Management of Dynamic Project Portfolio

Petr Fiala, Josef Arlt, and Marketa Arltova

***Abstract*—Project management is the discipline of planning, organizing, securing and managing resources to bring about the successful completion of specific project objectives. Project opportunities come in time and it is necessary to decide which will be accepted for creating a dynamic portfolio of projects and which will be rejected. The use of project portfolio management is increasingly becoming a tool for promoting the strategy of the organization, which is a very important role. Using of standard methods or trying to design and apply sophisticated methods based on quantitative analysis is possible for portfolio management. Selection of project portfolio is a dynamic multi-criteria decision-making problem under risk. The paper presents an approach for dynamic project portfolio management based on the Analytic Network Process (ANP) model. The ANP model consists of four basic clusters (projects, resources, criteria, time) with their elements and influences. An important factor of the proposed ANP model is time. Hybrid procedure for dynamics of the project portfolio management is proposed.**

***Index Terms*—Projects, project portfolio, ANP, resources, criteria, dynamics.**

I. Introduction

Project management is the discipline of planning, organizing, securing and managing resources to bring about the successful completion of specific project objectives (e.g. [1]). In an accelerating economic world, projects become tools for promoting the objectives of the organization. There is a very extensive literature on the management of individual projects and project portfolios. We start from a publication [2] that describes very clearly project management as a managerial process. Projects are in accelerating world rhythm the right option of solving problems of lot of organizations. Nothing is permanent, everything is temporary, and that makes pressure on companies to finish new products or services faster, cheaper and definitely not to fail. Risk is a very important factor in project management. Most project organizations exist in a multi-project environment. This environment creates the problems of project interdependency and the need to share resources. Projects are the way for implementing the organization's strategy. Strategic alignment of projects is of major importance to effective using of organization resources.

Selection criteria need to ensure each project is prioritized and contributes to strategic goals.

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Ensuring alignment requires a selection process that is systematic, open, consistent, and balanced. All of the projects selected become part of a project portfolio that balances the total risk for the organization. Management of the project portfolio ensures that only the most valuable projects are approved and managed.

Projects are considered as a tool for achieving the strategic goals of organizations. Continuous innovation, renewal and organizational learning are considered vital for survival. Intense global competition is forcing many organizations to look for new methods of management. The key to success in project portfolio management is to select the right projects at the right time (see [3], [4]). The project selection process is considered a major component of project portfolio management. This should be accompanied by periodically repeated inspections of project portfolio, which would identify projects that should be terminated. Effective portfolio management helps to achieve outperformance, making strategy real through organizational change. Strategic project portfolio management enables present a framework for organization to complete significant strategic projects. Portfolio management is a process. This process must improve over time. Building feedback into every stage of the process is critical for the improvement.

To select a portfolio of projects are basically two approaches, one is based on standard methods used in practice, the second approach is based on searching and applying new sophisticated methods based on quantitative analysis. The paper focuses on the of project portfolio selection problem solved by applying sophisticated models. The aim is to develop a general model, which would be completed for the specific needs of problems. This is not about managing individual projects, but their networks where relationships exist among projects. This paper aims to verify the ability to model and solve the problem of dynamic project portfolio using the Analytic Network Process (ANP) model. Portfolio management is a process. This process must improve over time. Building feedback into every stage of the process is critical for the improvement. The organization must decide under risk whether to assign all available resources to present proposals or to reserve a portion of the funds unused for some time and wait for better alternatives that may occur later. We propose to complete our ANP model by a decision tree with multiple criteria and interactive multi-criteria analysis for solving this problem.

II. Project Portfolio Selection Problem

The network economy is a term for today’s global relationship among economic subjects characterized by massive connectivity. The central act of the new era is to connect everything to everything in deep web networks at

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many levels of mutually interdependent relations, where resources and activities are shared, markets are enlarged and costs and risk are reduced. Network systems contain both positive and negative feedbacks. A variety of feedback processes create complex system behaviour (see [5]).

The portfolio management domain encompasses project management oversight at the organization level through the project level. Full insight of all components of the organization is crucial for aligning internal business resources with the requirements of the changing environment. Project portfolios are frequently managed by a project office that serves as a bridge between senior management and project managers and project teams. Project opportunities come in time and it is necessary to decide which will be accepted for creating a dynamic portfolio of projects and which will be rejected (see Fig. 1).

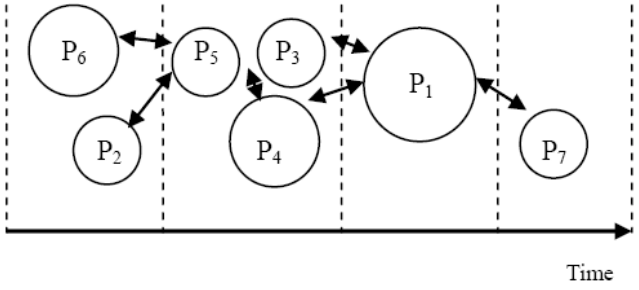

Fig. 1. Dynamic flow of projects.

