

## The Use of Fuzzy Logic at Support of Manager Decision Making

The use of fuzzy logic is the advantage especially at decision making processes where the description by algorithms is very difficult and criteria are multiplied. The advantage is that the linguistic variables are used. The fuzzy logic measures the certainty or uncertainty of membership of element of the set. Analogously the man makes decision during the mental and physical activities. The solution of certain case is found on the principle of rules that were defined by fuzzy logics for similar cases. The fuzzy logics belong among methods that are used in the area of decision making of firms and offices.

### The fuzzy processing

The calculation of fuzzy logics consists of three steps: fuzzyfication, fuzzy inference and defuzzyfication.

- The fuzzyfication means that the real variables are transferred on linguistic variables. The definition of linguistic variable goes out from basic linguistic variables, for example, at the variable risk it is set up the following attributes: none, very low, low, medium, high, very high risk. Usually there are used from three to seven attributes of variable. The attributes are defined by the so called membership function, such as  $\Lambda$ ,  $\pi$ ,  $Z$ ,  $S$  and some others. The membership function is set up for input and output variables.

- The fuzzy inference defines the behavior of system by means of rules of type <When>, <Then> on linguistic level. The conditional clauses evaluate the state of input variables by the rules. The conditional clauses are in the form

$$\langle \text{When} \rangle \text{Input}_a \langle \text{And} \rangle \text{Input}_b \dots \text{Input}_x \langle \text{Or} \rangle \text{Input}_y \dots \dots \langle \text{Then} \rangle \text{Output}_1,$$

it means, when (the state occurs)  $\text{Input}_a$  and  $\text{Input}_b, \dots, \text{Input}_x$  or  $\text{Input}_y, \dots$ , then (the situation is)  $\text{Output}_1$ .

The fuzzy logic represents the expert systems. Each combination of attributes of variables, incoming into the system and occurring in condition <When>, <Then>, presents one rule. Every condition behind <When> has a corresponding result behind <Then>. It is necessary to determine every rule and its degree of supports (the weight of rule in the system). The rules are created by the expert himself:

- The defuzzification transfers the results of fuzzy inference on the output variables, that describes the results verbally (for example, whether the risk exists or not).

The system with fuzzy logics can work as an automatic system with entering input data. The input data can be represented by many variables.

### Case I:

The first case presents the use of fuzzy logic at the decision making of grant of mortgage loan by the bank. The FuzzyTech program was used for the calculation. The application uses five input variables with three or five attributes, four rule boxes and one output variable with five attributes. See the model on the fig.1. It is necessary to design the variables, their attributes and their membership functions.

The inputs are represented by variables Asset, Income, Properties, Building and Land. The outputs from the rule blocks are Credit, Applicant and Construction. The output variable is Credit.

