MULTICRITERION CHOICE PROBLEM FOR ENTERPRISES TO CREDITING

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Abstract: *Observing an approach for multicriterion choice problem by means fuzzy sets. The brought model over determination problem of borrower for crediting banks.*

Keywords*: multicriterion choice, fuzzy sets, crediting, decision making.*

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Introduction

After crisis time the Ukrainian banks very diligently and carefully go near the choice of borrowers. In the conditions of large demand on resources and by small suggestion, the task of correct choice of client for a grant to the credit and in the end its timely returning appears very actual. The decision takes place on two, and sometimes and on more the stages. On the first stage analysts estimate indexes, interests and consequences that characterize the variants of decisions. On the second stage person who makes decision (PMD), collects the estimations of analysts, and on the basis of which deduces a conclusion for a final decision making (DM).

In-process was taken approach, that was based on the theory of fuzzy sets, which gave an opportunity to pass to the only scale of evaluation of many different criteria. DM about the choice of borrowers is conducted on the basis of belonging function values, that is convolution of belonging functions of fuzzy sets, that answer criteria after that they are estimated. Application of methods is considered on the real example from six alternative clients.

Mathematical model

For realization of researches above the task of choice we shall describe it by means of - the next mathematical vehicle. The great number of alternatives we shall mark through *X*, this great number can be as complete, that is possible alternatives can be enumerated $X = \{x_1, x_2, ..., x_n\}$, and continuous set by terms-limitations. We shall mark $K = \{K_i, i = 1,2,..., m\}$ multitude of the criteria of effectiveness, by means of that the estimation of every alternative is conducted out of multitude *X*. The great number of criteria is set in a ball scale. Thus, the task of choice can be set forth as follows: to choose the best alternative from the great number of *X*, when the estimations are known on this great number $K_i, i = 1,2,..., m$, where *m* – is an amount of estimations. Farther we will examine the tasks of choice, in that the great number of possible alternatives is discreted and completed, then the model of such task can be presented in the form charts:

	x_1	x_2	x_3	...	x_n
K_1	O_{11}	O_{12}	O_{13}	...	O_{1n}
K_2.	O_{21}	O_{22}	O_{23}	...	O_{2n}
.....					
K_m	O_{m1}	O_{m2}	O_{m3}	...	O_{mn}

or the matrixes decisions :

$$O = (O_{ij}),\ i = 1, \ldots, m;\ j = 1, \ldots, n; \tag{1}$$

where O_{ij} – it is an estimation j-alternatives i's- criterion.

We shall introduce into consideration point $T=(t_1, \ldots, t_m)$ from space R^m_{++} and we shall try to describe the fuzzy set of points.

We shall take the great number of alternatives of X, - for the great number of points, and the function of belonging we shall mark through $\mu_A(x)$ [Zadeh, 1965]. Then the task of choice can be described by means of the washed out model, and alternative to arrange in relation to the function of belonging :

$A_T = \{x, \mu_A(x)\},\ \forall\ x \in X \subset R^m_{++}$,

where A_T – the multitude of points, close to given point T, $\mu_A(x)$ characterises « degree of belonging" of elements to the $x \in X$ point of $T \in R^m_{++}$, that is this the function the appurtenances of affirmation "point x close to point T.

Determination. The point of pleasure" is named an imaginary alternative, at what estimation PMD would satisfy on all criteria [Malyar, 2006].

Coordinates of $T=(t_1, \ldots, t_m)$ are estimations for to the corresponding criteria the value of that satisfies PMD . Such estimations we will examine as points $t_i \in R_+$ from an inalienable set.

