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CLASSIFICATION OF REAL ALTERNATIVES AND ITS APPLICATION TO THE INVESTMENT RISK IN CONSTRUCTION

INTRODUCTION

Risk is an integral element of any economic project. It is impossible to avoid, therefore, it is necessary to be able to estimate and minimize it. Any investment in construction can be risky. The basic purpose of risk analysis might be formulated as follows: to give to potential partners of the project the facts on the issue related to making a decision whether to participate in the project and which method to choose so that financial losses are avoided [14].

A superficial assessment of the risk related to capital investment is one of the reasons why investment is not necessarily successful in practice.

Making a reliable qualitative analysis of the investments is a complicated task, since the criteria for assessing the probability of capital recovery have not been established yet. There are many factors that should be taken into account [12; 13]. Each of these factors influences the probability of capital recovery.

Classification is a very important aspect of decision making. It is the process of assigning projects to particular classes. Claims are often made that classes in decision making are determined by individual parameters, i.e. efficiency of technical and technological decisions, project credit value determination etc. It is hardly possible to achieve this process (of assigning projects to particular classes) without employing special techniques in multi-criteria environment [1; 5; 9; 11]. This article presents a verbal method of determining investment risk in construction. The problem under consideration consists in assessing investment projects depending on their level of risk.

Formally, the problem is stated as multicriteria classification. In fact, many different methods for solving multicriteria classification problems are widely known. The ORCLASS method, as an ordinary classification, was one of the first methods designed to solve these kinds of problems [3]. Then more recent methods appeared, such as DIFCLASS [4] and CYCLE methods [6].

A new way to solve the problem is offered – application of the CLARA method (Classification of Real Alternatives) [5]. The method is based on Verbal Decision Analysis approach. In this article methods of verbal analysis are disclosed, their value is analyzed and it is indicated in what cases these methods could be used depending on their productivity. A hierarchical approach for consideration of efficiency indicators is proposed. The efficiency of the method is proved. The procedure of applying the method for the problem in question in practice is described.

1. FORMAL PROBLEM STATEMENT

Investment risk management is a common practice of any bank providing loans for projects. The evaluation of credit risk should be made at various phases of the project [1]. It may be stated that risk management implies that all the procedures should be rigorously followed at any phase of the project, the risk exposure depending on the output and accuracy.

Given:

1. G – a feature, corresponding to the target criterion (e.g. treatment effectiveness).
2. $K = \{K_1, K_2, \dots, K_N\}$ – a set of criteria, used to assess each alternative (course of treatment).
3. $S_q = \{k_1^q, \dots, k_{w_q}^q\}$ – for $q = 1, \dots, N$ – a set of verbal estimates on the scale of criterion K_q , w_q – the number of estimates for criterion K_q ; estimates in S_q are ordered based on increasing intensity of the feature G .
4. $Y = S_1 \times \dots \times S_N$ – a space of the alternative features to be classified. Each alternative is described by a set of estimates obtained by using criteria K_1, \dots, K_N and can be presented as a vector $y \in Y$, where $y = (y_1, y_2, \dots, y_N)$, y_q is an index of estimate from set S_q .
5. $C = \{C_1, \dots, C_M\}$ – a set of decision classes, ordered based on the increasing intensity of feature G .

A binary relation of strict dominance is introduced:

$$P = \left\{ (x, y) \in Y \times Y \mid \forall q = 1 \dots N \begin{matrix} x_q \geq y_q \\ \exists q_0 : x_{q_0} > y_{q_0} \end{matrix} \right\} \quad (1)$$

One can see that this relation is anti-reflexive, anti-symmetric and transitive. It may be also useful to consider a reflexive, anti-symmetric, transitive binary relation of weak dominance Q :

$$Q = \{ (x, y) \in Y \times Y \mid \forall q = 1 \dots N, x_q \geq y_q \} \quad (2)$$

Goal: To create, on the basis of the DM's preferences, an imaginary F : $Y \rightarrow \{Y_i\}$, $i = 1, \dots, M$, where Y_i – a set of vector estimations belonging to class C_i , satisfying the condition of consistency:

$$\forall x, y \in Y : x \in Y_i, y \in Y_j, (x, y) \in P \Rightarrow i \geq j \quad (3)$$