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Project portfolio is set all projects that are implemented in the organization at that time. The basic objectives of the project portfolio management include:

- optimize the results of the entire project portfolio and not individual projects,
- the selection of projects to start,
- interruption or discontinuation of projects,
- defining priorities for projects,
- coordinate internal and external sources,
- organization learning from each other project.

It is generally expected that the portfolio should be designed in such a way as to maximize the possibility of achieving the strategic goals of the company. This is consistent with the notion that portfolio selection problem is a multi-criteria decision making. The main goal of each project is to increase the value of the organization, so most managers prefer financial criteria for project evaluation. The most commonly used indicators include net present value, internal rate of return, payback period, rate of return.

In addition to these financial indicators, however, in selecting a portfolio of projects should be taken into account other characteristics, which include for example:

- The probability of completing the project on time, within budget and within the proposed quality;
- Consistency between strategic and tactical plans;
- The balance between investment projects and maintenance projects;
- Efficient use of resources;
- Relations between projects;
- The scope of each project;
- Time-dependent consumption of resources on projects;
- Allocation of expenditure and resources for research and development;
- Allocation of marketing spending and resources.

Lot of professionals tried to find sophisticated way to improve techniques for project management in different ways. The paper presents an approach for dynamic project portfolio management based on the ANP model.

III. Analytic Network Process

The Analytic Hierarchy Process (AHP) is the method for setting priorities. A priority scale based on reference is the AHP way to standardize non-unique scales in order to combine multiple performance measures. The Analytic Network Process (ANP) is the method (see [6]) that makes it possible to deal systematically with all kinds of dependence and feedback in the performance system. The well-known AHP theory is a special case of the Analytic Network Process (see [7]).

The ANP approach seems to be very appropriate instrument for project portfolio management. Another issue is the appropriate selection of clusters, which would be the basis of the basic model and their fulfillment by system elements. Another specific problem is the creation of sub - networks in the ANP model characterizing the specific important circumstances of the model. The current economic environment is characterized by significant changes. An important problem of the model will be to capture the dynamics that would represent appropriate change

The ANP method is suitable for the determination of priorities in network systems where there are different types of dependencies between the elements of the system. Time dependent priorities play an increasingly important role in a rapidly changing environment of network systems. Long-term priorities can be based on time dependent comparisons of system elements. Short-term predictions can be based on using of compositional data exponential smoothing. A hybrid procedure that combines the advantages of both approaches is proposed.

The structure of the ANP model for dynamic project portfolio (DPP) is described by clusters of elements connected by their dependence on one another. A cluster groups elements (projects, resources, criteria, time) that share a set of attributes. At least one element in each of these clusters is connected to some element in another cluster. These connections indicate the flow of influence between the elements (see Fig. 2).

The ANP model consists of four basic clusters with their elements and influences:

A. Projects

This cluster consists of potential alternatives of projects of which will be selected a dynamic portfolio. There are priorities among projects for inclusion in the portfolio. The cluster has connections to all other clusters.

B. Resources

Resources are necessary for the implementation of projects. Main resources are human resources between which are relations important for creating project teams. The cluster has connections to all other clusters.

C. Criteria

Projects are evaluated according to criteria which include benefits, opportunities**,** costs, and risks (BOCR**)**. The cluster has connections to all other clusters.

D. Time

Time is measured in discrete units. Elements of other clusters vary in time and theirs values depend on the values in previous time periods.

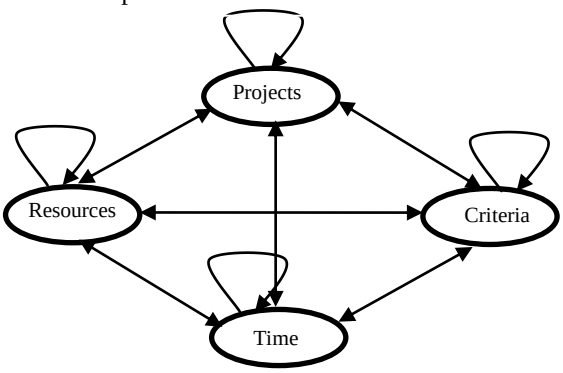

Fig. 2. Flows of influence between the elements.

E. Sub-Networks

The basic ANP model is completed by specific sub-networks. The sub-networks are used to model important features of the DPP problem. The most important features in our ANP-based framework for DPP management are captured in sub-networks:

- dynamic flow of projects,
- time dependent resources.

F. Dynamic Flow of Projects

Project opportunities come in time and it is necessary to decide which will be accepted for creating a dynamic portfolio of projects and which will be rejected. The sub-network connects clusters: time and projects.

G. Time Dependent Resources

A specific sub-network is devoted to model time dependent amounts of resources. The time dependent amount of resources is given by. The sub-network connects clusters: time, resources and projects.

IV. Dynamics of ANP Method

An important characteristic of project portfolio management is dynamics. Time dependent priorities in the ANP model can be expressed by forecasting using pairwise comparison functions (see [8]) or by predictions based on using of compositional data exponential smoothing (see [9]).

A. Time-Dependent Comparisons

Dynamic extensions of ANP method can work with time-dependent priorities in a networked system. There are two approaches for time-dependent pairwise comparisons:

- structural, by including scenarios
- functional by explicitly involving time in the judgment process.