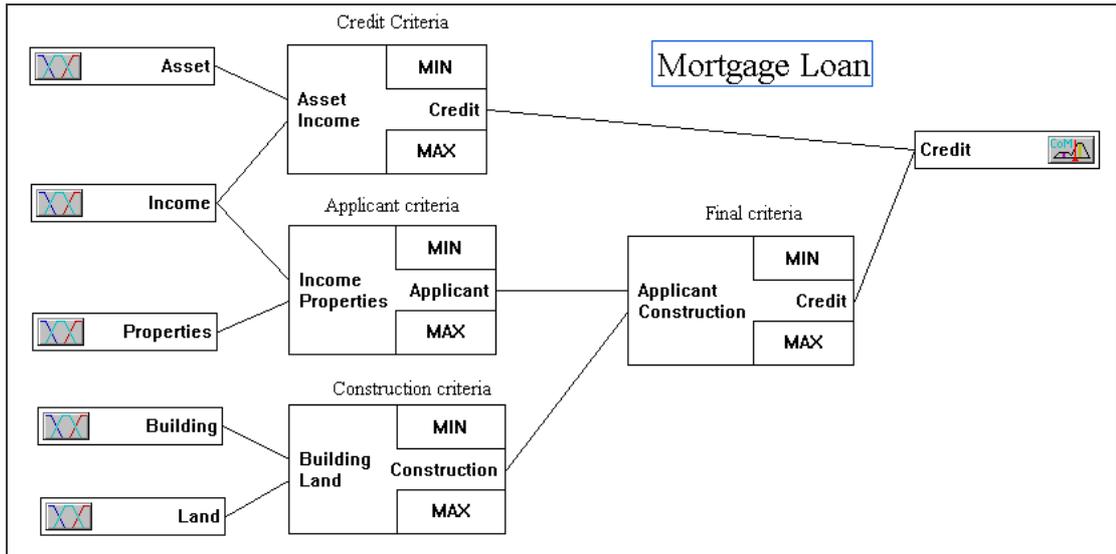


Fig.1. Project chart

The variable Building has five attributes and variables Asset, Income, Properties, Land have three attributes, the rule box Credit, Applicant, Construction have three attributes. The output variable Credit has five attributes. The membership functions are of the shape  $\Delta$ , S and Z. The variable Income is smooth curve. The following pictures show the attributes and membership functions some of the variables Building (fig.2), Properties (fig.3) and Income (fig.4).

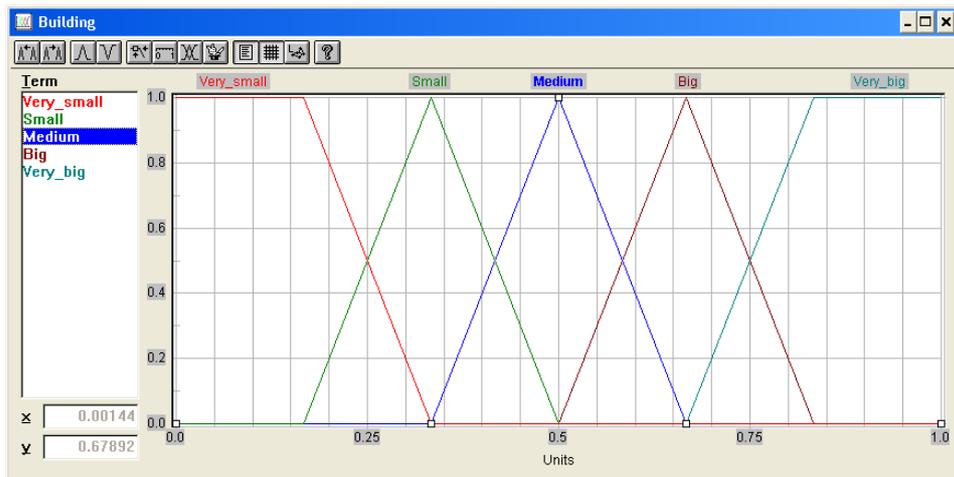


Fig.2. The attributes and membership functions of variable Building



Fig.3. The attributes and membership functions of variable Properties

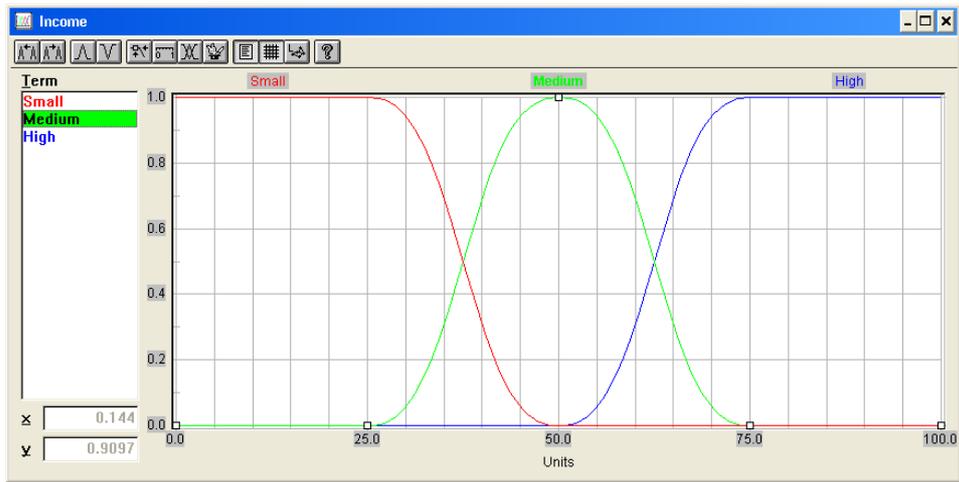


Fig.4. The attributes and membership functions of variable Income

The fig.5 shows the attributes and membership functions of the Applicant.