2. ANALYSIS OF VERBAL DECISION METHODS FOR CLASSIFICATION OF ALTERNATIVES

In this chapter some most frequently used verbal ordinal classification methods are considered. All these methods belong to Verbal Decision Analysis group and have the following common features [2; 9]:

1. The attribute scale is based on verbal description not changing in the process of solution, when verbal evaluation is not converted into the numerical form or score.
2. An interactive classification procedure is performed in steps, where the DM is offered an object of analysis (a course of treatment, for example). An object is presented as a small set of rankings. The DM is familiar with this type of description, therefore he or she can make the classification based on his or her expertise and intuition.
3. When the DM has decided to refer an object to a particular class, the decisions are ranked on the dominance basis. This provides the information about other classes of objects related to it by the relationship of dominance. Thus, an indirect classification of all the objects can be made based on a single decision of the DM.

4. The set of objects dominating over a considered object are referred to as the domination cone. A great number of objects have been classified many times. This ensures error-free classification. If the DM makes an error violating this principle, he or she is shown the conflicting decision on the screen and is prompted to adjust it.
5. In general, a comprehensive classification may be obtained for various numbers of the DM's decisions and phases in an interactive operation. The efficiency of multicriteria classification technique is determined based on the number of questions to the DM needed to make the classification. This approach is justified because it takes into consideration the cost of the DM's time and the need for minimizing classification expenses.

Let us consider several most commonly used methods in more detail.

ORCLASS [4; 6]. 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 the DM needed for building a comprehensive classification.

CLARA [5]. 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 [4]. 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 [6]. *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. A "chain" means here an ordered sequence of vectors $\langle x_1, \dots, x_d \rangle$, 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 obtain an algorithm close to the optimal by a minimum number of questions for the 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.

The method can be successfully applied to classification of investment projects when the decision classes and the criteria used are thoroughly revised.

3. RISK DETERMINATION AND DESCRIPTION OF THE OPERATIONAL FACTORS OF INVESTMENT PROJECT

After a few iteration series the following final decisions were chosen:

1. a) the lowest risk level,
b) low risk level.
2. a) satisfactory risk level,
b) average risk level.
3. a) high risk level,
b) the highest risk level.

Detailed description of these groups is provided below:

1. Group "evaluation of technical-technological IP risk" is composed of: qualified labour force, supply of construction materials, designing mistakes, progress of the construction work.
2. Group "evaluation of constructional IP risk" is composed of: transport problems, supply problems, production quality, management quality.
3. Group "evaluation of political IP risk" – separate criterion.
4. Group "evaluation of financial IP risk" is composed of: insolvency situations during construction, decrease of project production price in the market, construction expenditure, fluctuations in resource prices.
5. Group "evaluation of ecological IP risk" is composed of: accidents, laws regarding environmental requirements, change in the management attitude towards the project.
6. Group "evaluation of legal IP risk" is composed of: failure to comply with the contracts, inaccurate construction documentation, failure to coordinate the laws, internal and external legal processes.

Next, the classification of the possible investment project risks must be established taking into consideration all levels of their multi-purpose quality descriptions. During that phase the quality of the received results must be checked as well.

First, classification of the factors described on the second level is established. Quality class consists of common evaluations of the first hierarchy level. After classification these common evaluations are filled with concrete contents. Afterwards classification of the first level factors is provided. Final result consists of rules for solving investment project risk evaluation problem.

The DM can establish investment project risk taking into consideration the available classification. It should be noted that only factors from the first hierarchy level might be employed. If difficulties occur while assigning evaluations, the DM creates a second, more accurate level. Moreover, there is a possibility to use the second hierarchy level for separately selected first level factors.

We suggest a way to establish the risk of the construction investment project employing verbal analysis, using CLARA method, which is based on classification that allows evaluating construction investment project by the decision made according to the accurately established classes taking into consideration the respective criteria for risk size evaluation.

The idea of dynamic construction of the links allows for acquiring an algorithm close to the optimal based on the minimal numbers of questions for the DM necessary for establishing the whole classification.

4. CLARA (CLASSIFICATION OF REAL ALTERNATIVES)

A classifier, consisting of risk evaluation criteria and final class decisions, is compiled for establishing investment project risks (Figure 1) [2]. Constructional investment project risk evaluation criteria are provided on the first and second criteria levels.

