Assessment of feasibility of projects for creating information and management systems of the electric power complex under conditions of uncertainty

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Abstract. Evaluating the feasibility of implementing proposed projects for creating information management systems (IMS) for industrial facilities is a complex procedure due to the uncertainty surrounding the accurate data about the prepared project during its implementation. Therefore, the application of decision support methods, based on soft computing and methodology, is deemed appropriate to address the difficulties arising from non-factors (uncertainty, non-determinism) in the evaluation of the implementation of proposed projects for IMS creation. Consequently, the use of non-deterministic interval methods has been proposed for the evaluation of the suitability of project proposals for creating information management systems under conditions of interval non-determinism, highlighting its advantages.

1 Introduction

The evaluation of projects for creating information management systems (IMS) based on the vector criterion that characterizes the technical, financial, economic, and commercial indicators of existing projects is not sufficient for determining the feasibility of a project; instead, a multi-criteria evaluation considering uncertainty is widely adopted [13].

The analysis of models for the multi-criteria evaluation of alternatives under uncertain conditions indicates that parameter values in the models are often expressed as intervals due to the existence of diverse opinions among project implementers [3].

2 Materials and methods

The information is expressed in a fuzzy interval, it is appropriate to use the fuzzy-interval method, and its idea can be expressed as follows.

Let's assume that the set of alternative projects $K = \{k_i(y^{(j)})\}, i = \overline{1,n}$ evaluated by a tuple $Y = \{y^{(1)}, y^{(2)}, ..., y^{(m)}\}, y^{(j)} \in Y, j = \overline{1,m}$ with n special criteria is given.

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The main issue here:

$$L\left(y^{(j)}\right)=\sum_{i=1}^{n} w_i^{(nor)} l_i^{(nor)}\left(y^{(j)}\right), j=\overline{1,m}, i=\overline{1,n} \tag{1}$$

Using an interval calculus machine:

$$y^{(0)}=\arg\max_{y^{(j)}\in Y} L(y^{(j)}), j=\overline{1,m}, \tag{2}$$

Here is the normalized interval coefficient of the relative importance of the j-th special criterion of $w_i^{(nor)}$ the quantitative $y^{(j)} \in Y$ alternatives; is the normalized interval special criterion of $l_i^{(nor)}(y^{(j)})$ the quantitative alternatives) $y^{(j)} \in Y$ is to form the scalar interval values of the generalized benefit, which expresses the realization of each j -th alternative of the project preparation from the general alternative, with the possibility of later selection of the acceptable alternative.

3 Results and Discussion

The generalized scheme of the implementation of this method, which consists of five stages, can be shown as in the following Figure 1.

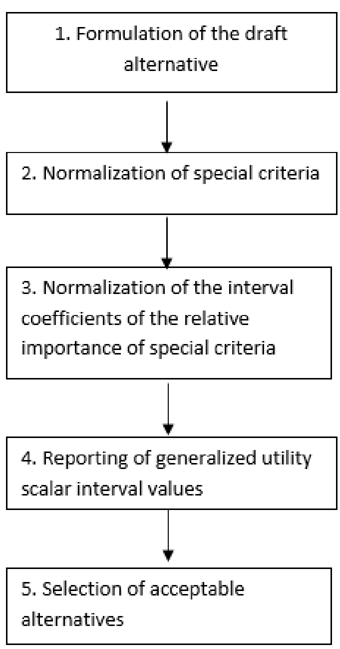

Fig. 1. Generalized scheme of implementation of fuzzy interval method.

Step 1. Formulation of project alternatives evaluated with $Y=\{y^{(1)},y^{(2)},...,y^{(m)}\}, y^{(k)}\in Y, j=\overline{1,m}$ special criteria $K=\{k_i(y^{(j)})\}, i=\overline{1,n}$.

Note that special criteria can be expressed in the form of intervals, fuzzy trapezoidal and triangular numbers [4].

Step 2. Normalization of special criteria for each k-th alternative of project development according to formulas (3) or (4) or (5) $l_i^{(nor)}(y^{(j)})$ [9].

1) $k_i(y^{(j)})=[k_{i1}(y^{(j)}),k_{i2}(y^{(j)})]$- for the interval

$$l_i^{(nor)}(y^{(j)})=\left[\frac{k_{i1}(y^{(j)})}{k_i^{\max}},\frac{k_{i2}(y^{(j)})}{k_i^{\max}}\right],k_i^{\max}=\max_{1\le j\le m}\{k_{i2}^{j}\} \tag{3}$$

So, $k_{i1}(y^{(j)}),k_{i2}(y^{(j)})$- numbers are the minimum and maximum values of the interval, respectively;

2) $k_i(y^{(j)})=[k_{i1}(y^{(j)}),k_{i2}(y^{(j)}),k_{i3}(y^{(j)})]$for fuzzy triangular numbers:

$$l_i^{(nor)}(y^{(j)})=\left[\frac{k_{i1}(y^{(j)})}{k_i^{\max}},\frac{k_{i2}(y^{(j)})}{k_i^{\max}},\frac{k_{i3}(y^{(j)})}{k_i^{\max}}\right],k_i^{\max}=\max_{1\le j\le m}\{k_{i3}^{j}\} \tag{4}$$

