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MULTIATTRIBUTE ANALYSIS OF INVESTMENT RISKS IN CONSTRUCTION

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ABSTRACT

The risk of investment in a construction objects is an important decision leading to the project success. The decision-making process, based on the established risk assessment principles expressed in linguistic terms, requires qualitative judgement and experiential knowledge of the construction experts. Presented structured and realistic model deals systematically with different risk management situations and assist the investors in reaching the correct risk assessment of possible alternatives will be of great value. This paper presents a method of multiattribute comparativite analysis of variants of investment classified risks in construction. A practical case to illustrate how the model works is presented.

KEYWORDS

SAW, investment risks, classification, multiattribute analysis

1. INTRODUCTION

Investment risk managing theory allows planning investment problems. Managing the risk of investments means presence of an effective control for all procedures in any phase of the project, when varying factors are taking place, which influence the realization of the project. In most cases, any investment project possesses several parameters of efficiency. Conditions of investor works continuously change assessment. For this reason rules of investment projects quality at this moment can be based only on the investor's leadership politics. The principle of quality valuation is based on the intuition and experience of the decision maker.

A role of a risk valuation during decision-making becomes particularly essential. Various methods for such problems solution are known. SAW [2] method is applied (a method of simple additive weighing) to the designation of investments risk in construction in the given work. The offered method was successfully applied for the building projects assessment. Different methods of multi-purpose choice of effective resource-saving investment are applied to select alternative, from the certain set of possible variants. For the majority of the problems solutions (TOPSIS - „Technique for Order Preference by Similarity to Ideal Solution“[1]; SAW [3]; COPRAS [6, 7]; LINMAP, „Linear programming techniques for Multidimensional Analysis of Preference“[4, 5], etc.) the cardinal (numerical) information is used. However, in praxis there are problems for which description the ordinal (serial) information or the information of both characters is necessary at the same time. Practical problems of the building investment project are solved at presence or absence of data on the importance of efficiency parameters.

2. SIMPLE ADDITIVE WEIGHING (SAW) METHOD

Calculations are carried out according to algorithm SAW shown on figure 1.

Stage 1. Decision-making matrix's forming.

$$P = \begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_m \end{array} \begin{array}{c} \begin{array}{cccc} x_1 & x_2 & \dots & x_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{array}, \quad (1)$$

Where: m – number of alternatives; n – number of attributes.

$i = 1,...,m$; $j = 1,...,n$.

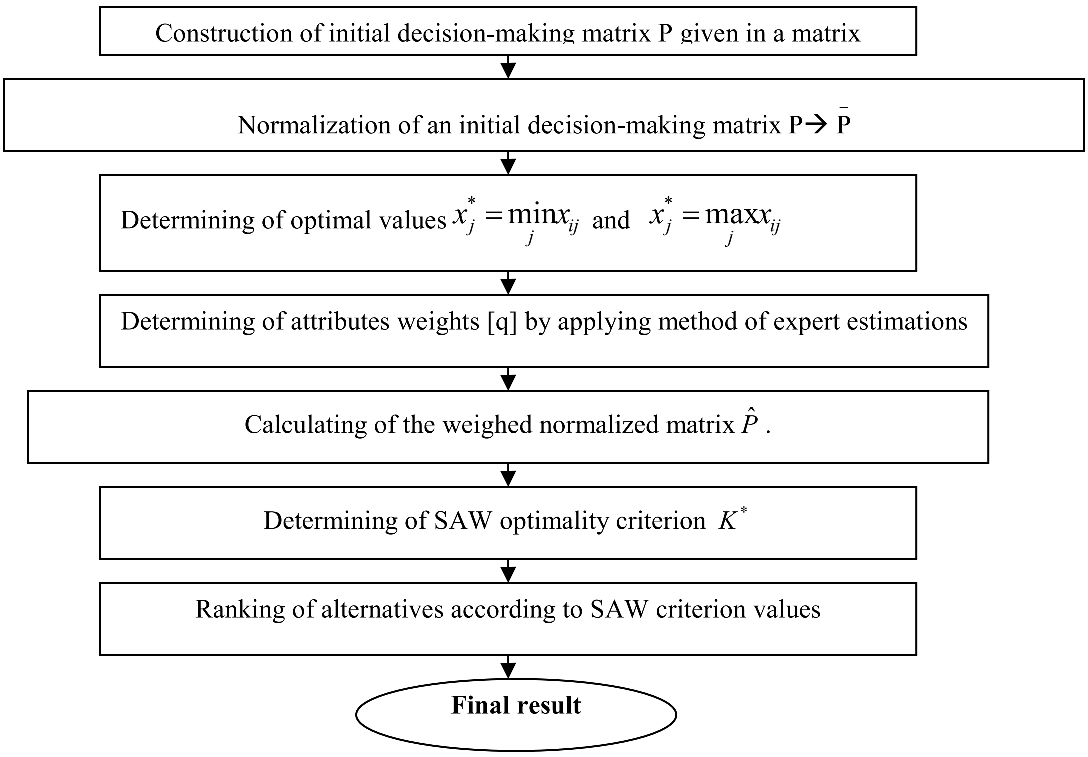

Figure 1. The block the scheme of algorithm SAW for defying a rank of risk for alternative investments

