Risk-Based Thinking and Decision-Making Methods in Conditions of Total Uncertainty

Nikolay Ivanov
Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
E-mail: IvanovNA@mgsu.ru

Abstract. Nowadays globalization, outsourcing and new technologies create the additional risks and uncertainties for organizations. An unclear and complicated reality establishes a new request for additional risk management tools for business. According to the conditions of the economic crisis, the construction industry, like most branches of the Russian economy, lacks financial resources for completing full elimination of inconsistency risks of real construction products with consumer expectations. First of all, this situation is usually for small companies which constantly have financial problems. In such a situation, classical models of nonconformance management, based on CAPA (Corrective and preventive action), become ineffective. There is a need for low-cost but acceptable approaches to management of non-conformities from the point of view of effectiveness. According to the author’s opinion, one of the ways of solving this problem can be the development of heuristic algorithms for the formation of an action plan aimed at reducing the risks of inconsistencies.

1. Introduction
In the scientific and specialized literature there is a general understanding of the term "risk management”. The Russian standard GOST R 53662-2009 defines risk management as "the process of making and executing management decisions aimed at reducing the likelihood of an unfavorable outcome and minimizing possible project losses caused by its implementation" [1]. Hubbard in [2] gives the following definition: "Risk management is the identification, evaluation, and prioritization of the risks, followed by coordinated and economical application of resources to minimize, monitor, and control the probability and / or impact of unfortunate events”.

Based on the above phrases, a few very important properties in risk management can be highlighted. Firstly, risk management is not a momentary act, but should be incorporated into the overall process of managerial decision-making. Secondly, the risk associated with unexpected events, the occurrence of which it is impossible to know in advance with certainty. Thirdly, random events are not important by themselves, but only when consequences of these events adversely affect the performance of the organization. And finally, the result of management effort should be to reduce the negative effect caused by unforeseen events, that is, the realization of economic risk. Answering the question "Why is risk management so critical these days?", the famous American expert in the field of risk management Greg Hutchins points out "Four reasons: Risk is inherent in globalization and outsourcing; Executives don't want to be blindsided, and they feel uncomfortable with uncertainty;
Executives want to manage outcomes and stakeholder expectations; Bottom line: Risk management is preventive and predictive, not reactive" [3].

This article is the result of research conducted by the author in the field of developing recommendations for the introduction and implementation of risk-oriented thinking in the practice of enterprises and organizations in the construction industry.

2. Materials and Methods
One of the most difficult but interesting tasks within the framework of the stated problem is the task of estimating the costs of rational risk management arising in the process of production activity of construction enterprises. The solution of this task consists of the formation of a set of measures aimed at eliminating all significant risks for the organization. It is important to note that each activity, whose goal is to reduce the level of risk or to completely eliminate it, is characterized by additional time and financial costs. In a number of cases, the implementation of the measures under consideration may require the introduction of changes to the construction organization (PIC) and / or the project for the production of work (PPR), adjusting the construction timetable, and changing the construction budget.

Thus, the set of measures should be effective: the total cost of all recruitment activities should be acceptable for the construction organization and at the same time the costs of implementing each activity should be significantly lower than the potential costs of eliminating non-conforming products due to unresolved inconsistencies.

The initial information for the solution of the problem is the data prepared at the stage of collecting and processing the records of inconsistencies and the causes of their occurrence: a list of inconsistencies, for each of which a list of causes that led to the occurrence of nonconformity was determined [4, 5]. The initial data can also include the amount of fixed costs for eliminating nonconforming products for each identified inconsistencies.

Assume that the incidence of inconsistencies is determined for one reason or another, and chains of inconsistencies are constructed, with the help of which the root causes for all fixed nonconformities are determined [6]. Let's assume that the basic set of corrective actions for elimination of each of the reasons of the revealed nonconformities is determined in an expert way or on the basis of a special classifier of problems and the potential costs associated with the implementation of each of the corrective actions are determined [5].

It is necessary to decide on the composition of the final risk management plan and the priority of the activities included in the plan.

The fact that, on the one hand, any risk is probabilistic, and, on the other hand, the decision is made in conditions of full or partial uncertainty, it is necessary to apply appropriate decision-making methods. In the current work, this method will be the method of least regrets Savage [7].

Savage's minimax regret model is an application of Wald's minimax model [8] to the 'regrets' associated with the payoffs. It can be formulated as follows:

\[
\min_{d \in D} \max_{s \in S} r(d, s)
\]

where

\[
r(d, s) := \max_{d' \in D} f(d', s) - f(d, s)
\]

is the regret of payoff \(f(d, s)\) associated with the (decision, state) pair \((d, s)\).

