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MULTI-ATTRIBUTE ANALYSIS OF INVESTMENTS RISK ALTERNATIVES IN CONSTRUCTION

Galina Shevchenko[1], Leonas Ustinovichius[2], Algirdas Andruškevičius[3]

Department of Building Technology and Management,
Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mail: [1]galina@st.vgtu.lt

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Abstract. In project development it is hardly possible to get exhaustive and accurate information. As a result, the situations occur, the consequences of which can be very damaging to the project. Inaccurate evaluation of the strategy related to capital investment and project implementation is one of the reasons why such estimates are not required in practice. Instead, a classification approaches may be used for this purpose. 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 methods 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 methods of multiattribute comparativite analysis (CLARA and SAW methods) of variants of investment classified risks in construction. A practical case to illustrate how the methods works is presented.

Keywords: expert system, decision-making, verbal analysis methods, methods of solving multicriteria classification problems.

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1. Introduction

Organizational and technological complexity of construction projects generates enormous risks. Investment risk managing theory allows planning investment problems (Ustinovichius and Kochin 2003; Nedzveckas and Rasimavichius 2000; Tamošiūnienė *et al.* 2006). 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.

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The principle of quality valuation is based on the intuition and experience of the decision maker (Ustinovicius *et al.* 2008b; Ustinovicius 2004).

In practical use task of getting expert knowledge in many cases can be formulated like task of classification, because expert intelligence is to sort objects (alternatives, state of object) through classes of decision. For example engineer analyzing breakdown in sophisticated technical system defines possible type of failure. Elements formatting some whole to be classified may have different origin. It can be different physical objects, cases of choice or condition of some object (Ustinovicius *et al.* 2006; Zavadskas *et al.* 2006, *etc*).

Describing the method of prescription of the object to a certain class of decision is complicated because of inverbality of the strategy expert uses. Anyway, these inverbal skills are effectively and promptly used, when expert solves task of classification in his sphere of knowledge. Classification is a very important aspect in decision making (Ustinovichius *et al.* 2008a, 2007a, 2007b; Ustinovichius and Kochin 2003; Ustinovichius 2004; Larichev *et al.* 2002). One of the tasks preparing base for classification is setting of numerous criteria (attributes), which are able to describe any object. Scale of all criterion is formed by setting finite set of possible values (Ustinovicius *et al.* 2008b). If in certain task scale of values of one or more criteria is infinite, it can be modified to finite by cutting it to finite set of intervals. Finally, on the base of expert knowledge must be organized classification of definite intervals and its components i.e. must be formulated rules according which any object can be prescribed to one of the predefined classes. Classified projects are described by assessing various efficiency criteria that could be both qualitatively and quantitatively expressed.

A role of a risk valuation during decision-making becomes particularly essential (Ustinovichius *et al.* 2006; Ustinovichius *et al.* 2008b; Ustinovichius and Kochin 2003; Vaidogas 2007). 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 (LINMAP, TOPSIS, SAW, ZAPROS (ЗАПРОС), ORKLASS (ОРКЛАСС), PARK (ПАРК), CIKL (ЦИКЛ), etc. (Ларичев, Мошкович 1996; Ларичев 2000; Асанов *et al.* 2001; Arditi and Gunaydin 1998; Srinivasan and Shocker 1973) the qualitative or quantitative 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.

Various methods for such problems solution are known (Figueira *et al.* 2005; Turskis *et al.* 2006; Turskis 2008; Viteikienė and Zavadskas 2007; Ginevičius 2008; Podvezko 2006; Viteikienė 2006). Multi-attribute decision-making methods have different characteristics (Triantaphyllou 2000; Šaparauskas and Turskis 2006). In this article, we present CLARA and SAW (Ustinovichius *et al.* 2007b; Ustinovichius *et al.* 2008b) methods to multi-attribute comparative analysis of investments risk alternatives in construction in the given work. The offered methods was successfully applied for the building projects assessment.