A question of construction function of belonging is one of major questions in the theory of the washed out sets. We shall describe approach of construction of function of belonging $\mu_A(x)$ [Malyar, 2006]. Imagine that we know matrix of decisions (1) and set point "of satisfaction" of T We shall define the great number of sizes as follows:

$$z_{ij} = 1 - \left|t_i - O_{ij}\right| \Big/ \max\left\{t_i - \min_j O_{ij}; \max_j O_{ij} - t_i\right\}, i\ =\ 1,\ \ldots,\ m, j\ =\ 1,\ \ldots,\ n \tag{2}$$

Each such size is the relative estimation of closeness of element of matrix (1) to the corresponding element of point of «satisfaction». As every alternative of $x \in X$ is the point of space of R^m_{++}, then the matrix of $Z = \{z_{ij}\}$ characterizes column-wise the relative estimations of closeness of alternative x_j to the point" of satisfaction" of T on every concrete criterion and takes off the question of different scales of evaluation.

Following step is an arranging of alternatives. For this purpose we will build the function belonging, as some convolution of numerical estimations. Let PMD knows or can set weighty coefficients to every criterion of efficiency $\{p_1, p_2, \ldots, p_m\}$ from an interval [0,a] (for consideration of expert and as it comfortably him for example, from 0 to 10, or from 0 to 100). Then it is possible to define the rationed weighty coefficients for every criterion:

$$\alpha_i = \frac{p_i}{\sum_{i=1}^{m} p_i},\ i\ =\ 1,\ \ldots,\ m\ ;\ \alpha_i \in [0,1], \tag{3}$$

which correspond to condition $\sum_{i=1}^{m} \alpha_i = 1$.

Farther we build the function of belonging, as one of offered convolution, depending on the psychosomatic mood of PMD:

$$\mu_A^2(x_j) = \frac{1}{\sum_{i=1}^{m} \frac{\alpha_i}{z_{ij}}} \text{ - pessimistic;} \tag{4}$$

$$\mu_A^3(x_j) = \prod_{i=1}^{m} (z_{ij})^{\alpha_i} \text{ - careful;} \tag{5}$$

$$\mu_A^4(x_j) = \sum_{i=1}^{m} \alpha_i z_{ij} \text{ - middle;} \tag{6}$$

$$\mu_A^5(x_j) = \sqrt{\sum_{i=1}^{m} \alpha_i (z_{ij})^2} \text{ - optimistic} \tag{7}$$

Between them there exists next subordination, [Osipova, 1968]: $\mu_A^2(x) \le \mu_A^3(x) \le \mu_A^4(x) \le \mu_A^5(x), \forall x \in X$.

Clients' choice problem

Let an aim - choice of borrower and great number of alternatives, which we will examine as enterprises with economic indexes is set. PMD necessary to choose enterprises that work stably have good economic indexes and better in all befit for the receipt of loan in a bank. We will consider that an aim is described by some great number of criteria for that ball estimations can be certain. We shall uncover the content of criteria, meanings and scale according to points of scale. Criteria $\{K_1, K_2, ..., K_{10}\}$ of effectiveness are following:

Criterion	Name of criterion
K_1	The index of immediate liquidity
K_2	The index of current liquidity
K_3	The index of general liquidity
K_4	The index of financial independence
K_5	The index of manoeuvrability of the personal funds
K_6	The index of financial leveriju
K_7	The Gain dynamics from products realization
K_8	The analysis of incomes and damages
K_9	Profitability of production
K_{10}	Credit history

We shall expose maintenance and gradations of criteria in accordance with a ball scale [NBU 2000]

1. An instantaneous liquidity ratio will calculate by means of formula:

K_1 = (*Current financial investments + the Monetary resources in national currency + Equivalents of monetary resources in foreign currency)/Current liabilities.*

Accounts and the gradations of scale criterion K_1 :

- – if meaning K_1 less than 0,2;
- 10 – if meaning K_1 0,2-0,25;
- 20 – K_1 more 0,25.

2. The index of current liquidity is calculated in accordance to equality :

K_2 =(*Account receivable for commodities, works, services them net realization cost + account receivable after calculations + Other floating debtor debt + the Current financial investments + the Monetary resources in national currency + Equivalents of monetary resources in foreign currency)/Current liabilities.*

Accounts and the gradations of scale criterion K_2 :

- 0 – if meaning K_2 less than 0,5;
- 10 – if meaning K_2 0,5-1,0;
- 20 – K_2 more 1,0.