We find the best values of each parameter according to the formula (2)

$$x_j^* = \min_j x_{ij}\text{, if preferable is minimum of } j^{th} \text{ attribute,}$$
$$x_j^* = \max_j x_{ij}\text{, if preferable is maximum of } j^{th} \text{ attribute.} \quad (2)$$

Stage 2. Performing normalization of the decision making matrix. The normalization values of normalized decision making matrix $\overline{P}$ are calculated according to the formula (3)

$$\overline{x}_{ij} = \frac{x_{ij}}{\max_j x_{ij}}\text{, if preferable value of the } j^{th} \text{ attribute is maximum,}$$
$$\overline{x}_{ij} = \frac{\min_j x_{ij}}{x_{ij}}\text{, if preferable value of the } j^{th} \text{ attribute is minimum.} \quad (3)$$

Stage 3. Defining weighted normalized matrix $\hat{P}$. Values of the $\hat{P}$ matrix are calculated multiplying values of $\overline{P}$ matrix by corresponding weights of significances of each attribute:

$$\hat{P} = \begin{bmatrix} q_1\overline{x}_{11} & q_2\overline{x}_{12} & \dots & q_n\overline{x}_{1n} \\ q_1\overline{x}_{21} & q_2\overline{x}_{22} & \dots & q_n\overline{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ q_1\overline{x}_{m1} & q_2\overline{x}_{m2} & \dots & q_n\overline{x}_{mn} \end{bmatrix} \quad (5)$$

Stage 4. Defining efficiency criterion for each alternative:

$$K_i = \frac{1}{n}\sum_{j=1}^{n}\hat{x}_{ij}\text{ , } i = 1,\dots,m\text{ ; } j = 1,\dots,n\text{ .} \quad (6)$$

Optimum variant and ranks of the alternatives are established by size K_i.

$$K^* = \left\{ a_i \middle| \max_i \sum_{j=1}^{n} q_j\overline{x}_{ij} \right\}\text{ ,} \quad (7)$$

$$i = 1,\dots,m\text{ ; } j = 1,\dots,n\text{ ; } \sum_{j=1}^{n} q_j = 1\text{ .}$$

After parameters are defined, it is necessary to estimate its weights. The expert method of pair comparison is applied to determine of attributes Saaty [5] for this purpose.

It is known, that in a basis of human perception of surrounding reality, the decomposition and synthesis present. While studying any system, the person makes its decomposition to subsystems. Having revealed attitudes between subsystems makes its synthesis. Decomposition of a problem is made on the basis of the risk qualifier (presented in the form of table 1). We make the synthesis by applying SAW method.

To determine a priority it is recommended to use an importance scale which was offered by Saaty [5]. The group valuation can be considered enough reliable only in the case, when opinions of interrogated experts are consentaneous. Therefore, investigating the information received from experts statistically, it is necessary to valuate a coordination of their opinions and to determine the information heterogeneity reasons [8]

3. THE MEASUREMENT OF INVESTMENT RISK IN CONSTRUCTION METHOD

There are different types of risk in construction. The analysis of investment projects risk covers the basic types of risk:

- Technological risk. (Designing mistakes; Lacks of technologies; Management Mistakes; The Lack of the qualified labor);
- Constructional risk;

A - the period before the termination of construction work. (Delays in construction; Default liability of the supplier);

B- the period after the termination of construction work (Quality of production; Quality of management; Product realization).

- Financial risk. (Inconstancy of economy in the country; Inflation; the Situation of payment failure in any sphere of manufacture);
- Political risk. (Changes in tax system; Changes of legislative system);
- Ecological risk. (Operating troubles);
- Lacks of legislative system;
- Legal risk. (Incompatibility of laws; Discrepancies in the documentation).

4. CASE STUDY: DETERMINATION OF THE MOST SUITABLE ALLTERNATYVE FOR INVESTMENTS

An example of the implementation of the proposed method is included provided below and will provide the reader with a better understanding of the proposed methodology.

The investment company engaged in investments considered five possible alternatives of investments into construction of different objects. Projects have various volumes of investments and complexity of realization:

1. Very big and very complicated object - A first alternative;
2. Two complicated objects - A second alternative;
3. Three objects of average complexity - A third alternative;
4. Six objects of average complexity – A fourth alternative;
5. Eleven simple objects - A fifth alternative.

The aim of the investor is to assess a risk level of projects and to choose one and the most effective project

After some iterations, as final classes of solutions for a valuation investment risk problem there were chosen (table 1):

- *The Highest category of quality*: investors all obligations performance is practically assured, the credit line is opened for the investor, and the limit of crediting is established.
- *High category of quality:* the in-depth analysis of company activity and the investment project shows high probability of the borrower (investor) performance of all contracted obligations.
- *Satisfactory category of quality:* the investor can have some difficulties with performance of contracted obligations.
- *Low category of quality:* the investor can have the certain difficulties with performance of treaty obligations.
- *Unprofitable category of quality:* the investor is not capable to make repayment of the basic duty independently.

