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The Ex Ante Risk Assessment in the Project in Interval Analysis Description

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Abstract. Ongoing enterprise projects often have a unique and unrepeatable character. Referring to future solutions, their results may be different from their assumptions and aims. The uncertainty and its description is usually the main problem in quantitative risk estimation goals. Mathematical methods for taking into account the impact of uncertainty are based on the following attempts: deterministic with elements of statistical analysis, stochastic, using fuzzy logic and using interval computations. In risk analysis, the following areas of risks are usually taken into account: project milieu, client and contract, suppliers, maturity of the organization, project characteristics and project team. The aim of the paper is the *ex ante* risk assessment of the project based on six partial risks specified in the scope of project milieu (client, terms and conditions of the contract, suppliers, maturity of an organization, scope of the project, project team) with application of the interval analysis arithmetic for description of uncertainty.

Introduction

The analysis of risk for projects is not easy to realize in a quantitative form. One of the interesting and useful forms of the quantitative ex ante assessment was proposed by K. Bradley [1]. Application and generalization of the Bradley's method using the risk-list method for risk-assessment in the project was done by the authors in [2,3].

The uncertainty existing in realization of projects is difficult to include in quantitative risk estimation. Mathematical models used for its description are based on the following four attempts: deterministic with elements of statistical analysis, stochastic, using fuzzy logic or using interval computations. Statistical analysis and interpretation was applied by the author for the identification of stage phase growth [4] or for the non-parametric assessment of uncertainty in the analysis of airfoil blade traces [5]. The application of fuzzy logic attempt for the description of uncertainty for the *ex ante* risk assessment in the project was discussed by the authors in [6]. There are combined statistical-fuzzy logic attempts, as it is presented in [7].

The theoretical background of interval arithmetic was formalised in the 60s of the XX century. In this theory, the real value is identified with individually defined range on the real axis. The basic arithmetic operations such as summation, subtraction, multiplication and division can be defined. Moreover, the elementary functions can be defined and used in the interval analysis description [8]. The authors applied the interval arithmetic to choose the values of a dynamical damper [9] or to identify the stage phase in companies [10].

In the article, a comparison is made of the results obtained by the application of the interval analysis with the results obtained by the application of statistic and the fuzzy logic attempts for the *ex ante* risk assessment in the project.

Such an analysis may be very useful in many industrial and research fields, in which there is a high uncertainty of activities and the associated high level risk of failure, e.g. heat flow [11], hydraulics of heavy-duty machines [12, 13], surface layer enhancement [14], designing of materials [15, 16] and biomaterials [17]. It should be particularly advantageous in the case of such risky activities as biotechnology [18, 19] or with such fuzzy and unreliable data as in any case where the human factor is involved [20, 21].

Total risks and partial risks in the project

Analyses of risk were conducted in many scientific disciplines. In 1964, D.B. Hertz introduced the notion of risk in the context of analysis of uncertainty concerning capital investments [22]. It is worth noting that in 1921, F. Knight pays attention to identify the two notions, namely uncertainty and risk. In his fundamental work entitled *Uncertainty and Profit,* F. Knight separated the *sensu stricto* unmeasurable uncertainty from measurable uncertainty, namely the risk [23, 24].

Risk identification in a project is a dynamic process and requires determining the time of identification. In a project, a risk assessment may be performed:

- *ex ante*, which involves the anticipation of probability and effects of risk occurrence in a project. *Ex ante* risk assessment conducted at an initial stage of project preparation bears impact on a decision to take up implementation of a project,
- *on-line*, refers to ongoing monitoring or partial risks assessed in an initial phase of project implementation as well as identification of new ones, which occurred during its implementation,
- *ex post*, which concerns the final risk assessment connected with closing a project.

The *ex ante* assessment of risk in a project gives the possibility of real management of partial risks in an initial phase of preparation, as well as during the implementation of a project.

To take into account the external proximal project milieu, the following six areas are quantitatively rating: partial risk connected with a client, terms and conditions of a contract, suppliers, as it was proposed by K. Bradley [1] and generalized and applied by the author [2, 6].

Interval analysis

Interval analysis based on interval arithmetic is a mathematical theory whose methods give possibility to desribe uncertainty in the value of a generalised number. The uncertainity is taken into account by defining the lower limit a_{min} and upper limit a_{max} of the value *[a]* defined in form (1). Hence, the real (point) value has interval arithmetic interpretation as the point range *[a]=[a,a]*.

$$[a] = [a_{\min}, a_{\max}] = \{a \in R : a_{\min} \le a \le a_{\max}\} \tag{1}$$

The distance between interval elements can be defined in form (2). In this case, a set of all the real compact ranges of the real set with metrics (2) builds a complete metric space.

$$q([a],[b]) = \max\{|a_{\min} - b_{\min}|, |a_{\max} - b_{\max}|\} \tag{2}$$

The arithmetic operations can be defined for the elements of an interval set [8]. Especially operations of summation, used in the analysis, are defined in form (3).

$$[a]+[b]=[a_{\min}+b_{\min},a_{\max}+b_{\max}] \tag{3}$$

Comparable analysis

Application of the above mentioned Bradley's concept related to the six areas [1] is a useful method of ex ante risk analysis in the project. The formulated criteria are related to the following six areas: client, terms and conditions of the contract, suppliers, maturity of the organization, scope of the project and project team. Bradley orders the approval of applicable weight for each of the criteria w_i , at the same time proposing the scope of variability of value of these weights. In such a formulation, the value of total project risk coefficient *RP* is designated according to formula (4), where r_i are values describing the partial risks ($N = 1,\ldots,6$). They are taking values from the range [0,4].

$$RP=\frac{\sum_{i=1}^{N}w_i r_i}{\sum_{i=1}^{N}w_i} \tag{4}$$

The obtained value of total project risk coefficient *RP* is a basis for classification of a project as a project with: (Bradley, 2003):

- low risk – for the value of resulting coefficient below 2.0;
- moderate risk - for the value of resulting coefficient from the division [2.0, 2.2];
- high risk - for the value of resulting coefficient from the division [2.2, 2.6];
- very high risk - for the value of resulting coefficient above 2.6.

Table 1. Partial and total risk interval assessment

No	**Area of risk estimation**	w_i	r_i
1	Client	0.075	[2,3]
2	Terms and conditions of the contract	0.080	[1,2]
3	Suppliers	0.130	[2.4]
4	Maturity of the organization	0.100	[2,3]
5	Scope of the project	0.375	[1,3]
6	Project team	0.240	[1,3]
	Total project risk estimation coefficient RP	**-**	**[1.31,3.05]**

The analysis was performed following the acceptance of values of partial risks given in Table 1, which are equivalent to those analyzed in the articles [2, 6].

The performed analysis which uses interval analysis allows for the designation of complete project risk assessment, such as the average value of partial risks, to the mid value of the range equal to range of the value of 2.18, which in the descriptive interpretation means moderate risk. The same linguistic description of risk is applied in the risk-list method and by application of the fuzzy logic attempt.

Summary

Quantitative *ex* ante risk assessment may be a very useful tool for managers during realization of a project, especially a technical one. A difficult and important problem in estimation is the way of taking into account uncertainty in the obtained values of quantitative score of some criterion. Among a few attempts, application of the interval arithmetic is a convenient solution.

Results of analyses show the same quantity and descriptive (moderate risk) results of risk assessment after the application of a risk-list method with statistical attempt (2.12) [2], the fuzzy login one (2.13) [6] and the interval one (2.18). The fact of sensitivity results of the analyses on the length of the assumed ranges for partial risk estimation parameters should be kept in mind during the application of interval description.

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