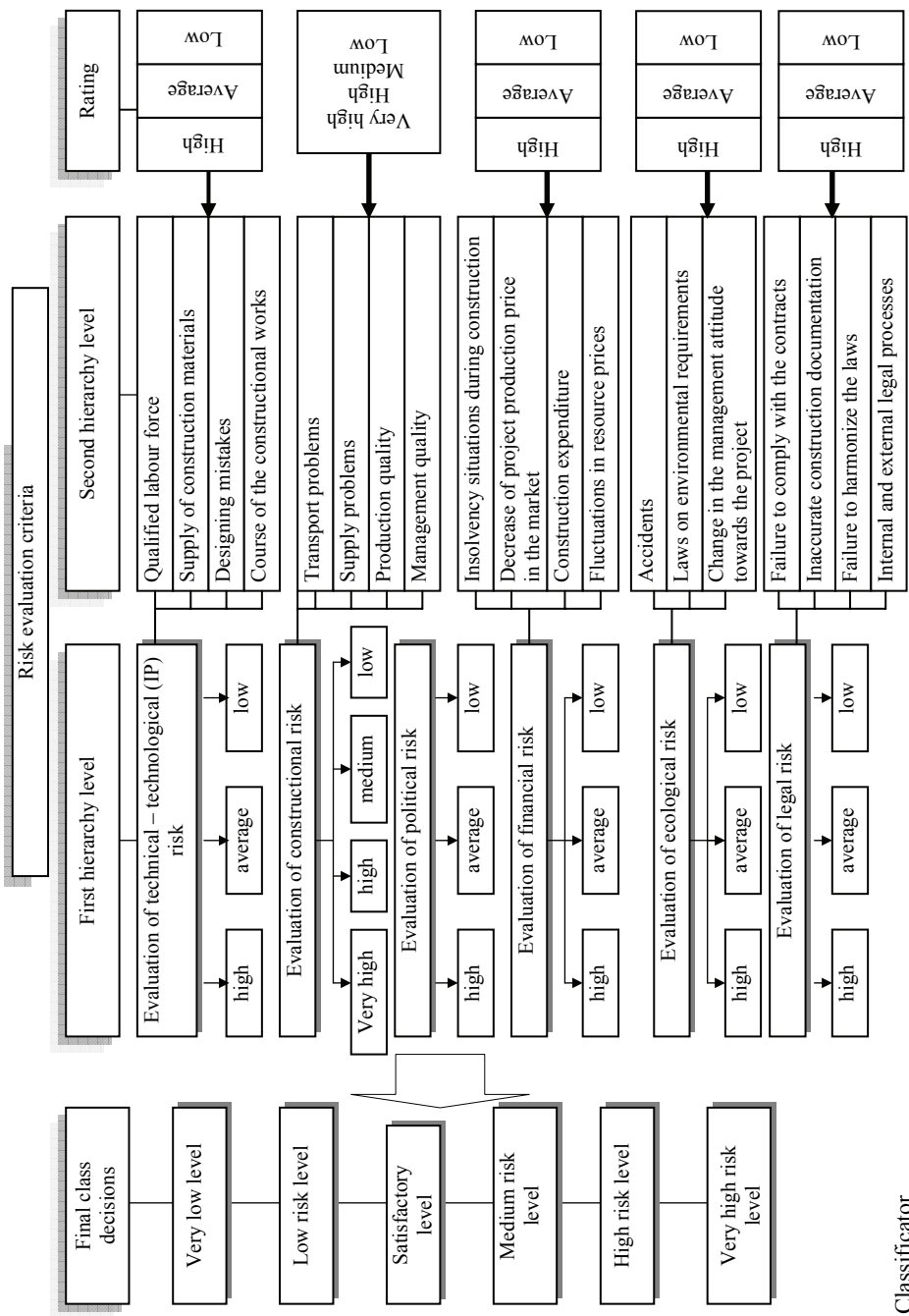


Fig. 1. Classifier

A construction investment project is evaluated by taking into consideration:

- Technical-technological risk
 - Constructional risk
 - Financial risk
 - Political risk
 - Ecological risk
 - Legal risk
- } First hierarchy
level criteria

First hierarchy level is the main one. Construction investment project risk can be evaluated according to the criteria of this level. Each first hierarchy level criterion is assigned an evaluation: low, average, high or very high. When the evaluations are introduced, the result is obtained, i.e. risk levels are established.

