DECISION MAKING IN UNCERTAINTY, BY FUZZY THEORY AND LOGIC, IN THE FIELD OF ROMANIAN INVESTMENTS

LUAREA DECIZIILOR ÎN CONDIȚII DE INCERTITUDINE, UTILIZÂND TEORIA ŞI LOGICA FUZZY ÎN DOMENIUL INVESTIȚIONAL DIN ROMÂNIA

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Abstract: *The paper presents a case study of decision making: the choice of a production line for natural juices among 10 offers coming from 5 countries. 6 performance criteria are applied, two of them being fuzzy.*

Rezumat: *În această lucrare este prezentat un studiu de caz specific procesului decizional: alegerea unei linii de productie pentru obtinerea sucului natural din 10 oferte venite din 5 tari diferite. 6 criterii de performanta sunt utilizate in aplicatie, iar doua dintre ele sunt fuzzy.*

Key words**:** *decision making, uncertainty, fuzzy decision making process, decisional matrix*
Cuvinte cheie: *luarea deciziilor, incertitudine, procesul de luare a deciziilor în condiții fuzzy, matrice decizională*

INTRODUCTION

Decision-making is generally a most difficult domain of the contemporary management. Firms constitute a vast market for raw materials, equipment, installations and business services. The companies that sell raw materials and equipment must understand the buyers need, their resources, policies and buying procedures.

It is well known that the industrial market consists of all the individuals and organizations that acquire products and services that enter into the production process of other products/services that are sold, rented or supplied to others. The major types of industries making up the industrial market are agriculture, forestry, mining, manufacturing, constructions, transportations, communications and public utilities.

For us, in this paper, agriculture and food production will be the field of interest.

The industrial buyer is an investor that faces a whole set of decisions in making a purchase. The number of decision depends on the type of the buying situation. Making decision means to make a choice between more possibilities. If the decision making process describes an investment situation where the purchasing department reorders on a routine bases, we will call this buying situation "straight re-buy". They are cases when the investor chooses from suppliers the product/equipment specifications, which in the past give him the higher buying and using satisfaction.

"The modified re-buy" describes a purchasing situation where the buyer wants to modify the product/equipment specifications, prices or terms. The modified re-buy usually expands the number of decision participants.

"The new task" faces a purchaser buying a product or a service for the first time. The greater the cost and/or risk, the longer the number of decision participants and the greater their information seeking. The new task situation is the investors' greatest opportunity and challenge. Also the marketer tries to reach as many key buying influences as possible and provide helpful information and assistance.

The numbers of decisions that the investor/buyer has to make are fewest in the straight

re-buy and the most in the new-task situation.

Industrial buyers are subject to many influences when they make their decisions. Some marketers assume that the most important influences are economic. They see the buyers as favouring the supplier who offers the lowest price, or best product, or most service. Other marketers see buyers responding to personal factors such as favours, attention, or risk avoidance. Industrial marketers must know their customers and adapt their tactics to individual, economical, organizational and environmental situations.

Investors do not buy goods/equipment/services for personal consumption. They buy to make more money, to reduce costs, to obtain profits and to satisfy a social obligation.

The choice between more possibilities, which could appear in the making decision process, must be underlined by different conditions specific for the decisional criteria. These conditions can be uncertain, or maybe they could generate risks for the manager, the decision maker and the environment.

The paper analyses the decision-making process in uncertainty, particularly in investments in Romania.

MATERIALS AND METHODS

In uncertainty could appear more than one possible events, we know these events but we can't estimate the probabilities of their appearance.

Uncertainty always exists in human life. The research of uncertainty needs probabilities and fuzzy elements to build up specific decisional models.

Human behaviour is uncertain. That's why researchers developed new studies of this behaviour by using fuzzy logic. To understand how it works in business, we will take as example the activity of a manager who works in food industry, in a firm specialized in the production of 100% natural forest-fruit juices.

The main activity of the firm is to collect from all over Romania or to cultivate in their own greenhouse forest fruits, and to produce natural juice, packed in Tetra-Pack.

So, the main product of our firm is natural juice. In the technological process, near the forest fruit juice the firm produces also secondary products like: forest fruit jams, yogurts, sherbets and alcoholic drinks. For our study we are interested in the main product of the firm: 100% natural forest-fruit juice of different ranges.

To obtain this product, the manager has to make a lot of investments. One of these investments is the acquisition of a production line.

In Romania the only possibilities for our manager to buy a high tech production line is to buy it from abroad, that means to import the production line. The product manager of the firm studied the market of the offered production lines for natural juices, and the result was that in the whole world, the highest quality of such products are supplied by firms from the following countries: Italy, America, Germany, Holland, Spain, France, Australia and Austria. Which of these products will be the best for our manager? Which is the best decision to make?