2. The data of the problem

The problem may be formally represented in the following way:

1. G is the property satisfying the target criterion of the problem;

2. $K = \{K_1, K_2, ..., K_Q\}$ is a set of evaluating criteria of an object;
3. $S_q = \{k_1^q, ..., k_{w_q}^q\}$ for q=1,...,Q is a set of estimates based on the criterion K_q, w_q is the number of graduation marks on the scale of the criterion K_q; the scales are arranged in the order of distinctness of the property G;
4. $Y = S_1 \times S_Q$ is the state space of the objects to be classified. Every object is described by a number of estimates based on the criteria $K_1, ..., K_Q$. In this way, a set of alternatives $\{y_1, y_2, ..., y_L\}$ is defined, where $L = |Y| = \prod_{q=1}^{Q} w_q$ is cardinality of a set Y, (the number of alternatives);
5. $C = \{C_1, C_2, ..., C_M\}$ is a set of classes to be obtained by breaking down the set Y^a, which should be arranged in the ascending order of distinctness of the property G (in the class C_{n+1} this property is more distinct, while in the class C_n it is less distinct);
6. $Y^a \subseteq Y$ is a set of *admissible* real objects.

Since the estimates based on each criterion are ordered, then, the scale showing the order of classes S_q can be compared with the numerical scale $B^q = \{1, 2, ..., w_q\}$, where $b_i^q < b_j^q$, if b_i^q is less preferable for a decision maker (DM), then b_j^q.

The information of the DM preferences determines the relationships of rigorous preference (or dominance) P^0 in the set Y:

$$P^0 = \left\{ (y_i, y_j) \in Y \times Y \middle| \forall q \in K \; b_i^q \geq b_j^q \wedge \exists q^0 : b_i^{q^0} > b_j^{q^0} \right\}$$

implying that the alternative $x \in Y$ is dominant over the alternative $y \in Y$.

On the other hand, it is known that the classes of solution are ordered for the DM. It means that any alternative belonging to the class n+1 is more preferable for the DM than any alternative of the class n. This is shown by the following binary preference relationship in the set Y:

$$P^1 = \{ (y_i, y_j) \in Y \times Y | y_i \in Y_k, y_j \in Y_l, k > l \}.$$

It can be assumed that none of the vector estimates in the set Y, dominating over the given one, should be referred to a less preferable class. This statement is known as the "hypothesis of distinctness". It can be formally expressed as follows:

$$(y_i, y_j) \in P^0 \Rightarrow (y_j, y_i) \notin P^1. \quad (1)$$

Definition. Breaking down a set of vector estimates Y into the M ordered classes is consistent if the condition (1) is *satisfied* for any $y_i, y_j \in Y$.

Based on the preferences of decision maker, it is *required* to construct a consistent representation of $F : Y^a \rightarrow \{Y_l\}$, $l = 1, 2, ..., M$, such that

$Y^a = \bigcup_{l=1}^{M} Y_l ; Y_l \cap Y_k = 0$ where $k \neq l$, Y_l is a set of the vector estimates from Y, assigned to the class C_l.

3. The analysis of verbal decision methods for classification of alternatives

In this chapter some most frequently used verbal ordinal classification methods are considered. Let us consider several most commonly used methods in more detail.

ORCLASS (Ларичев 2000) This method (Ordinal CLASSification) allows us to build a consistent classification, to check the information and to obtain general decision rules. The method relies on the notion of the most informative alternative, allowing a great number of other alternatives to be implicitly assigned to various classes. ORCLASS takes into account possibilities and limitations of the human information processing system.

Method assessment: The main disadvantage of the method is low effectiveness due to the great number of questions to DM needed for building a comprehensive classification.

CLARA (Ustinovichius *et al.* 2008a, 2007a, 2007b). This method (CLAssification of Real Alternatives) is based on ORCLASS, but is designed to classify a given subset rather than a complete set of alternatives (*Y* space). Another common application of CLARA is classification of full set with large number of exclusions, i.e. alternatives with impossible combinations of estimations. In both cases CLARA demonstrates high effectiveness.

DIFCLASS (Ларичев 2000). This method was the first to use dynamic construction of chains covering *Y* space for selecting questions to DM. However, the area of DIFCLASS application is restricted to tasks with binary criteria scales and two decision classes.