Thus, $k_{i1}(y^{(j)}),k_{i2}(y^{(j)}),k_{i3}(y^{(j)})$- numbers are the minimum, most expected and maximum values of the interval, respectively;

3) $k_i(y^{(j)})=[k_{i1}(y^{(j)}),k_{i2}(y^{(j)}),k_{i3}(y^{(j)}),k_{i4}(y^{(j)})]$for fuzzy trapezoidal numbers:

$$l_i^{(nor)}(y^{(j)})=\left[\frac{k_{i1}(y^{(j)})}{k_i^{\max}},\frac{k_{i2}(y^{(j)})}{k_i^{\max}},\frac{k_{i3}(y^{(j)})}{k_i^{\max}},\frac{k_{i4}(y^{(j)})}{k_i^{\max}}\right],k_i^{\max}=\max_{1\le j\le m}\{k_{i4}^{j}\} \tag{5}$$

Thus, $k_{i1}(y^{(j)}),k_{i4}(y^{(j)})$- numbers are the pessimistic and optimistic values of the intervals, respectively, $k_{i2}(y^{(j)}),k_{i3}(y^{(j)})$- numbers are the interval of the most expected values.

It should be noted that the normalization of specific criteria is necessary because their numerical values differ in the order of units and quantities, which makes working with given criteria even more difficult. Specific criteria can be given as interval or fuzzy LR-type (eg, triangular, trapezoidal) numbers [5].

Step 3:

$$w_i^{nor}=\frac{w_i}{\sum_{i=1}^{n}w_i},\ i=\overline{1,n} \tag{6}$$

Normalization of relative significant interval coefficients of special criteria . $i=\overline{1,n}$ Here, - w_i is the interval coefficient of the relative importance of the *i -th special criterion* presented as intervals, fuzzy triangle and trapezoidal numbers, which can be formed based on the survey of project managers' opinions .

If the normalized relative significant interval coefficient of the i-th special criterion $w_i^{nor}=[\beta_{i1},\beta_{i2}]$ is given in the form of an interval, then $\sum_{i=1}^{n}\beta_{i1}<1,\sum_{i=1}^{n}\beta_{i2}>1$ we assume that So β_{i1},β_{i2} - are the minimum and maximum values of the interval, respectively. Otherwise, $\sum_{i=1}^{n}\beta_i=1$ problem (2) cannot be solved due to non-fulfillment of the constraint.

If the normalized relative significant interval coefficient of the ith special criterion $w_i^{nor}=[\beta_{i1},\beta_{i2},\beta_{i3}]$ is given in the form of a fuzzy triangular number, then $\sum_{i=1}^{n}\beta_{i1}<1,\sum_{i=1}^{n}\beta_{i3}>1$ we assume that So, $\beta_{i1},\beta_{i2},\beta_{i3}$ - are the minimum, most expected and maximum values of the interval, respectively. Otherwise, problem (2) cannot be solved.

If the normalized relative significant interval coefficient of the ith special criterion $w_i^{nor}=[\beta_{i1},\beta_{i2},\beta_{i3},\beta_{i4}]$ is given in the form of a fuzzy trapezoidal number, then β_{i1},β_{i4} - represents the pessimistic and optimistic values of the intervals, $[\beta_{i2},\beta_{i3}]$ and - represents the interval of the most expected values, and it $\sum_{i=1}^{n}\beta_{i1}<1,\sum_{i=1}^{n}\beta_{i4}>1$ is assumed that Otherwise, problem (2) cannot be solved.

Step 4. A report based on relation (1) of the generalized utility scalar interval values for each i-th alternative of project development . $L(y^{(j)})$

Step 5 . Selection of the acceptable design alternative based on the interval value of greatest importance.

It should be noted that if the intervals of special criteria do not intersect, that is, it is possible to compare the intervals among themselves, and if "big" or "small" relationships are possible, then question (2) is correctly set [2]. If condition (2) is not satisfied, then problem (1) is not the only solution and it must be transformed based on the use of additional information beyond the initial problem. In solving multi-criteria optimization problems, the carrier of such information is the project manager, so he makes the decision. Currently, methods are widely used to transform the initial multi-objective optimization problem into a single-objective scalar optimization problem. These methods include the main criterion principle, sequential optimization scheme, analysis of hierarchies, etc. includes [4].