Unfortunately, because of the complexity and the uncertainty of this problem it is hard to make the right choice without using a decision making model. Two of the 8 countries (America and Germany) offers two types of production lines, because there exist two brands with high quality and low consumption inside the American and German markets.

When our manager makes a decision he is interested by the following criteria, which may concern in an acquisition process of production lines:

C_1 = the production capacity (litre/hour); C_2 = the price (euro); C_3 = the energy consumption (kw/h); C_4 = the return on investment (years); C_5 = manoeuvrability; C_6 = the firm's degree of confidence

C_1, C_2, C_3 and C_4 are 100% quantitative criteria while C_5 and C_6 are qualitative. That means we have to use a scale (between 0 and 1) to establish crisp values for these elements.

All the data concerning the 10 types of production lines and the 6 criteria are represented in table 1. Our manager wants to choose a high quality production line because he wishes the main product of the firm to become an excellent brand and an image of high quality.

In the decisional matrix we have quantitative and qualitative elements for each of the six criteria, and also we use importance coefficients for these criteria. That means each manager gives higher or lower importance to each criteria using as factors of influence: the type of the alternatives, the specific of the decisional process, the objectives of the firm and the experience in making decisions of each manager. To establish exactly the importance coefficients we will use the well known test of the universal specialist (TSU). This test starts with the identification of all the people concerned about the decisional process (in our case managers and engineers) who will make a subjective top of the criteria, using nothing else but their own experience and competence.

Practically in our fuzzy decision making process we will use in the TSU test only 2 managers and 2 engineers. The estimation of the importance coefficients starts with table 2, the top of the criteria in subjective order.

Table 1

The decision matrix

Firm	Contry	C_1	C_2	C_3	C_4	C_5	C_6
V_1	Italy	55	100,500	50	3	medium	medium
V_2	USA	75	155,000	65	4	easy	low
V_3	USA	80	175,000	90	4	very easy	high
V_4	Germany	90	180,000	100	5	easy	very high
V_5	Germany	90	195,000	100	6	easy	medium
V_6	Holland	50	200,000	70	3	very hard	low
V_7	France	60	185,000	60	7	very hard	low
V_8	Spain	65	205,000	75	7	heavy	high
V_9	Australia	55	215,000	95	9	easy	high
V_{10}	Austria	50	165,000	95	9	heavy	very low
-	K_j	2	2	1.66	1.34	2	1

K_j is the importance coefficient estimated as follows:

Table 2

Individual top TSU

Top	Manager M_1	Manager M_2	Engineer E_1	Engineer E_1
1	C_3	C_2	C_5	C_1
2	C_5	C_1	C_3	C_2
3	C_2	C_3	C_1	C_5
4	C_1	C_5	C_2	C_4
5	C_6	C_4	C_4	C_6
6	C_4	C_6	C_6	C_3

Each place in the top of this table will have a number of points in reverse order, so 6 points will have the first place and 1 point the last place, as follows in table 3.

Table 3

The estimation of the importance coefficients

C_j	Manager M_1	Manager M_2	Engineer E_1	Engineer E_2	Total	Place in top	Points	K_j
C_1	3	5	4	6	18	I	6	2
C_2	4	6	3	5	18	I	6	2
C_3	6	4	5	1	16	II	5	1.66
C_4	1	2	2	3	8	III	4	1.34
C_5	5	3	6	4	18	I	6	2
C_6	2	1	1	2	6	IV	3	1

For example, column M_1 shows that C_1 is in table 2 on the 4th place, which means it, will earn 3 points. C_2 is on the 3rd place and will receive 4 points, and so on.

To estimate finally the value of the coefficients we will make the following calculus:

$K_0 = 10/30 = 0.33$; $K_1 = 6 \times 0.33 = 2$; $K_2 = 6 \times 0.33 = 2$; $K_3 = 5 \times 0.33 = 1.66$; $K_4 = 4 \times 0.33 = 1.32$; $K_5 = 6 \times 0.33 = 2$; $K_6 = 3 \times 0.33 = 1$

The sum of the six importance coefficients has to be 10. We have now all the data needed to start the fuzzy decision logic, namely the estimation of the membership functions.

Suppose that $V_i = \{V_1, V_2 \ldots V_i\}$ a multitude of alternatives which concurred with a multitude of criteria $C_j = \{C_1, C_2 \ldots C_i\}$

V_1 is the alternative with utility 1 (the highest) and V_0 is the alternative with utility 0 (the lowest). For example C_1 is a maximum criterion because each manager wants to have the highest possible production capacity. The maximum value of C_1 will be pointed with 1 in the matrix of the membership functions. C_2 is a minimum criterion because each manager wants to buy the cheapest product. That means the lowest price will be pointed with 0. C_3 and C_4 are minimum criteria. C_5 and C_6 are qualitative criteria, so to estimate them we will use a scale with points between 0 and 1 as follows:

For C_5: very heavy means 0 points, heavy 0.25, medium 0.5, easy 0.75, very easy 1

For C_6: very low means 0 points, heavy 0.25, medium 0.5, high 0.75, very high 1.