CYCLE (Асанов *et al.* 2001). CYCLE (Chain Interactive Classification) algorithm overcomes DIFCLASS restrictions, generalizing the idea of dynamic chain construction to the area of ordinal classification task with arbitrary criteria scales and any number of decision classes. The chain here means an ordered sequence of vectors $\langle x_1, ..., x_d \rangle$, where $(x_{i+1}, x_i) \in P$ and vectors x_{i+1} and x_i differ in one of the components.

Method assessment: As comparisons demonstrate, the idea of dynamic chain construction allows us to get an algorithm close to optimal by a minimum number of questions to DM necessary to build a complete classification. The application of ordinal classification demonstrates that problem formalization as well as introduction of classes and criteria structuring allows solution of classification problems by highly effective methods.

Nowadays, computer software can assist many management techniques like sensitivity analysis and improve the efficiency of the analyzing process. Computer simulation packages are thought to be more realistic than theoretical calculations. The method/program CLARA can be successfully applied to classification of investment projects when the decision classes and the criteria used are thoroughly revised.

4. A method of comprehensive order classification

First stage, the alternatives of the set *Y* are numbered in the specified order (Ustinovichius 2004; Ustinovichius and Kochin 2003; Korhonen *et al.* 1997). In this case, it is valid that $y_i > y_j \Rightarrow i < j$. This preliminary numbering ensures that a particular alternative is considered when all the alternatives dominant over it had been already analysed.

The use of the hypothesis of distinctness (1) allows us to considerably reduce the number of questions to an expert, required to make the classification.

Let us denote by G^i a set of class numbers $Y_l\,(1 \le l \le M)$, admissible for the vector estimate $y_i \in Y$. Before questioning the DM (an expert), $G^i = \{1, 2, ..., M\}$ is assumed for $\forall y_i \in Y$, because we do not have any information about the expert's preferences. Finally, it is required that all G^i consist of only one element.

Suppose that the expert decided that the vector estimate $y_i \in Y$ should belong to the class $Y_l\left(1 \le l \le M\right)$, according to its global quality. Following the hypothesis of distinctness, in this case a vector estimate, described by a number of the criteria values, which are not less preferable for an expert, cannot belong to a less preferable class.

Similarly, a vector estimate, described by a number of the criteria values which are not more preferable that those of y_i, cannot belong to a more preferable class.

Consequently, the data, relating only to one vector estimate of Y, which were elicited from an expert, can result in the reduction of the sets G^i, corresponding to other vector estimates. In this way, in a particular case, vector estimates can be referred to a particular class of vector estimates without being submitted to an expert.

It is necessary to take into consideration the possibility of referring a particular vector to a particular class. The indicator p_{il} (assessing the possibility of referring the vector y_i to the class Y_l) shows the proximity of the vector considered to the members of this class because the vectors of the same class usually make compact groups in multidimensional space. To calculate pil, the normalized distance between the vector y_i and the center of the class C_k can be used.

Relying on two indicators, p_{il} and G^i, a unified quantitative estimate of the informativity of any not estimated state Φ can be obtained:

$$\Phi_i = f\left(\left\{p_{il}, g_{il} \middle| l \in G^i\right\}\right), \tag{2}$$

where f is a certain real function, g_{il} is the number of vectors from Y whose membership of a particular class becomes known (i.e. cardinal number of the respective set of the class numbers G^i is equal to one) if the expert refers the vector yi to the class Y_l.

A subset of the alternatives Y_g for which the set G^i of the admissible classes contains more than one element is determined. If Y_g is empty, pass on to stage 7 (Ustinovichius *et al.* 2006):

The algorithm of CLARA method includes this stages:

1. The indicators p_{il} are calculated for all the alternatives from Y_g and g_{il} is determined for $\forall l \in G^i$;
2. The indicators p_{il} are found from the formula;
3. Based on the above indicators, the amount of information of the vector $y_i - \Phi_i$ is determined;
4. $y_i \in Y_g : \Phi_i = \max\limits_{y_j \in Y_g} \Phi_j$ is determined;
5. The above vector is submitted to an expert to be referred to one of the classes;
6. The sets G^i are modified in accordance with the class specified to the vector by the expert. Pass on to stage 1;
7. The procedure is completed.