Realization of risk classification in possible investment projects on all levels of the multi-purpose quality description. Firstly, the risk level at the second level of hierarchy is defined. The valuation of parameters occurs on a scale of risk definition (from 0 up to 9). Further an orderliness of parameters and classification of risks on top-level hierarchies takes place. The final result - by the received quantitative results the most comprehensible project is defined. As a whole the analysis of the investment risk project by the SAW method is carried out in 3 stages. According to the calculations presented in the article, the most comprehensible from possible alternatives wads chosen 5th variant, i.e. eleven simple objects.

Table 1. The result table of experts' interrogation - a matrix of decision-making

				q	a_1	a_2	a_3	a_4	a_5
10	**Technological risk**	x_1	Mistakes of designing	*0.0411*	7	6	5	3	2
11		x_2	Lacks of technologies	*0.0365*	5	4	4	2	1
12		x_3	Erroneous calculation of capacity	*0.0350*	5	4	3	2	2
13		x_4	Mistakes of management	*0.0328*	7	4	5	2	1
14		x_5	Shortage of the qualified labour	*0.0321*	7	5	5	3	2
15		x_6	Failure of building materials delivery	*0.0318*	4	3	2	2	1
16		x_7	Non-observance by contractors	*0.0314*	5	4	3	2	1
17		x_8	Changes in prices of materials and	*0.0313*	4	3	2	2	1
18		x_9	Increase in charges at a wages	*0.0308*	5	4	3	2	2
19		x_{10}	Increase in the prices of equipment	*0.0306*	3	2	2	1	1
	Construction								
21	***A- Period Before Termination of construction works***	x_{11}	Delays in construction	*0.0305*	7	6	4	2	2
22		x_{12}	Default from obligations of the supplier	*0.0305*	5	4	2	2	1
23		x_{13}	Stop of civil work on fault of the	*0.0302*	5	4	2	2	1
24		x_{14}	Risk of building materials shortage	*0.0299*	3	2	2	1	1
25		x_{15}	Availability of the contractor	*0.0299*	3	3	2	2	1
31	***B-Period after termination of construction works***	x_{16}	Quality of production	*0.0291*	3	4	5	6	6
32		x_{17}	Quality of management	*0.0289*	4	3	3	5	6
33		x_{18}	Realization of production	*0.0289*	5	4	3	5	6
34		x_{19}	Export – import	*0.0288*	6	5	4	6	7
35		x_{20}	Losses	*0.0282*	4	3	2	2	1
36		x_{21}	Transport	*0.0281*	4	3	3	2	3
37		x_{22}	Deliveries	*0.0277*	6	5	4	5	6
38		x_{23}	Incomparability of equipment	*0.0277*	6	5	3	2	1
41	*Financial risk*	x_{24}	Inconstancy of economy in the country	*0.0276*	4	3	3	2	2
42		x_{25}	Inflation	*0.0274*	5	5	4	4	5
43		x_{26}	Situation payment delay in what or	*0.0274*	4	3	2	1	1
51	*Political risk*	x_{27}	Changes in tax system currency	*0.0268*	4	4	2	2	2
52		x_{28}	Changes on sales and the customs control	*0.0268*	6	5	3	2	1
53		x_{29}	Changes of legislative system	*0.0267*	6	5	4	3	2
61	*Ecological risk*	x_{30}	Lacks of legislative system	*0.0267*	6	5	4	3	2
62		x_{31}	Failures	*0.0263*	5	4	3	4	5
63		x_{32}	Change of a position of the state on	*0.0249*	5	4	3	2	1
71	Legal risk	x_{33}	Incompatibility of laws	*0.0242*	6	6	5	4	3
72		x_{34}	Discrepancies in the documentation	*0.0234*	5	4	3	2	1
			Optimization direction for all attributes is minimum						
			K_i		**1**	**2**	**3**	**4**	**5**
					0.42	**0.41**	**0.57**	**0.63**	**0.89**
			Ranks of alternatives		4	5	3	2	1

5. CONCLUSION

In conditions of market attitudes, an introduction of technical innovations and acceptance of effective decisions is necessary. Some courageous, not trivial decisions increase risk, however it does not mean, that it is necessary to avoid risk. It is necessary to be able to valuate a degree of risk and to operate it. The general conceptual approach for managing the investment risk in construction consists of following stages:

a) Revealing possible consequences of investment activity in a risky situation;

b) Development of measures which are not supposing, preventing or reducing damage from influence up to the end of not considered risky factors, unforeseen circumstances;

c) Such risk consideration system realization in business, where not only negative probable results can be neutralized or compensated, but also maximum chances of the high income are used.

Multi-objective risk assessment of investment in construction model was created. According to this model it is possible to solve problems of risk operation and management.

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