3. A general liquidity ratio is determined as circulating assets are divided into current liabilities.

Estimations and gradations of scale of criterion K_3 :

- 0 – if value K_3 less than 1,0;
- 15 – 1,0-1,9;
- 20 – 2,0-2,5;
- 0 – K_3 more than 2,5.

4. The coefficient of financial independence is calculated by means of formula:

K_4 =(Providing of next charges and single-sourcing + is the Long-term debt + Current liabilities)/ Property asset.

Estimations and gradations of scale of criterion:

- 25 – K_4 less than 1,0;
- 15 – 1,0;
- 5 – K_4 more than 1,0;
- 0 – if value of property asset less than " 0".

5. The coefficient of manoeuvrability of the personal funds is determined, as a difference between a property asset and inconvertible assets is divided into a property asset.

Estimations and gradations of scale of criterion K_5 :

- 5 – less then 0,5;
- 15 – 0,5;
- 25 – more then 0,5;
- 0 - if value of property asset less than " 0".

6. The coefficient of financial leveriju is calculated in accordance with equality :

K_6 = (A long-term debt + the Short-term credits of banks + the Floating debt after a long-term debt)/Property asset.

Estimations and gradations of scale of criterion K_6 :

- 5 - less than 0,7;
- 15 - 0,7;
- 25 - more than 0,7;
- 0 - if value of property asset less than " 0".

7. Dynamics of profit yield from realization of products (commodities, works, services) will define in a percentage ratio in comparing to the corresponding period of the last year.

Estimations and gradations of scale of criterion K_7 :

- 30 is an increase in comparing to the corresponding period last year (increase anymore 20%);
- 25 is an increase in comparing to the corresponding period last year (increase of 10-20%);
- 20 is an increase in comparing to the corresponding period last year (increase less than 10%) or absence of changes;
- 0 is reduction in comparing to the corresponding period last year (a decline of volume is more than on 20%);
- 5 is reduction in comparing to the corresponding period last year (decline of volume of 10-20%);
- 15 is reduction in comparing to the corresponding period last year (a decline of volume is less than on 10%).

8. We shall write down estimations and gradations of scale of criterion K_8 :

- 120 - activities profitable for the previous year;
- 140 - profitable activity for the last two years;
- 20 - losing activity over the past year;
- 0 - unprofitable activity for the last two years;
- 70 - activities in the absence of gains and losses or lack of activity;
- 0 - a report for the previous financial year not given.

9. Profitability of production is calculated in obedience to equality:

K_9 = (Net income* of 100%)/(Material expenses + of Expense on the remuneration of labour + of Contribution on social measures + Depreciation + Other operating charges).

Estimations and gradations of scale of criterion K_9 :

- 0 - less than 5%;
- 10 - 5%-10%;
- 15 -more than 10%.

10. We shall write down estimations and gradations of scale of criterion K_{10} :

- 80 - paid off a credit in good time;
- 60 - paid off a credit with violation of term 1-30 days, but in good time paid percents;
- 30 - paid off a credit with violation of term 31 - 90 days;
- 10 - paid off a credit with violation of term 91 - 180 days;
- 0 - paid off a credit with violation of term more than 180 days;
- 50 is redemption in a period covered unforeseen.

Practical realization of model

Let bank six requests entered from enterprises for the receipt of loan. Enterprises will examine as alternatives, among what PMD must choose one for delivery of credit.

