Information technologies for taking into account risks in business development programme

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Abstract. The paper describes the information technologies for taking into account risks in business development programme, which rely on the algorithm for assessment of programme project risks and the algorithm of programme forming with constrained financing of high-risk projects taken into account. A method of lower-bound estimate is suggested for subsets of solutions. The corresponding theorem and lemma and their proofs are given.

1. Introduction

The risk management includes such basic processes as identification of risks, determination of their major characteristics, selections of risk response (mitigation, transfer, avoidance, acceptance).

Two indicators are used to describe a risk – probability of a risk event and damage caused by its occurrence. The degree of risk impact is a generalizing characteristic, which is defined as expected damage.

Formally, to analyze and manage risks within a project, Project Expert, Spider, Open Plan, Welcom Risk software packages based on heuristic algorithms can be used with certain hard-to-analyze results obtained [1].

Recently, the studying of risk management objectives based on assessment of their qualitative characteristics has been drawing serious attention. A two-estimate scale is the simplest one: low probability – high probability, minor damage – major damage, low degree of impact – high degree of impact. One of the ways to reduce the risk of business development programme is the project risk assessment and constraining financing for high-risk projects [2-6].

2. Algorithm for Assessment of Business Development Programme Project Risk

Problem setting. There are n projects of the business development programme. Each project is characterized by effect $\alpha_{ij}$, which contributes to one indicator, contribution of project $i$ to indicator $j$.

There are two variants to implement each projects – with low risk or with high risk. Let us denote the costs of low-risk projects by $b_i$, and the costs of high-risk projects by $c_i$ (it is obvious that $b_i > c_i$,
One needs to determine the reliability of implementation of programme projects assuring the achievement of required value of business, due diligence with the minimum costs under the conditions of constrained financing of high-risk projects.

To set the problem formally, let us denote \( x_i = 1 \), if project \( i \) is included into the plan with low risk, if not \( x_i = 0 \). Consequently, let us denote \( y_i = 1 \), if project \( i \) is included into the plan with high risk, if not \( y_i = 0 \). It is obvious that:

\[
x_i + y_i \leq 1, i = 1, n.
\]

At specified values, the effect for the corresponding indicator will be:

\[
R(x) = \sum_{i=1}^{n} (x_i + y_i) \cdot \alpha_i.
\]

Let us take that the defined boundary values of effect \( A_j, j = 1, m \) are such that if:

\[
A_j < R(x) < A_{j+1},
\]

then the score equals \( j \).

To take into account risk constraints, let us denote the maximum permissible amount of financing high-risk projects by \( C \), then the constraint will take on the following form:

\[
\sum_{i=1}^{n} y_i c_i \leq C.
\]

The problem is to determine \( x_i, y_i, i = 1, n \), which minimize:

\[
\Phi = \sum_{i=1}^{n} (b_i x_i + c_i y_i)
\]

under constraints (2), (4) and \( \sum_{i=1}^{n} (x_i + y_i) \cdot \alpha_i \geq A \), where \( A \) equals one of \( A_j \) values depending on the objective specified for this indicator.

To use the branch-and-bound method, one needs to apply the lower-bound estimate method to subsets of solutions. Let us solve this problem based on the algorithm suggested in paper [7]. For this purpose, let us tentatively go to new variables \( z_i = x_i + y_i, i = 1, n \). With new variables, the problem will be written as follows: to minimize:

\[
\Phi(z, y) = \sum_{i=1}^{n} (b_i z_i - \Delta_i y_i),
\]

where \( \Delta_i = b_i - c_i \) (cost reduction if the project is implemented with high risk) under constraints (2), (4):

\[
\sum_{i=1}^{n} z_i \alpha_i \geq A
\]

Let us consider to estimation problems.

Problem 1. To minimize:

\[
F_1(\varepsilon) = \sum_{i=1}^{n} b_i z_i
\]
Problem 2. To maximize:

\[ F_2(y) = \sum y_i \Delta_i \]  \hspace{1cm} (9)

under constraint (4).

Let us denote value \( F_1(z) \) in optimum problem solution 1 by \( \Phi_1 \), and value \( F_2(y) \) in optimum problem solution 2 by \( \Phi_2 \).

Theorem. Quantity:

\[ \Phi_1 - \Phi_2 \]

is the lower bound for the objective function of problems (2), (4), (6), (7).

The proof follows from the known inequality:

\[ \min \Phi(z, y) \geq \min F_1(z) + \min(-F_2(y)) = \min F_1(z) - \max F_2(y). \]

Let us use estimate (10) in the branch-and-bound method.

Lemma. If there are optimum solutions \( z, y \) to problems 1 and 2 such that \( y < z(y_i \leq z_i, i = 1, n) \), then pair \( (z, y) \) determines the optimum solution to problems. The proof is obvious as \( (z, y) \) is the permissible solution.

The problem has the following solving algorithm.

