particular, the company can operate the developed facilities. Considerable attention has been paid to systemic accounting of factors, which affect the capability of implementing projects and their outcome.

A questionnaire has been proposed for the managers to collect enough information for solving the problem. Along with collecting objective data, the questionnaire provides for collecting subjective information. In the first place, this relates to assessing stakeholders' concernment and their influence on the projects considered.

For project portfolio selection, we suggest to account for the following: the mission, values, vision, and goals of the company; the potential financial resources for implementing projects; market attractiveness; the assessment of project outcomes for company development and achievement of strategic goals; the assessment of management of each project, including an assessment of project complexity and feasibility for a specific company, and an assessment of stakeholders' influence.

For the sets of projects being tested, it is proposed to validate them from the standpoint of meeting the requirements to yielding adequate profit and income in the planned period.

Besides, it is proposed to validate the sufficiency of funds earmarked for implementing projects. From the practical standpoint, it is crucial to evaluate the load on company resources during project portfolio management.

If desired, the persons who prepare the decision can also solve the portfolio formation optimisation problem. A mathematical model of such a problem with an

analytical target function, and with algorithmic and analytical constraints has been developed.

4.2 Implementation and exploitation

One of the authors of the method has extensive experience in development and appraisal of investment projects in many industries in Ukraine, including an appointment with UNIDO as a national expert.

Many years' observations in project portfolios selection and their management in many companies have identified crucial factors, among which the foremost are subjective opinions and stakeholders' influence. As a result, a method was developed, which can be a work tool for large and medium-business managers.

The offered method for project portfolio formation can be used in companies in virtually any industry.

5. CONCLUSIONS

In the area of project portfolio selection, a situation has arisen when practitioners rely mainly on business plan data and very simple calculations for evaluating the adequacy of financial and other company resources. Often this is insufficient for the company to operate in conditions of increasing competition and decreasing demand. The drawbacks of this approach are especially evident when considering projects in business areas new to the company.

Over the past decades, experts in system analysis have developed models and methods for optimisation of project portfolios; however, they inadequately reflect the factors affecting the situation, and these primarily are subjective factors. Due to this, these models and methods have not been widespread.

The study has proposed a method allowing experts and company managers to collect complete and detailed information on the problem, including data on possible stakeholders' influence. The method allows for validating required constraints and, if desired, solving the optimisation problem.

6. REFERENCES

Burkov V.N., Kvon O.F. (1998), *Models and methods of multiproject management*. Moscow: IPU RAN, p 62.

Coffin M.A. and Taylor B.W. (1996), *Multiple Criteria R&D project selection and scheduling using fuzzy logic*. Computer&Operations Research, 23, pp 207-221.

Ghasemzadeh F., Archer N.P. and Iyogun P. (1999), *A zero-one model for project portfolio selection and scheduling*. J. Operational Research Soc., 50, 7, pp 745-755.

Kononenko I.V. (2006), *Computerization of management of industrial and economical systems development*. Kharkiv: NTU “KhPI”.

Kosko B. (1986), *Fuzzy Cognitive Maps*. International Journal of Man-Machine Studies, 24, pp 65-75.

Markowitz H. (1952), *Portfolio Selection*. The Journal of finance. Vol. VII, No.1, March 1952.

Matveyev A.A., Novikov D.A. (2005), *Models and methods of project portfolio selection*. Moscow: MGU, Informational economy, pp 138–149.

Matveyev A.A., Novikov D.A. and Tsvetkov A.V. (2005), Models and methods of project portfolio management. Moscow: PMSOFT.

Moiseyev N.N. (1981), *Mathematical problems of system analysis*. Moscow: Nauka.

PMI. (2004), *A Guide to the Project Management Body of Knowledge (PMBOK Guide), 3rd edn*. Newtwon Square, PA: Author.

Radulescu, C.Z., Radulescu, M., Filip, F.G., et al. (2001), *Decision analysis for the project selection problem under risk.* 9th IFAC Symposium on Large Scale Systems: Theory and Applications 2001 (LSS'01).

Roberts F.S. (1976), *Discrete Mathematical Models, with applications to social, biological and environmental problems.* New York: Prentice-Hall, Englewood Cliffs.

Tolman E.C. (1948), *Cognitive Maps in Rats and Man.* Psychological Review. Vol. 55(4), Jul 1948, pp 189-208.

Tsarev V.V. (2004), *Estimation of investment cost-effectiveness*. St. Petersburg: Piter.