These criteria (first level) are not always sufficient for establishment of constructional investment project risk level. Therefore, each first hierarchy level criterion is split into lower level criteria. This way the second hierarchy level is created. Criteria of the second hierarchy level are necessary for performing an accurate analysis (each risk type is analysed) [2].

The following risk evaluation scheme is obtained:

Evaluations of the second hierarchy level criteria \Rightarrow Evaluations of the first hierarchy level criteria \Rightarrow risk level.

Risk level might be established using the composed classifier, but many criteria must be compared. It is a very difficult task for any person, and takes much time. Therefore, it is possible to use the computer program CLARA (classification of real alternatives). This method allows for evaluating construction investment project according to accurately established classes with the respective criteria for risk size evaluation.

Classifier establishment process. Data input into the program

STAGE 1. Evaluation of technical-technological investment project (IP) risk (Figure 2)

For the second hierarchy level evaluation the following criteria are introduced:

- Criterion 1 – qualified labour force.
- Criterion 2 – supply of construction materials.
- Criterion 3 – designing mistakes.
- Criterion 4 – progress of the construction work.

Criteria evaluation classes:

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

Criteria 1-4 are chosen for evaluation of technical-technological IP risk. While analysing two projects (two alternatives) the expert determines whether the chosen labour force is sufficiently qualified, whether constant supply of materials will be ensured during the construction, what is the estimated progress of work. After the project is has been analysed, it is determined if there are any errors in it.

Fig. 2. Criteria for evaluation of technical-technological investment project risk

STAGE 2. Evaluation of constructional investment project risk (Figure 3)

Data input into the program is analogous to the first stage.

- Criterion 1 – transport problems.
- Criterion 2 – supply problems.
- Criterion 3 – production quality.
- Criterion 4 – management quality.

Criteria for evaluating the constructional IP risk are estimated in this stage: during the construction and after the construction.

STAGE 3. Evaluation of financial investment project risk (Figure 4)

Four criteria are used:

- Criterion 1 – insolvency situations during construction.
- Criterion 2 – decrease of project production price in the market.
- Criterion 3 – construction expenditure.
- Criterion 4 – fluctuations in resource prices.

The screenshot shows a software window titled "K/1APA - [1-4 technique technologine.des]". The interface is in Russian. At the top, there is a menu bar with "Файл", "Правка", "Вид", "Метод", "Справка", and "Выход". Below the menu bar is a toolbar with various icons. The main area is divided into two sections. The top section is titled "Number of criterion" and has a value of 4. It lists four criteria, each with three sub-items (0, 1, 2) and a scale estimation field. The criteria are: Criterion 1: Transport problems; Criterion 2: Supply problems; Criterion 3: Production quality; Criterion 4: Management quality. The bottom section is titled "Number of classes" and has a value of 3. It lists three classes: A: Evaluation of constructional investment project risk - high; B: Evaluation of constructional investment project risk - average; C: Evaluation of constructional investment project risk - low. The status bar at the bottom shows "Ready" and "NUM".

Fig. 3. Criteria for evaluation of constructional investment project risk

STAGE 4. Evaluation of ecological investment project risk

Criteria:

- Criterion 1 – accidents.
- Criterion 2 – laws regarding environmental requirements.
- Criterion 3 – change in the management's attitude towards the project.

STAGE 5. Evaluation of legal investment project risk

Criteria:

- Criterion 1 – failure to comply with the contracts.
- Criterion 2 – inaccurate construction documentation.
- Criterion 3 – failure to coordinate the laws.
- Criterion 4 – internal and external legal processes.

Classification is performed when verbal risk evaluation scheme data are put into the program.

The screenshot displays a software window titled "K/ADAP - [1-4 technique technologine.des]". The interface is organized into several sections:

- Number of criterion:** Set to 4.
- Criterion 1:** "Insolvency situations during construction". It includes three sub-items: "Insolvency situations during construction - high", "Insolvency situations during construction - average", and "Insolvency situations during construction - low". A scale estimation of 3 is shown.
- Criterion 2:** "Decrease of project production price in the market". It includes three sub-items: "Decrease of project production price in the market - high", "Decrease of project production price in the market - average", and "Decrease of project production price in the market - low". A scale estimation of 3 is shown.
- Criterion 3:** "Construction expenditure". It includes three sub-items: "Construction expenditure - high", "Construction expenditure - average", and "Construction expenditure - low". A scale estimation of 3 is shown.
- Criterion 4:** "Fluctuations in resource prices". It includes three sub-items: "Fluctuations in resource prices - high", "Fluctuations in resource prices - average", and "Fluctuations in resource prices - low". A scale estimation of 3 is shown.
- Number of classes:** Set to 3.
- Classes:**
 - A: Evaluation of financial investment project risk - high
 - B: Evaluation of financial investment project risk - average
 - C: Evaluation of financial investment project risk - low

The status bar at the bottom indicates "Ready" and "NUM".