The detailed algorithm of CLARA method is presented in Fig. 1.

5. Simple additive weighing (SAW) method

Calculations are carried out according to algorithm SAW shown on Fig. 2.

Stage 1. Decision-making matrix's forming.

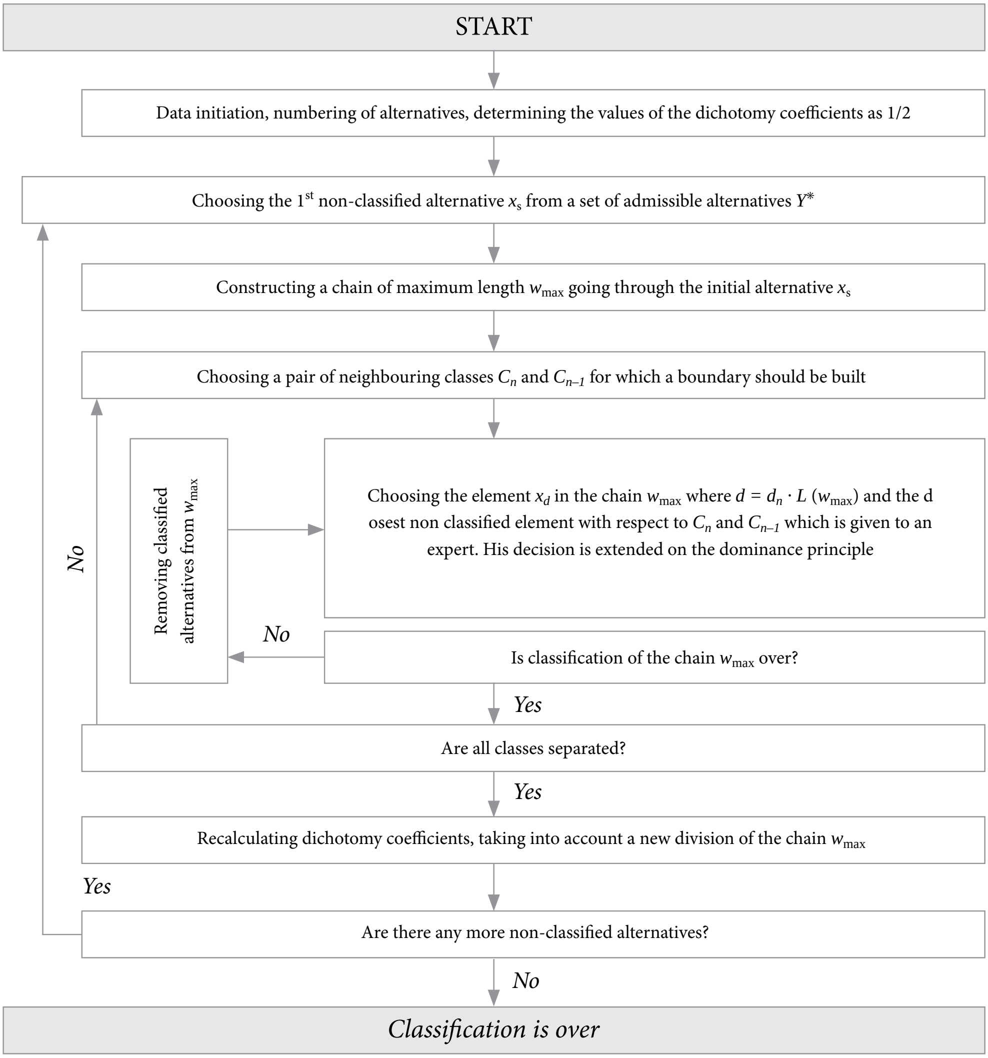

Fig. 1. A general block-diagram of the algorithm CLARA

$$P = \begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_m \end{array} \begin{array}{c} \begin{array}{cccc} x_1 & x_2 & \dots & x_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{array}, \qquad (3)$$

where: m – number of alternatives; n – number of attributes.
$i = 1, ..., m;\ j = 1, ..., n.$