The choice of priority actions proposed is to be undertaken on the basis of this method.

3. Results
For simplicity, let us consider an example of applying the proposed method to managing the risks of a construction organization that builds residential houses from monolithic concrete with partitions and brick lining.
When checking the quality of work on the arrangement of internal partitions in the apartments of the two entrances of the building under construction, the nonconformities listed in Table 1 were identified.

**Table 1. Identified nonconformities**

| Code               | Nonconformity                                |
|--------------------|----------------------------------------------|
| Nonconformity1     | The laying was performed by a low-level bricklayer |
| Nonconformity2     | In the masonry, more broken bricks were found than required |
| Nonconformity3     | Over-run of cement mortar                    |

An analysis of the causes of inconsistencies (Table 2) and the chain of inconsistencies (Figure 2) made it possible to identify 4 root causes.

**Table 2. Nonconformities and causes of their occurrence**

| Nonconformity                                      | Cause                                                                 |
|----------------------------------------------------|----------------------------------------------------------------------|
| Nonconformity1. The laying was performed by a low-level bricklayer | Cause1. Absence in the staff of the organization a mason of the required level  
Cause2. Parallel maintenance of masonry on 2 objects |
| Nonconformity2. In the masonry, more broken bricks were found than required | Cause3. A batch of bricks contained a large amount of breakage  
Cause4. The brick was pricked because of low qualification of the mason |
| Nonconformity3. Over-run of cement mortar           | Cause5. Bad weather conditions prevented the finishing of the job  
Cause6. Over-run due to low qualification of the mason |

Based on the acts of eliminating non-conforming products, the total additional costs associated with each cause of a particular nonconformity were determined (Table 3).

**Table 3. The costs of eliminating nonconforming products depending on the nonconformity and the reasons for its occurrence, thousand rubles**

| Cause’s code | Cause’s description                                                   | Non-conformity2 | Non-conformity3 | Total costs |
|--------------|----------------------------------------------------------------------|-----------------|-----------------|-------------|
| cause1       | Absence in the staff of the organization a mason of the required level | 80              | 40              | 120         |
| cause2       | Parallel maintenance of masonry on 2 objects                        | 40              | 20              | 60          |
| cause3       | A batch of bricks contained a large amount of breakage               | 50              | 15              | 65          |
| cause5       | Bad weather conditions prevented the finishing of the job           |                 | 35              | 35          |
| Total        |                                                                    | 170             | 110             | 280         |

We construct the initial cost matrix for eliminating non-conforming production $F$, adding to it the column of costs for risk management measures. (Table 4). Using (2), we construct the matrix of additional losses $R$ (Table 5).
As a result, the best solution will be measure 2. The cost of its implementation is much lower than the total costs of eliminating non-conforming products due to the lack of an employee with the required qualifications. Therefore, the event “Dismissal of a worker with low qualifications and the hiring of a worker with high qualifications” becomes the highest priority in the formed risk management plan.

**Table 4.** The initial matrix of costs of measures for risk elimination, thousand rubles

| Possible risks | Risk reduction measure | Implementation costs of the measure | H2H3 | H2; not(H3) | not(H2); H3 | not(H2); not(H3) |
|----------------|-----------------------|------------------------------------|------|-------------|-------------|-----------------|
| Measures       | 1. Improvement of professional skills of the mason | 20 | 85 | 50 | 35 | 20 |
|                | 2. Dismissal of a worker with low qualifications and hiring of a worker with high qualifications | 15 | 85 | 50 | 35 | 15 |
|                | 3. The acquisition of a program for more efficient allocation of labor resources | 12 | 220 | 130 | 90 | 12 |
|                | 4. Replacing the brick supplier | 5 | 215 | 120 | 95 | 5 |
|                | 5. Development of measures to minimize losses of non-stock materials | 2 | 230 | 170 | 60 | 2 |

| Possible risks | Risk reduction measure | H2H3 | H2; not(H3) | not(H2); H3 | not(H2); not(H3) | max |
|----------------|-----------------------|------|-------------|-------------|-----------------|-----|
| Measures       | 1. Improvement of professional skills of the mason | 0 | 0 | 0 | 18 | 18 |
|                | 2. Dismissal of a worker with low qualifications and hiring of a worker with high qualifications | 0 | 0 | 0 | 13 | 13 |
|                | 3. The acquisition of a program for more efficient allocation of labor resources | 135 | 80 | 55 | 10 | 135 |
|                | 4. Replacing the brick supplier | 130 | 70 | 60 | 3 | 130 |
|                | 5. Development of measures to minimize losses of non-stock materials | 145 | 120 | 25 | 0 | 145 |