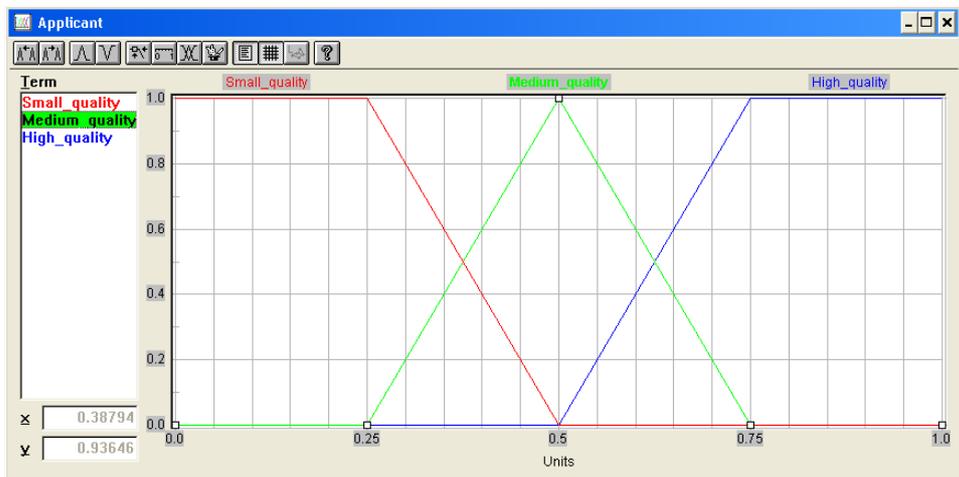


Fig.5. The attributes and membership functions of variable Applicant

The fig.7 shows the attributes and membership functions for the output variable Credit. The set up attributes present the amount of money to be granted: None, Low, Medium, High and Full.

The fig.6 show two from four rule blocks with their rules and degree of support that set up the relation between input and output variables. The fig. 6a shows the rule block Construction and the fig. 6b shows the rule block Credit (input Applicant and Construct).

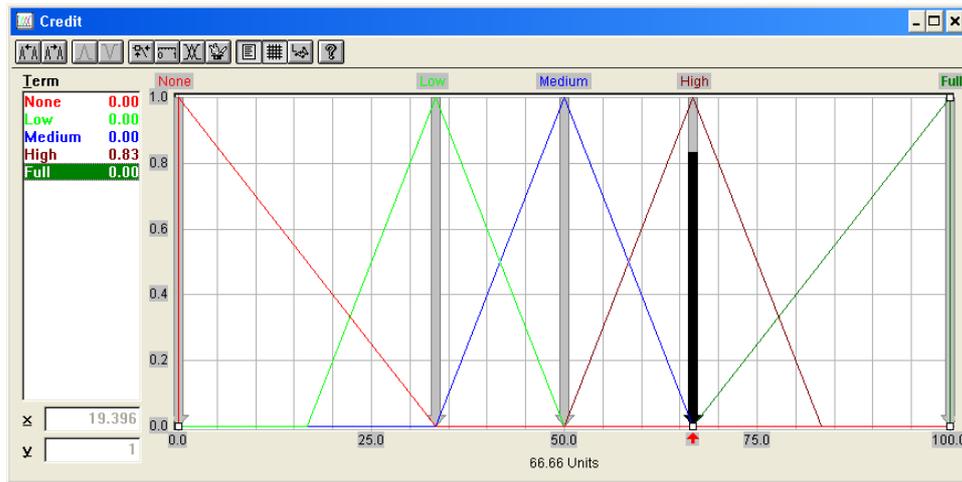
Spreadsheet Rule Editor - Construction				
	IF		THEN	
	Building	Land	DoS	Construction
1	Very_small	Small	1.00	Small
2	Very_small	Medium	1.00	Small
3	Very_small	Large	1.00	Medium
4	Small	Small	1.00	Small
5	Small	Medium	1.00	Medium
6	Small	Large	1.00	Medium