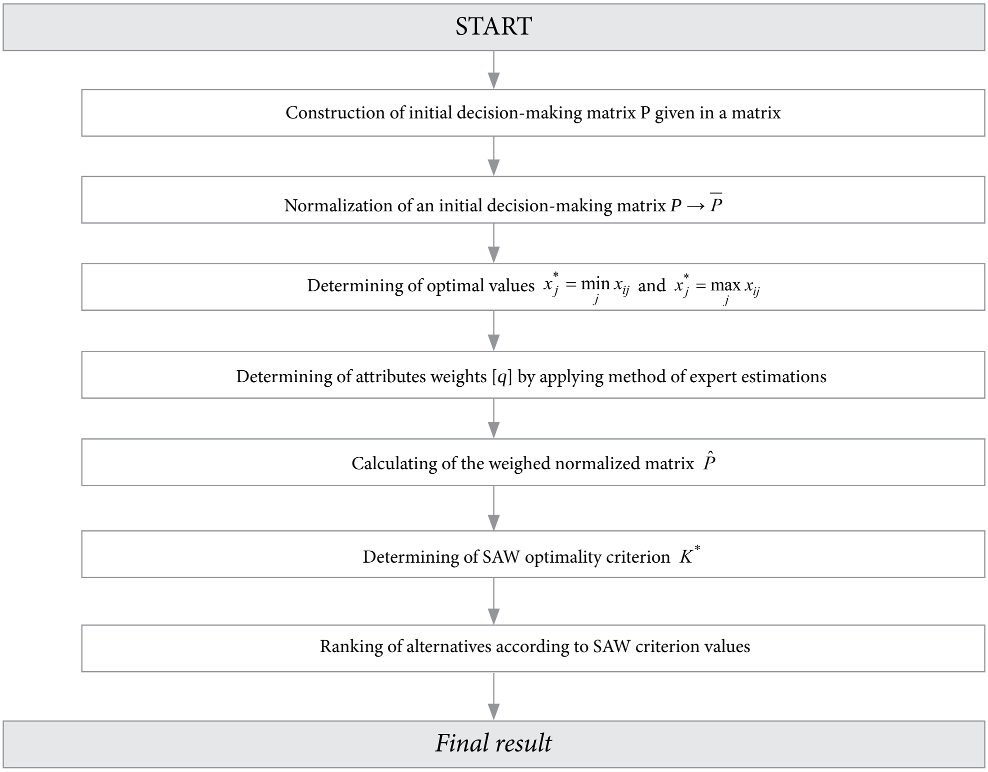

Fig. 2. The block the scheme of algorithm SAW for defying a rank of risk for alternative investments

We find the best values of each parameter according to the formula (4)

$$\begin{aligned} x_j^* &= \min_j x_{ij}, \text{ if preferable is minimum of } j^{th} \text{ attribute,} \\ x_j^* &= \max_j x_{ij}, \text{ if preferable is maximum of } j^{th} \text{ attribute.} \end{aligned} \tag{4}$$

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 (5)

$$\begin{aligned} \overline{x}_{ij} &= \frac{x_{ij}}{\max_j x_{ij}}, \text{ if preferable value of the } j^{th} \text{ attribute is maximum,} \\ \overline{x}_{ij} &= \frac{\min_j x_{ij}}{x_{ij}}, \text{ if preferable value of the } j^{th} \text{ attribute is minimum.} \end{aligned} \tag{5}$$

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:

$$\hat{P} = \begin{bmatrix} q_1\bar{x}_{11} & q_2\bar{x}_{12} & \dots & q_n\bar{x}_{1n} \\ q_1\bar{x}_{21} & q_2\bar{x}_{22} & \dots & q_n\bar{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ q_1\bar{x}_{m1} & q_2\bar{x}_{m2} & \dots & q_n\bar{x}_{mn} \end{bmatrix}. \quad (6)$$