**Table 5.** Matrix of additional losses R, thousand rubles

| Possible risks | Risk reduction measure | H2H3 | H2; not(H3) | not(H2); H3 | not(H2); not(H3) | max |
|----------------|-----------------------|------|-------------|-------------|-----------------|-----|
| Measures       | 1. Improvement of professional skills of the mason | 0 | 0 | 0 | 18 | 18 |
|                | 2. Dismissal of a worker with low qualifications and hiring of a worker with high qualifications | 0 | 0 | 0 | 13 | 13 |
|                | 3. The acquisition of a program for more efficient allocation of labor resources | 135 | 80 | 55 | 10 | 135 |
|                | 4. Replacing the brick supplier | 130 | 70 | 60 | 3 | 130 |
|                | 5. Development of measures to minimize losses of non-stock materials | 145 | 120 | 25 | 0 | 145 |

**min ->** 13
We will correct the data of Tables 3 and 4 taking into account the above decision and write them into Tables 6 and 7.

**Table 6.** Updated data on the costs of eliminating non-conforming products, thousand rubles

| Cause’s code | Cause’s description | Non-conformity2 | Non-conformity3 | Total costs |
|--------------|---------------------|-----------------|-----------------|-------------|
| cause3       | A batch of bricks contained a large amount of breakage | 50              | 15              | 65          |
| cause5       | Bad weather conditions prevented the finishing of the job |                 | 35              | 35          |
| Total        |                     | 50              | 50              | 100         |

**Table 7.** Updated matrix of costs of measures for risk elimination, thousand rubles

| Risk reduction measure | Possible risks | Implementation costs of the measure |
|------------------------|----------------|-------------------------------------|
|                        |               | H2 H3 H2; not(H3) H3 not(H2); H3 not(H2); not(H3) |
| Measures               |               |                                    |
| 4. Replacing the brick supplier | 5 | 35 | 0 | 35 | 5 |
| 5. Development of measures to minimize losses of non-stock materials | 2 | 50 | 50 | 0 | 2 |
| min                    | 35            | 0                                   | 0                | 2           |

Form the matrix of additional losses for the updated cost matrix (Table 8).

**Table 8.** Matrix of additional losses R (updated), thousand rubles

| Possible risks | Implementation costs of the measure | H2 H3 | H2; not(H3) | H3 not(H2); H3 not(H2); not(H3) |
|----------------|-------------------------------------|-------|-------------|-------------------------------|
| Measures       |                                     |       |             |                               |
| 4. Replacing the brick supplier | 5 | 0 | 0 | 35 | 3 | 35 |
| 5. Development of measures to minimize losses of non-stock materials | 2 | 15 | 50 | 0 | 50 |
| min            |                                    | min -> | 35 |

Analysis of the obtained data shows that from the two measures, number 4 will be more rational. The costs for its implementation are lower than the total costs for eliminating inappropriate products due to poor quality of the supplied brick. Therefore, the measure "Replacing the brick supplier" can be included in the formed risk management plan.
Further reasoning shows that the risk of over-run of cement mortar due to bad weather conditions can be reduced or eliminated completely only by measure number 5. It is also included in the risk management plan. The task is solved.

4. Conclusions

Analysis of the practice of construction organizations in Russia in terms of risk management showed that this measure is most often implemented in a limited budget [9]. As a rule, from the list of measures aimed at reducing risks, the least expensive ones are selected. This does not take into account the probabilistic characteristics of potential risks, or the possible additional costs due to an incorrect decision. Leaders have to make decisions in conditions of uncertainty, often in the absence of reliable information about possible influences of external factors. The discussed task is a part of the risk management process, which helps make a decision, both under conditions of uncertainty, and in conditions of a certain probability of events or circumstances affecting the execution of the organization's tasks.

The algorithm proposed in the article makes it possible to apply a well-proven method of decision-making under conditions of uncertainty when forming a risk management plan. The proposed solution can be used in any construction organization, regardless of its place in the chain of production of construction products. The software implementation of the algorithm can be implemented quite simply, since the algorithm does not contain any complex mathematical calculations and transformations.

References

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