Fig. 6a

Rule block

Spreadsheet Rule Editor - Credit				
	IF		THEN	
	Applicant	Construction	DoS	Credit
1	Small_quality	Small	1.00	Low
2	Small_quality	Medium	1.00	None
3	Small_quality	High	1.00	None
4	Medium_quality	Small	1.00	Medium
5	Medium_quality	Medium	1.00	Low
6	Medium_quality	High	1.00	None

Fig. 6b

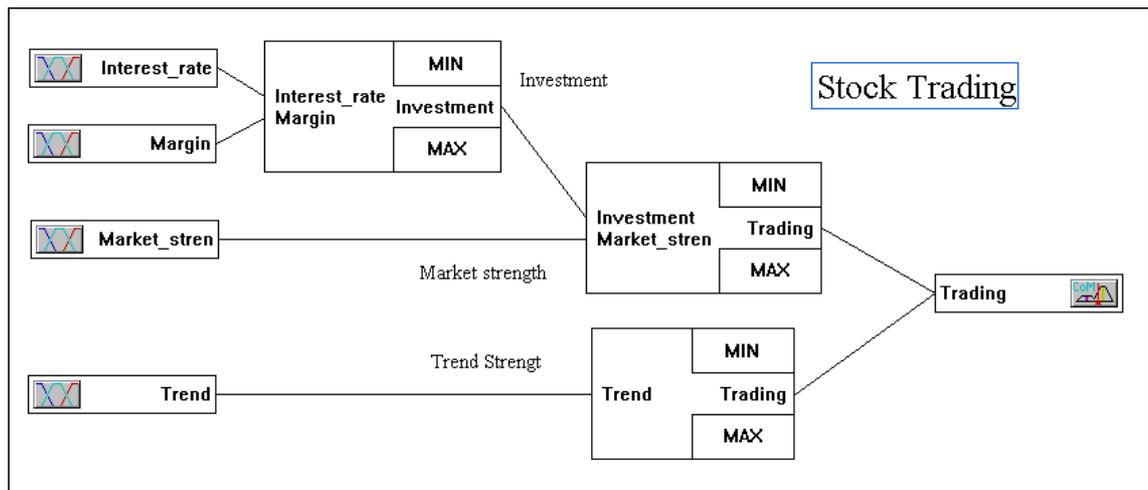


**Fig.7** The output Credit and the result of fuzzy processing

When the model is made, it is necessary to tune it (to set up the inputs on known values, evaluate the results and to change the rules or weights, if necessary). If the system is tuned, it is possible to use it in practice. The fig.7 shows the result, where the grant of credit is evaluated to High amount of money.

### Case II:

The second case presents the use of fuzzy logic at stock trading, if the trade to realize or not. See the model on fig.8.



**Fig.8** Project chart

The input variables and their attributes are Interest rate (low, medium, high), Margin (insignificant, significant), Market strength (low, medium, high) and Trend of shares (strong, weak). The rules box with attributes are Investment (unsuitable, neutral, suitable), Trading - Market strength (yes, no) and Trading – Trend strength (yes, no). The output variable Trading (yes, no) determines, whether to make a trade or not.

### Case III:

The third case presents the use of fuzzy logic at direct mailing, whether the client visit personally, sent him a letter or not to speak to him. See the model on fig.9.