**Step 1.** Let us solve problems 1 and 2. Let us denote the set of optimum solutions of problem 1 by \( M_1 \), and the set of optimum solutions of problem 2 by \( M_2 \). If there is pair \( (z, y) \) such that \( y < z \), then, by virtue of lemma, \( (z, y) \) is the optimum solution. If not, proceed to the second step.

**Step 2.** Let us select project \( j \) such that \( y_j = 1 \), and \( z_j = 0 \), and let us separate the set of all solutions into two subsets. In the first one \( y_j = 1, z_j = 1 \), and in the second one \( y_j = 0 \). Next, let us solve the estimation problems for these subsets, select a subset with better estimate, etc. according to the branch-and-bound method.

3. **Algorithm of business development programme forming with constrained financing of high-risk projects taken into account**

Let us consider the problem of forming of programme assuring the required value of business due diligence with the minimum costs and risk taken into account. Let set \( Q_{hi} \) of projects with high risk exist in each business development direction. To take the risks into account, let us introduce the constraint for financing of high-risk projects (11):

\[ \sum_{i} \sum_{k \in Q_{hi}} c_k \leq D. \]  \hspace{1cm} (11)

Thus, the financing of all high-risk projects shall not exceed \( D \).

The problem has the following solving algorithm.

**Step 1.** Let us solve the following problem for each directions: let us determine \( x_k, k = 1, n \), which minimize:

\[ C(x) = \sum_k c_k \cdot x_k \]  \hspace{1cm} (12)

under constraints (13) and (14):

\[ \sum_k \alpha_k \cdot x_k \geq N, \]  \hspace{1cm} (13)
\[
\sum_{k \in Q_\theta} c_k x_k \leq d ,
\]
where \(0 \leq d \leq D\) is a parameter.

To solve this problem, let us take the dichotomous representation structure composed of final vertex and two subtrees.

The first subtree contains all projects of set \(Q_\theta\); the second subtree – all other projects. Let us solve minimization problem (15) for the first subtree under constraint (16):

\[
C_\theta(x) = \sum_{k \in Q_\theta} c_k x_k ;
\]
\[
A_\theta(x) = \sum_{k \in Q_\theta} \alpha_k x_k \geq N_\theta ,
\]

where \(0 \leq N_\theta \leq A_3\) (direction number is to be dropped).

Eventually, we obtain the dependence of minimum costs of high-risk projects \(C_\theta \ (C_\theta \leq D)\) on effect \(N_\theta\) received from them.

Let us solve minimization problem (17) for the second subtree under constraint (18):

\[
C_H(x) = \sum_{k \in Q_H} c_k x_k ;
\]
\[
A_H(x) = \sum_{k \in Q_H} \alpha_k x_k \geq N_H ,
\]

where \(Q_H = Q \setminus Q_\theta , \ 0 \leq N_H \leq A_3\).

Eventually, it is possible to obtain the dependence of minimum costs of low-risk projects \(C_H\) on effect \(N_H\) received from them.

Next, let us solve the problem of sum minimization (19) under constraint (20):

\[
S = C_\theta + C_H ,
\]

where \(C_\theta \leq d \ (0 \leq d \leq D)\)

\[
N_\theta + N_H \geq A_3 .
\]

Eventually, one obtains the dependence of minimum costs \(S_j\) required to get estimate \(j = 1.3\) on constraint \(d\) for financing of high-risk projects.

Step 2. In step 2, let us solve the problem of determination of a programme variant and, consequently, constraints \(d_i, \ i = 1, m\) for financing of high-risk projects in each direction in such a way as to assure the required due diligence value with the minimum costs. The problem shall be solved by successive solving of optimization problems with two variables in accordance with the structure of dichotomous representation of due diligence system [8]. All in all, \((m-1)\) of same-type problems shall be solved.

Let us described the solution algorithm for one problem.

Dependences \(S_{j1}(d)\) are considered for the first directions and \(S_{j2}(d)\) – for the second direction, \(j = 1.3\). Dependence \(S_{j}(d)\) shall be obtained for generalized estimate obtained based on convolution of direction 1 and 2 estimates.

Let us describe the algorithm.
For each estimate $j$, let us determine set $T_j$ of pairs of direction 1 and 2 estimates giving generalized estimate $j$. Let us consider all pairs $(k, z) \in T_j$ and calculate (21) for each pair $(k, z)$:

$$S_j(d) = \min \left[ S_{k1}(d_1) + S_{z2}(d_2) \right]$$

under constraint $d_1 + d_2 \leq d$, where $0 \leq d \leq D$.

Eventually, one will obtain a table of minimum costs assuring estimate $j = 1.3$ for generalized direction.

Such problem shall be solved for each matrix of a due diligence system. In the finite matrix, one will obtain the dependence of minimum costs required to achieve the required due diligence values under constraint $D$ for financing high-risk projects. The optimum solution shall be determined by the counter motion method [9, 10].

4. Conclusion
In the paper, the authors have suggested the methods for taking into account risks in the business development programme, presented the algorithm for assessment of programme project risk based on a two-estimate scale, and the algorithm of programme forming with high-risk project financing constraints taken into account.

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