Fig. 4. Criteria for evaluation of financial investment project risk

Implementation of classification in the program

After introducing all the criteria that will be taken into consideration while evaluating two available investment projects, the last stage is performed, i.e. the criteria are compared.

The comparison (Figure 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.

For example, if the following combination is taken as input in the program:

1. Qualified labour force – Average.
2. Supply of construction materials – Average.
3. Designing mistakes – High.
4. Progress of the construction work – High.

The expert assigns it to class A – high evaluation.

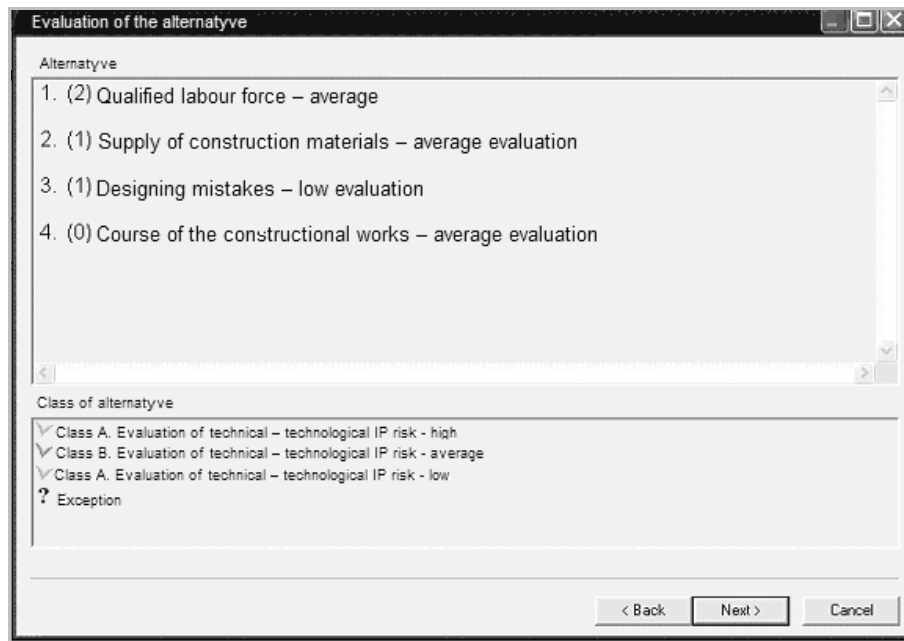


Fig. 5. Evaluation of the alternative

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 until all the combinations are assigned to the respective class.

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.

If the program CLARA is used, all the contradictions are eliminated during the work.

After the work is finished, the program saves all the data, performs analysis and shows the number of the given DM questions, the number of classified combinations and the number of eliminated combinations. It also shows the number of the evaluated combinations assigned to classes A, B or C.

Evaluations of all second hierarchy level criteria are established in an analogous way.

In our case, five available files are processed; their use helps to establish the first and the second levels of investment project risk.

Problem solving analysis

Two construction investment project variants are analysed [11].

Description of the first variant [11]. Two-storey housing block with the garret (6 houses) on the nice site outside the city. The holding is in Trakai region, in Čekeliai village, the size of the holding is eleven hectares, the price of the holding, 60 000 Litas. The self-cost price of the real estate is 2 454 130 Lt.

The expert evaluates the available project according to the respective criteria. The evaluations are put into CLARA program data base:

Evaluation of technical-technological IP risk

After analysing the project we obtain the following evaluation:

- Qualified labour force – average evaluation.
- Supply of construction materials – average evaluation.
- Designing mistakes – low evaluation.
- Progress of the construction work – average evaluation.

When these results are input in the program, we find out that the evaluation of technical-technological IP risk is *average – class B*.