Stage 4. Defining efficiency criterion for each alternative:

$$K_i = \frac{1}{n}\sum_{j=1}^{n}\hat{x}_{ij}, \; i = 1, ..., m; \; j = 1, ..., n. \quad (7)$$

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

$$K^* = \left\{ a_i \left| \max_i \sum_{j=1}^{n} q_j \bar{x}_{ij} \right. \right\}, \; i = 1, ..., m; \; j = 1, ..., n; \; \sum_{j=1}^{n} q_j = 1 \cdot \quad (8)$$

After parameters are defined, it is necessary to estimate its weights. The expert method of pair comparison is applied to determine of attributes Saaty (Saaty 1994) 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 (Saaty 1994). 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 (Завадскас 1987).

6. The measurement of investment risk in construction projects

There are different types of risk in construction (Ustinovichius *et al.* 2007b; Vaidogas 2007). 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).

7. Method CLARA for investment risks level evaluation

Many researchers (Zavadskas and Vilutienė 2006; Kaklauskas *et al.* 2007; Ustinovichius and Kochin 2003, Ustinovichius *et al.* 2007a, 2006, 2007b; Turskis *et al.* 2006; Ziari and Khabiri 2007; Podvezko 2006; Turskis 2008; Zavadskas and Turskis 2006, etc) have pointed out that in construction it is essential to be able to take into account the impacts of cultural, social, moral, legislative, demographic, economic, environmental, governmental and technological change, as well as changes in the business world on international, national, regional and local real estate markets. Every construction project is unique and each has different risk allocation, capital requirements, management teams, construction methods etc. All these factors could affect project cost, and thus it is necessary to identify and analyse the risks associated with project budget and realization.

After a few iteration series expert (DM) can choose final decisions – Final class decisions (Fig. 3). Detailed description of these groups is provided in the first hierarchy level. Further the classification of the possible investment project risks must be established taking into consideration all levels of their multi-purpose quality descriptions -second hierarchy level. During that quality of the received results must be checked as well.

Such risk evaluation work course is received following the drawn scheme – *evaluations of the second hierarchy level criteria → evaluations of the first hierarchy level criteria → risk level.*

Risk level might be established using the composed classificator, but a lot of criteria must be compared. It is a very difficult task for any person (for expert too), besides it takes a lot of time. Therefore, it is possible to use computer program CLARA (classification of real alternatives). This method (program) allows evaluating constructional investment project according to accurately established classes with the respectful offered criteria for risk size evaluation.

Classificator establishment course. Data input into the program.

1 Stage – For second hierarchy level evaluation criteria are introduced (Fig. 4):

- Criterion 1 – qualified labour force;
- Criterion 2 – supply of construction materials;
- Criterion 3 – designing mistakes;
- Criterion 4 – course of the constructional works.

Criteria evaluation classes:

- Class A – high;
- Class B – average;
- Class C – low.

Criteria 1–4 are chosen for evaluation of technical – technological risk. While analysing two projects (2 alternatives) the expert determines where the chosen labour force is qualified enough, where permanent continuous supply of materials will be ensured during the construc-