Is to regularize generalized utility value intervals represented as trapezoidal fuzzy numbers $L(y^{(j)})$. To compare fuzzy trapezoidal numbers, we use Chiu-Park, Chang, Kaufman-Gupta methods [1]:

- Chiu-Park method. First, the parameter w is noted, and then for each $Y = [y_1, y_2, y_3, y_4]$ trapezoidal number, the corresponding $P = \frac{y_1 + y_2 + y_3 + y_4}{4} + w\frac{y_2 + y_3}{2}$ smooth number is set against it.
- Chang's method. $Y = [y_1, y_2, y_3, y_4]$ Trapezoidal numbers $Ch == \frac{y_3^2 + y_3 y_4 + y_4^2 - y_1^2 - y_1 y_2 - y_2^2}{4}$ are arranged by increasing their value.
- Kaufman-Gupta method. $Y = [y_1, y_2, y_3, y_4]$ for trapezoidal numbers, the following three quantities are first calculated:

$$G_1 = \frac{y_1 + 2y_2 + 2y_3 + y_4}{6}; G_2 = \frac{y_3 + y_4}{2}; G_3 = y_4 - y_1 .$$

Then it is regulated according to the following rule:

If $G_1(Y_1) > G_1(Y_2)$ or $G_1(Y_1) = G_1(Y_2)$ or $G_2(Y_1) > G_2(Y_2)$ or $G_1(Y_1) = G_1(Y_2), G_2(Y_1) = G_2(Y_2)$ and $G_3(Y_1) > G_3(Y_2)$, then $Y_1 \geq Y_2$ it is.

Note that the above-discussed methods for selecting an acceptable project alternative may yield different results.

$Y = [y_1, y_2, y_3]$ *in the case of* fuzzy triangular numbers, the choice of an acceptable project alternative should be made according to the expected value of y_2. The one with the highest expected value is taken as the acceptable alternative.

Now let's consider an example of evaluating and selecting an acceptable design alternative under si interval uncertainty.

Assume that the number of design alternatives is finite and the specific criteria are given as fuzzy trapezoidal numbers and so their boundaries intersect.

For project development $(y^{(1)}, y^{(2)}, y^{(3)})$, which in turn are described by the following three specific criteria:

- k_1 – project implementation period, months.
- k_2 – project price, thousand manats.
- k_3 – cost payback period, months.

The development of the project should be evaluated with the possibility of choosing an acceptable alternative for further implementation.

The calculated values of specific criteria for each alternative are given in the following table (Table 1). According to this table, $l_i^{(nor)}(y^{(j)})$ - special criteria are normalized and the results are described in a new table (Table 2).

Table 1. Report values of special criteria for realization of alternatives.

Project alternatives	**Special criteria for the implementation of alternatives**		
	k_1	k_2	k_3
$y^{(1)}$	[9.5,10,10.5]	[650, 730, 760]	[1.5, 2.3, 2.7]
$y^{(2)}$	[8.5, 9.5, 10]	[700, 770, 800]	[2.5, 2.9, 3.5]
$y^{(3)}$	[10, 11, 12]	[650, 800, 850]	[2, 2.5, 3]

Table 2. Normalized reporting values of special criteria for realization of alternatives.

Project alternatives	Normalized values of special criteria for realization of alternatives		
	k 1	***k 2***	***k 3***
$y^{(1)}$	[0.79, 0.83, 0.88]	[0.76, 0.86, 0.89]	[0.43, 0.66, 0.77]
$y^{(2)}$	[0.71, 0.79, 0.83]	[0.82, 0.91, 0.94]	[0.71, 0.83, 1]
$y^{(3)}$	0.83, 0.92, 1	[0.76, 0.94, 1]	[0.57, 0.71, 0.86]

Then, the interval coefficients of the relative importance of specific criteria are normalized based on the opinion survey of the project implementers. Relative significant coefficients are known to be in the form of the following fuzzy trapezoidal numbers:

$$w_1 = [3,3.5,4], w_2 = [3.3,4,5], w_3 = [1.2,2,3].$$

In addition, based on relation (6), normalized interval coefficients of the relative importance of certain criteria are calculated:

$w_1^n = [0.28,0.37,0.57], w_2^n = [0.28,0.4,0.64], w_3^n = [009,0.22,0.33].$

Then the generalized useful scalar interval values $L(y^{(j)})$ are calculated for each project option: $L(y^{(1)}) = [0.55,0.77,1.45]$, $L(y^{(2)}) = [0.63,0.98,1.77]$, $L(y^{(3)}) = [0.19,0.57,0.94]$.

It is not possible to choose the best alternative according to expression (2) since the intervals of special criteria intersect. In this example, the choice of the best alternative is based on the expected cost: $G(L(y^{(1)})) = 0.77;$ $G(L(y^{(2)})) = 0.98;$ $G(L(y^{(3)})) = 0.57$.

The best alternative of project preparation is $y^{(2)}$ - alternative, followed by $y^{(1)}$ - alternative.

4 Conclusion

Based on the comparative analysis of possible alternatives for the preparation of the project under the conditions of uncertainty of the interval of the initial data, a method was proposed to evaluate the feasibility of the projects of creating the IIS using the interval calculator. The evaluation of each alternative for the development of the project consists in the formation of scalar interval values of the generalized benefit. The proposed method allows to choose the most appropriate acceptable alternative for creating an IIS in case of intersection of values of specific criteria for project alternatives.

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