For the functional dynamics there are analytic or numerical solutions. The basic idea with the numerical approach is to obtain the time dependent principal eigenvector by simulation (see [8]).

Judgment matrix in dynamic form

$$A(t)=\begin{pmatrix} a_{11}(t) & a_{12}(t)\dots & a_{1k}(t) \\ a_{21}(t) & a_{22}(t)\dots & a_{2k}(t) \\ \vdots & \vdots & \vdots \\ a_{k1}(t) & a_{k2}(t) & a_{kk}(t) \end{pmatrix}.$$

Forecasting using pairwise comparison functions brings a problem with keeping the consistency of paired comparisons. A procedure based on exponential smoothing was designed, which is suitable for short-term predictions (Raharjo *et al*., 2009).

B. Compositional Data Analysis

The compositional data are everywhere, where we need to work with data containing only relative information, which is useful for working with weights. Time series for compositional data were analysed (see [10]).

The following operations are defined on the simplex space (see [11])

$$S^k=\left\{x=(x_1,x_2,\dots,x_k),x_i>0,i=1,2,\dots,k,\sum_{i=1}^{k}x_i=1\right\}$$

C. Closure Operator

For any vector

$$x=(x_1,x_2,\dots,x_k)\in R_+^k$$

$$C(x)=\left(\frac{x_1}{\sum_{i=1}^{k}x_i},\frac{x_2}{\sum_{i=1}^{k}x_i},\dots,\frac{x_k}{\sum_{i=1}^{k}x_i}\right).$$

D. Perturbation

For any two vectors from simplex space $X,Y\in S^k$

$$x\oplus y=C(x_1y_1,x_2y_2,\dots,x_ky_k)\ .$$

E. Power Transformation

For any vector from simplex space $X\in S^k$ and $\alpha\in R_+$

$$\alpha\otimes x=C\left(x_1^{\alpha},x_2^{\alpha},\dots,x_k^{\alpha}\right)$$

F. Difference

$$x\ominus y=x\oplus(-1\otimes \mathrm{y})$$

Exponential smoothing with compositional data can be

used for predicting weights in a short time.

$$w_t = (w_{t1}, w_{t2}, \ldots, w_{tk}), w_{ti} > 0, i = 1, 2, \ldots, k, \sum_{i=1}^{k} w_{ti} = 1$$

G. Simple Exponential Smoothing

Vector of observations at time *t*

$$x_t = (x_{t1}, x_{t2}, \ldots, x_{tk}), x_{ti} > 0, i = 1, 2, \ldots, k, \sum_{i=1}^{k} x_{ti} = 1,$$

elements of simplex space.

Vector of predictions at time *t*

$$y_t = (y_{t1}, y_{t2}, \ldots, y_{tk}), y_{ti} > 0, i = 1, 2, \ldots, k, \sum_{i=1}^{k} y_{ti} = 1,$$

elements of simplex space.

The formula for simple exponential smoothing of compositional data:

$$y_t = \alpha \otimes x_{t-1} \oplus (1-\alpha) \otimes y_{t-1} .$$

H. Double Exponential Smoothing

Classical double exponential smoothing (see [12]) is generally useful for trend modelling. We introduce for trend modeling a vector of trend values u_t, a vector of slopes v_t, a smoothing constant $0 \le \alpha \le 1$, a trend constant $0 \le \beta \le 1$.

Formulas for double exponential smoothing of compositional data:

$$u_t = \alpha \otimes x_t \oplus (1-\alpha) \otimes (u_{t-1} \oplus v_{t-1}),$$

$$v_t = \beta \otimes (u_t \ominus u_{t-1}) \oplus (1-\beta) \otimes v_{t-1},$$

$$y_t = u_{t-1} \oplus v_{t-1}.$$

V. Hybrid Procedure

For the prediction of time-dependent priorities ANP method we propose a hybrid procedure that combines the benefits of long-term forecasting of pairwise comparison functions and short-term weight predictions using exponential smoothing compositional data. This procedure also mutually enriches both procedures obtaining more accurate data. Both procedures were presented in the previous sections and here we limit ourselves to a brief summary of the hybrid procedure steps.

Step 1: Formulation of pairwise comparison functions.

Step 2: Testing and improving consistency of pairwise comparisons.

Step 3: Collection of historical data by ANP priorities over time.

Step 4: Using of compositional exponential smoothing.

Step 5: Selection of the best coefficient α, β with lowest value of error.

Step 6: Forecasting of priorities for next time periods.

Step 7: Re-formulation of pairwise comparison functions based on short-run model. Go to Step 2.

VI. Conclusion

The paper presents a proposed methodology for dynamic project portfolio management. The basic ANP model with clusters (projects, resources, criteria and time) was created. The proposed ANP model captures the relationships between the clusters and their elements. An important factor of the ANP model is time. The paper proposes a hybrid procedure for time-dependent priority setting. The procedure is based on a combination of pairwise comparison functions and exponential smoothing. The methodology is verified on the projects of an engineering company. The experimental results will affect the specification, completing and extending the model.

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