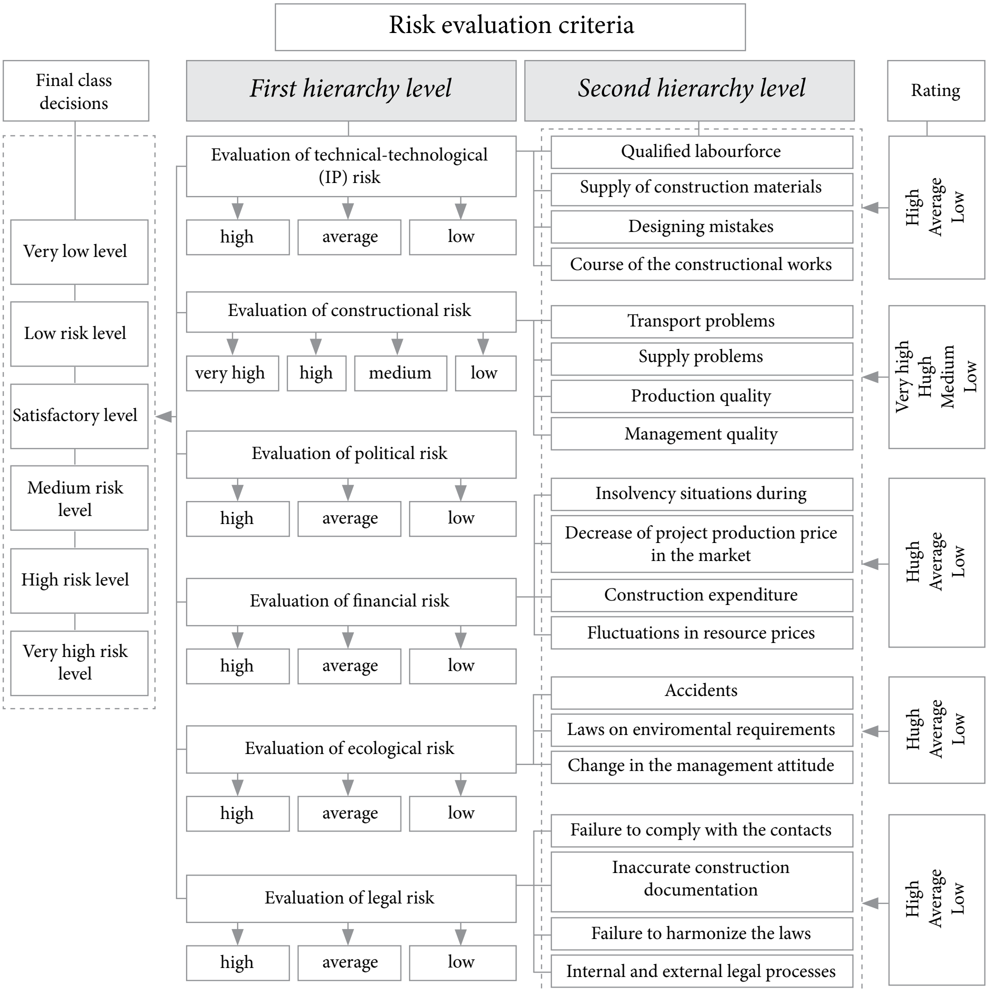

Fig. 3. The classifikator of investment risks level evaluation

tion, what is the estimated course of works. After the project is analysed, it is determined if there are no mistakes in it. Other stages are input adequately to stage 1.

Classification implementation in the program. After introducing all the criteria that will be taken into consideration while evaluation 2 investment alternatives, the last stage is performed, i.e. the criteria are compared. The comparison (Fig. 5) is made in the following way: the program selects one evaluation of each criterion and composes their combinations. The expert assigns the available evaluation combination to the respectful class.

When the assigning is finished, a transfer is made to the next stage (by pushing the button "NEXT"). Another evaluation combination is provided. This is done up to a moment, until all the combinations are allotted to the respectful class.

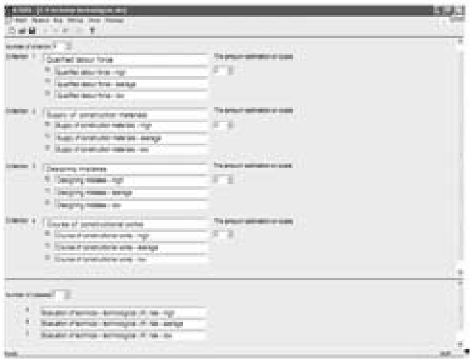

Fig. 4. Data input into the program

Fig. 5. Evaluation of the alternative

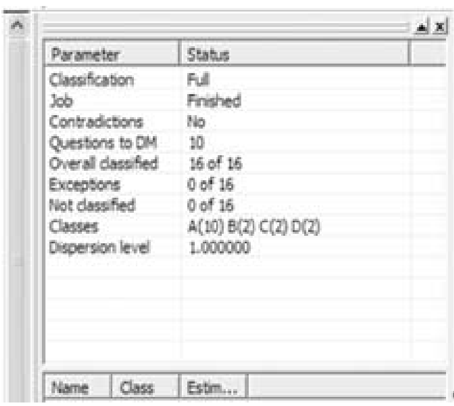

Fig. 6. The data of program

Fig. 7. Data base (I hierarchy level)

During the work the expert might make a mistake or change his opinion, therefore, contradictions might appear in his answers.