Evaluation of constructional IP risk

- Transport problems – very high evaluation.
- Supply problems – very high evaluation.
- Production quality – high evaluation.
- Management quality – high evaluation.

Evaluation of constructional IP risk *very high – class A*.

Evaluation of political IP risk

Evaluation of political IP risk is *low – class C*. This criterion was not evaluated according to separate criteria groups. The expert immediately assigned low evaluation to it.

Evaluation of financial IP risk

- Insolvency situations during construction – low evaluation.
- Decrease of project production price in the market – average evaluation.
- Construction expenditure – average evaluation.
- Fluctuations in resource prices – average evaluation.

Evaluation of financial IP risk average – class B.

Evaluation of ecological IP risk

- Accidents – high evaluation.
- Laws on environmental requirements – average evaluation.
- Change in the management's attitude towards the project – high evaluation.

Evaluation of ecological IP risk high – class A.

Evaluation of legal IP risk

- Failure to comply with the contracts – high evaluation.
- Inaccurate construction documentation – average evaluation.
- Failure to coordinate the laws – average evaluation.
- Internal and external legal processes – low evaluation.

Evaluation of legal IP risk average – class B.

Data base is provided below. It is directly connected with the criteria classification composed in CLARA program. If a person wants to establish the risk level of the construction investment project, he or she must put the evaluations made by the expert into the data base.

We proceed to the second construction investment project evaluation.

Description of the second variant. Two-storey housing block with the garret (6 houses) on the nice site outside the city. The holding is in Molėtai region, Čivyliai village, the size of holding is seven hectares, the price of the holding, 55 000 Litas. The self-cost price of the real estate is 2 554 000 Lt.

The evaluations of the second project are put into CLARA program data base.

Evaluation of technical-technological IP risk

After analysing the project we obtain the following evaluation:

- Qualified labour force – high evaluation.
- Supply of construction materials – average evaluation.
- Designing mistakes – average evaluation.
- Progress of the construction work – average evaluation.

Evaluation of technical-technological IP risk average – class B.

Evaluation of constructional IP risk

- Transport problems – high evaluation.
- Supply problems – high evaluation.
- Production quality – average evaluation.
- Management quality – low evaluation.

Evaluation of constructional IP risk *average – class C.*

Evaluation of political IP risk

Similarly to the evaluation of the first project, the evaluation of the political IP risk is *low – class C*. This criterion was not evaluated according to separate criteria groups. The expert immediately gave it low evaluation.

Evaluation of financial IP risk

- Insolvency situations during construction – high evaluation.
- Decrease of project production price in the market – average evaluation.
- Construction expenditure – low evaluation.
- Fluctuations in resource prices – average evaluation.

Evaluation of financial IP risk *average – class B.*

Evaluation of ecological IP risk

- Accidents – high evaluation.
- Laws on environmental requirements – low evaluation.
- Change in the management's attitude towards the project – low evaluation.

Evaluation of ecological IP risk *average – class B.*

Evaluation of legal IP risk

- Failure to comply with the contracts – average evaluation.
- Inaccurate construction documentation – low evaluation.
- Failure to coordinate the laws – high evaluation.
- Internal and external legal processes – average evaluation.

Evaluation of legal IP risk *average – class B.*

We proceed with the first hierarchy level of the evaluation of the construction investment project.

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 of both projects, i.e. we establish their risk levels.

We have six first hierarchy level criteria. Criteria evaluation classes are:

- Class A – the lowest risk level.
- Class B – low risk level.
- Class C – satisfactory risk level.
- Class D – average risk level.
- Class E – high risk level.
- Class F – the highest risk level.

Evaluation combination of the first project according to the second hierarchy level evaluations (Figure 6):

- Evaluation of technical-technological IP risk – average.
- Evaluation of constructional IP risk – very high.
- Evaluation of political IP risk – low.
- Evaluation of financial IP risk – average.
- Evaluation of ecological IP risk – high.
- Evaluation of legal IP risk – average.

Result: according to such evaluations the first construction investment project can be assigned to class B – low risk level.