Their criterion estimations are given as a table:

	x_1	x_2	x_3	x_4	x_5	x_6
K_1	10	20	20	20	10	10
K_2	0	10	10	20	10	20
K_3	15	0	20	15	15	15
K_4	25	15	5	5	5	15
K_5	15	5	15	25	25	0
K_6	15	25	5	15	25	15
K_7	30	25	20	15	5	30
K_8	140	120	120	70	20	120
K_9	10	15	10	0	15	10
K_{10}	80	60	30	50	30	80

Let the great number of points "of pleasure", for example, PMD has defined as follows - *T*={20; 20; 15; 20; 15; 15; 25; 120; 10; 60}. Weight of criteria an expert estimated in numbers from an interval [0,10] accordingly: {8, 10, 9, 8, 7, 6, 7, 5, 8, 9}. Then the rationed weighty coefficients we shall calculate on a formula (3) and we shall write down as a great number: {0,10; 0,13; 0,12; 0,10; 0,09; 0,08; 0,09; 0,06; 0,10; 0,12}.

Let's arrange the alternatives in relation to the point "of satisfaction" of *T*. Calculate sizes by means of formula (2) and result we shall write down as a matrix of *Z*:

$$Z = \begin{pmatrix} 0,0000 & 1,0000 & 1,0000 & 1,0000 & 0,0000 & 0,0000 \\ 0,0000 & 0,5000 & 0,5000 & 1,0000 & 0,5000 & 1,0000 \\ 1,0000 & 0,0000 & 0,6667 & 1,0000 & 1,0000 & 1,0000 \\ 0,6667 & 0,6667 & 0,0000 & 0,0000 & 0,0000 & 0,6667 \\ 1,0000 & 0,3333 & 1,0000 & 0,3333 & 0,3333 & 0,0000 \\ 1,0000 & 0,0000 & 0,0000 & 1,0000 & 0,0000 & 1,0000 \\ 0,7500 & 1,0000 & 0,7500 & 0,5000 & 0,0000 & 0,7500 \\ 0,8000 & 1,0000 & 1,0000 & 0,5000 & 0,0000 & 1,0000 \\ 1,0000 & 0,5000 & 1,0000 & 0,0000 & 0,5000 & 1,0000 \\ 0,3333 & 1,0000 & 0,0000 & 0,6667 & 0,0000 & 0,3333 \end{pmatrix}.$$

For the choice of the best alternative we shall calculate middle and optimistic convolution with help of formulas (6) - (7) and we shall write down them as a table:

	$\mu_A^4(x_j)$ Middle	Ranging	$\mu_A^5(x_j)$ Optimistic	Ranging
x_1	0,6180	2	0,7358	2
x_2	0,5931	4	0,7010	5
x_3	0,5747	5	0,7065	4
x_4	0,6147	3	0,7277	3
x_5	0,2641	6	0,4306	6
x_6	0,6699	1	0,7770	1

From a previous table evidently, that for middle and optimistic convolution the best alternative will be x_6. Calculation of alternatives is impossible for careful and pessimistic convolution, so as a matrix of *Z* has zero values. Thus, the choice of the best alternative generally speaking depends on the psychosomatic mood of PMD.

Conclusion

Choice problem model of depends on the "point of pleasure" and determination of fuzzy set that can be formulated in different ways. The considered approach of designing of multicriterion task of choice allows to build arranging row for alternatives using their comparing to the "point of pleasure" and using the different types of convolution. It differs from the known approaches because it does not need pair comparison of alternatives.

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Bibliography

[Malyar, 2006] Маляр М.М. Задача вибору та підхід до її розв'язання // Вісник СевДТУ. Вип.50: Інформатика, електроніка, зв'язок: Зб. наук. Пр.. – Севастополь: Вид-во СевДТУ, 2006.- С.98 - 104.

[Osipova, 1968] Методика и техника статистической обработки первичной социологической информации. Под. ред. Г.В.Осипова.- М.: Наука,1968.-326с.

[Zadeh, 1965] Zadeh L. Fuzzy Sets // Information and Control. — 1965. — №8. — P. 338–353.

[NBU, 2000] Положення НБУ "Про порядок формування та використання резерву для відшкодування можливих втрат за кредитними операціями банків"; Затв. постановою Правління НБУ №279 від 06.07.2000р.

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