In such case, the program shows a warning that contradictions have occurred and it will ask to confirm the new answer or to change it.

After the work is finished, the program saves all the data, perform analysis and shows the number of the given DM questions, the number of eliminated combinations. It also shows how many of evaluates combinations were allotted to classes A, B or C (Fig. 6). Evaluating of all second hierarchy level criteria are established in an analogous way.

Final solving analysis. The final analysis is performed according to the evaluations of the first hierarchy level. After the final analysis is performed, we get evaluation data, i.e. we establish risk levels (Fig. 7).

8. Application of SAW method to multi-attribute comparative analysis of investments risk alternatives

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 multipurpose 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.

9. Conclusions

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

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 (subcontractors) of terms of construction	*0.0314*	5	4	3	2	1
17		x_8	Changes in prices of materials and energy carriers	*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 risk								
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 contractor	*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 sphere of manufacture	*0.0274*	4	3	2	1	1
51	***Political risk***	x_{27}	Changes in tax system currency transactions	*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 changes in the project	*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

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.

Investment risk in construction can be evaluated efficiently enough using CLARA method. This method allows to classify all possible constructional investment projects presented by evaluations on the predefined criteria into several accurately defined classes reflecting the project risk level. The algorithm CLARA (Classification of Real Alternatives) is based on the dichotomy of the alternatives chains, beginning with the longest chain.

Combination composition idea allows to receive an algorithm close to optimal according to the minimal amount of the DM (Decision Maker) questions.

Criteria of the classificatory and the evaluations are introduced into verbal decision analysis support system CLARA, which allows to perform criteria combination classification rather quickly. After all the above mentioned actions are performed, the person who wants to evaluate the investment risk, it is enough to introduce the respectful evaluations into the composed program data base and the program will provide the result – the risk level.

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STATYBOS ALTERNATYVŲ INVESTICINĖS RIZIKOS DAUGIATIKSLĖ ANALIZĖ TAIKANT SAW IR CLARA METODUS

G. Ševčenko, L. Ustinovičius, A. Andruškevičius

Santrauka

Šiame straipsnyje nagrinėjamos daugiatikslės analizės metodų taikymo galimybės. Svarbus investicijų efektyvumo garantas yra nuodugni investicinių projektų analizė ir vertinimas. Tai leidžia pagal tam tikrus kriterijus nustatyti investavimo variantų efektyvumą. Vertinimo kriterijai turi būti grindžiami tiek investicinį projektą įgyvendinančio subjekto, tiek investuotojo interesais. Analizuojant investicinius procesus yra susiduriama su įvairaus pobūdžio informacija – kokybinė ir kiekybinę. Šiame straipsnyje yra siūlomi du metodai, analizuojantys (įvertinantys) investicinę riziką – SAW ir CLARA metodai. Pateikti metodų pritaikymo rezultatai.

Reikšminiai žodžiai: ekspertinės sistemos, sprendimų priėmimas, verbalinės analizės metodai, CLARA, SAW.

Galina ŠEVČENKO. PhD student in Construction Technology and Management Department.Vilnius Gediminas Technical University. Research interests: risk management, decision-making theory, automation in design, expert systems.

Leonas USTINOVIČIUS. Doctor Habil, Professor, Chairman of laboratory of Construction Technology and Management. Vilnius Gediminas Technical University. Doctor (1989), Doctor Habil (2002). Publication: more than 150 scientific papers. Research interests: building technology and management, decision-making theory, automation in design, expert systems.

Algirdas ANDRUŠKEVIČIUS. Doctor, Associate Professor, Dept of Building Technology and Management. Vilnius Gediminas Technical University. Doctor of Science (1984). Research interests: building technology and management. Author of more than 110 papers.