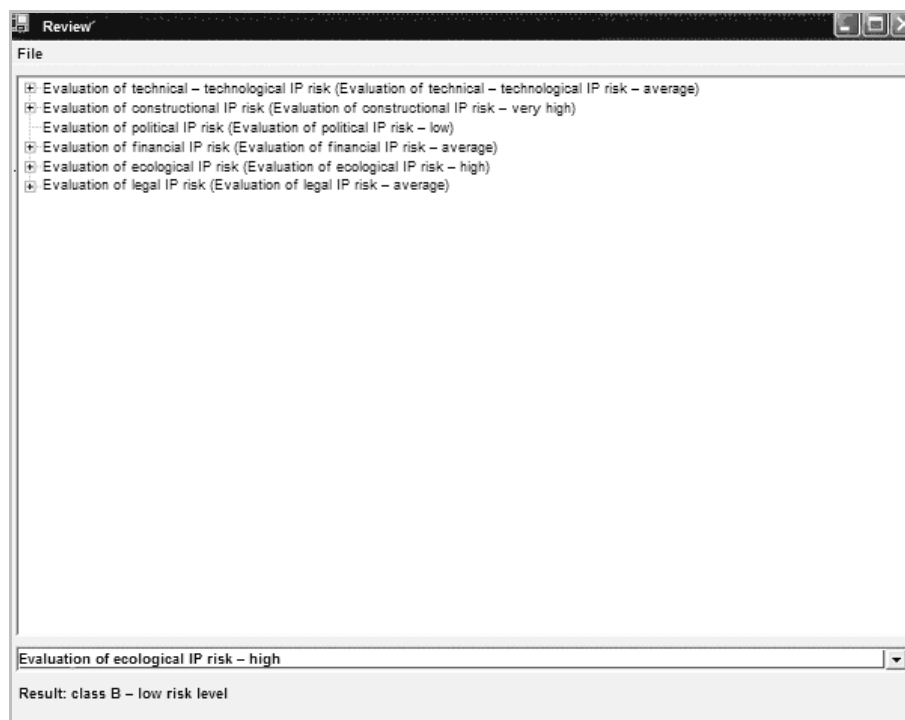


Fig. 6. Data base (first hierarchy level of the first project)

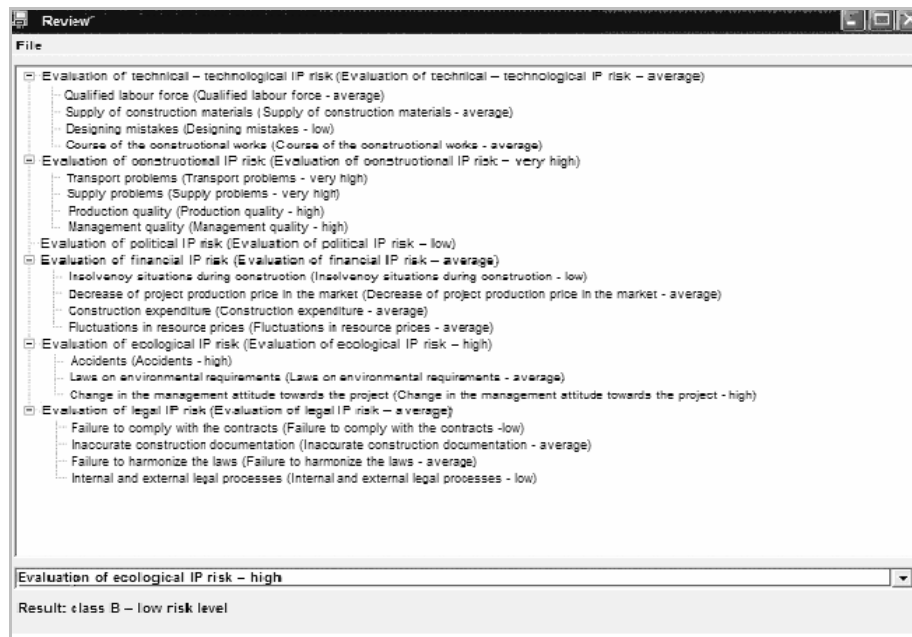


Fig. 7. Data base (second hierarchy level of the first project)

Second project evaluation combination (Figure 8):

- Evaluation of technical-technological IP risk – average.
- Evaluation of constructional IP risk – average.
- Evaluation of political IP risk – low.
- Evaluation of financial IP risk – average.
- Evaluation of ecological IP risk – average.
- Evaluation of legal IP risk – average.

Result: according to such evaluations the second construction investment project is assigned to class C – satisfactory risk level.