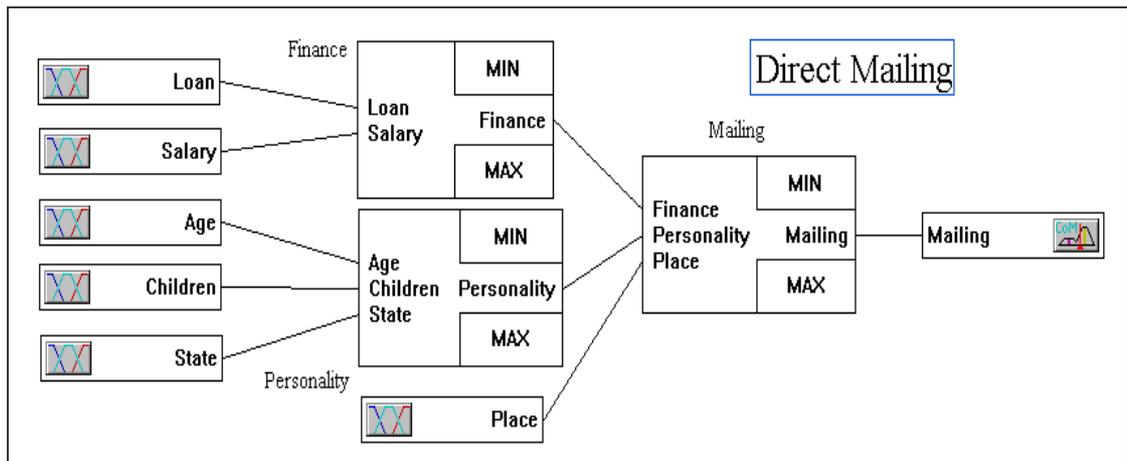


Fig.9 Project chart

The input variables and their attributes are Loan (none, small, medium, high), Salary (low, medium, high), Age (young, medium, old, very old), Children (no, a few, many), State (single, married, divorced) and Place (big city, city, village). The rule blocks with attributes are Finance (excellent, good, bad), Personality (unsuitable, suitable, good, excellent); and Mailing (inactivity, mail, personally). The output variable Mailing with the attributes evaluates whether the client will be visited or a letter will be sent to him or he will not be spoken to him. See fig.10.

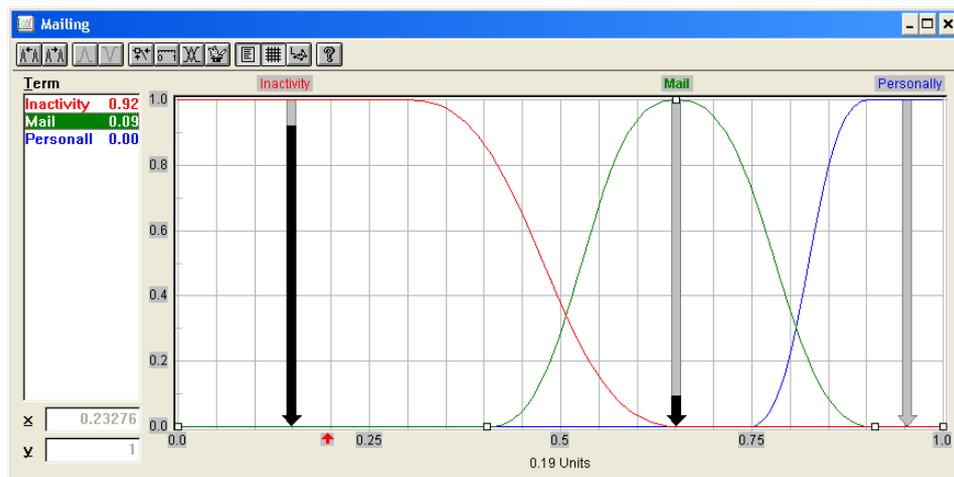


Fig.10 The attributes and membership functions of output variable Marketing

The set up of the rule block distinguish single cases. For example, the result of decision making is the inactivity with client in case when the person has a low salary and a lot of loans, he lives in a village, he is of old age, he is single and without children.

The effort is to bring the profit in future from the investment into the marketing. The evaluation, whether the marketing project is profitable or loss-making, is possible to evaluate after certain time.

### Conclusion:

The mentioned three cases are only the fractions of possible variants of the use of fuzzy logic in various areas of decision making. The theory of fuzzy logic contributes to the quality of decision making. The decision making process is an important activities of the firms. It is possible to say, that the successful decision making make the firm successful.

It is necessary to emphasize, that these methods support the decision making and that the responsibility of optimal variant or variants are on those, who makes the decision.

The fuzzy logic besides artificial neural networks and genetic algorithms belongs to relative strong method as a tool for the support of decision making.