Using the above scales and the points established for the six criteria, we shall build the matrix of distance degrees.

Table 4

C_j and V_j	C_1	C_2	C_3	C_4	C_5	C_6
V_1	0.38	0	0	0	0.5	0.5
V_2	0.17	0.35	0.23	0.25	0.75	0.25
V_3	0.11	0.42	0.44	0.25	1	0.75
V_4	0	0.44	0.5	0.4	0.75	1
V_5	0	0.48	0.5	0.5	0.75	0.5
V_6	0.44	0.49	0.28	0	1	0.25
V_7	0.33	0.45	0.16	0.57	1	0.25
V_8	0.27	0.51	0.93	0.57	0.25	0.75
V_9	0.38	0.53	0.47	0.66	0.75	0.75
V_{10}	0.44	0.39	0.47	0.66	0.25	0

The estimation of the distance grades is different for the maximum and minimum criteria. For example, C_1 is a maximum criterion. The calculus will be:

x_1^* (distance grade for V_1 and C_1) $= 1 - a_{ij}/a_{1j}$

Where a_{ij} is the consequence of a variable V_i using C_j criterion.

$x_1^* = 1 - 55/90 = 0.38$ $x_6^* = 1 - 50/90 = 0.44$

$x_2^* = 1 - 75/90 = 0.17$ $x_7^* = 1 - 60/90 = 0.33$

$x_3^* = 1 - 80/90 = 0.11$ $x_8^* = 1 - 65/90 = 0.27$

$x_4^* = 1 - 90/90 = 0$ $x_9^* = 1 - 55/90 = 0.38$

$x_5^* = 0$ $x_{10}^* = 1 - 50/90 = 0.44$

C_2 is a minimum criterion, so the calculus of the distance grades is inversely as before:

$x_1^* = 1 - a_{1j}/a_{ij}$

We obtain:

$x_1^* = 1 - 100{,}500/100{,}500 = 0$

$x_2^* = 1 - 100{,}500/155{,}000 = 0.35$

$x_3^* = 1 - 100{,}500/175{,}000 = 0.42$

$x_4^* = 1 - 100{,}500/180{,}000 = 0.44$

$x_5^* = 1 - 100{,}500/195{,}000 = 0.48$

……..and so on for each criterion.

Table 5

The matrix of distance degrees (coefficients of importance)

C_j and V_j	C_1	C_2	C_3	C_4	C_5	C_6
V_1	0.76	0	0	0	1	0.5
V_2	0.34	0.70	0.38	0.33	1.5	0.25
V_3	0.22	0.84	0.73	0.33	2	0.75
V_4	0	0.88	0.83	0.53	1.5	1
V_5	0	0.96	0.83	0.67	1.5	0.5
V_6	0.88	0.98	0.46	0	2	0.25
V_7	0.66	0.90	0.26	0.76	2	0.25
V_8	0.54	1.02	1.54	0.76	0.5	0.75
V_9	0.76	1.06	0.78	0.88	1.5	0.75
V_{10}	0.88	0.78	0.78	0.88	0.5	0

RESULTS AND DISCUSSION

Using the values established in table 5, we can estimate another value called "the affiliation degree at the best variant". This value will be used to optimize the decisions.

The affiliation degree is estimated by using the mathematical functions e^x and e^{-x}.

Table 6

The matrix of affiliation degree e^{-x}

C_i and V_i	C_1	C_2	C_3	C_4	C_5	C_6	Σ	Σ/C_j
V_1	0.47	1	1	1	0.37	0.61	4.45	0.74
V_2	0.71	0.5	0.68	0.72	0.22	0.78	3.61	0.60
V_3	0.8	0.43	0.48	0.72	0.14	0.47	3.04	0.51
V_4	1	0.41	0.44	0.59	0.22	0.37	3.03	0.51
V_5	1	0.38	0.44	0.51	0.22	0.61	3.16	0.53
V_6	0.41	0.38	0.63	1	0.14	0.78	3.34	0.56
V_7	0.52	0.41	0.77	0.47	0.14	0.78	3.09	0.52
V_8	0.58	0.36	0.21	0.47	0.61	0.47	2.70	0.45
V_9	0.77	0.35	0.46	0.41	0.22	0.47	2.38	0.4
V_{10}	0.41	0.46	0.46	0.41	0.61	1	3.35	0.56

$e^{-0.76} = 0.47$; $e^{-0.34} = 0.71$; $e^{-0.22} = 0.8$ and so on.

CONCLUSIONS

The values of the affiliation degree are between 0 and 1. The best decision of choosing a production line is given by the highest value of Σ/C_j. This is 0.74.

So, our manager will choose V_1, a production line made in Italy.

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