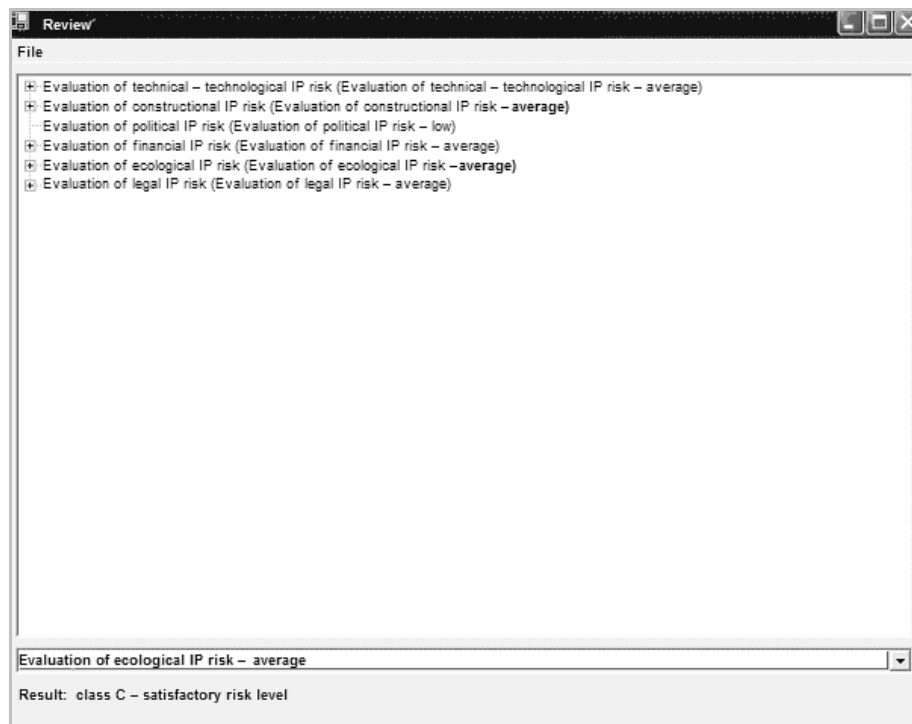


Fig. 8. Data base (first hierarchy level of the second project)

Solution conclusion: after comparing the results obtained we find out that the first project, belonging to class B (low risk level) is less risky than the second project, belonging to class C (satisfactory risk level).

CONCLUSIONS AND SUGGESTIONS

- In practice it is impossible to avoid insufficient and inaccurate information, therefore, unfavourable risky situations occur, the consequences of which can be very damaging to the project. Due to close cooperation of the participants of the project the risk occurring in one stage of the project can transfer to other stages and one type of risk can change into another. This means that chain reaction is characteristic to the risk and it decreases efficiency and safety of any project.

- Various types of risk can be caused by different factors. Classification of risk is determined by efficiency of risk management organisation. Risk classification is understood as risk assignment according to certain features into concrete groups for reaching the set objectives. Conceptually reasoned risk classification allows to define the role of each type of risk in the whole system of all types of risks.
- After reviewing the scientific literature, it is possible to stress that there are many investment project risk evaluation methods, but not all of them are connected by all types of evaluation. This creates difficulties when attempts are made to perform an exhaustive and versatile investment project risk analysis, because often only certain risk evaluation criteria are taken into consideration.
- For establishing the risk of common construction investment project, i.e. for evaluation of all risk factors that influence the efficiency of the project, the available verbal solution analysis methods can be applied. The purpose of these methods is: to determine, in the presence of many problem evaluation criteria, which decision should be made for evaluating the respective problem joining all criteria combinations.
- Investment risk in construction can be evaluated efficiently enough using CLARA method. This method allows to classify all possible construction investment projects presented by evaluations on the predefined criteria into several accurately defined classes reflecting the project risk level. The combination composition idea allows us to obtain an algorithm close to the optimal according to the minimal number of the DM questions.
- The classifier provided in the paper is the main rule for making decisions, evaluating the risk of construction investment projects. It joins factors that influence the probability of risk.
- Criteria of the classifications and the evaluations are introduced into verbal decision analysis support system CLARA, which allows to perform criteria combination classification rather quickly. With all the above-mentioned actions performed, in order to evaluate the risk of the construction investment project it is sufficient to introduce the respective evaluations into the composed program data base and the program will provide the result, that is, the risk level.

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