# RISK MANAGEMENT AND FUZZY LOGIC

## 1. Introduction

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.

## 2. Fuzzy logic - theory

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 Λ, Π, Z, S and some others. The membership function is set up for input and output variables.

• The fuzzy inference defines the behaviour 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

<When> $Input_a$ <And> $Input_b$ ….. $Input_x$ <Or> $Input_y$ …….. <Then> $Output_1$,

it means, when (the state occurs) $Input_a$ and $Input_b$, ….., $Input_x$ or $Input_y$, …… , then (the situation is) $Output_1$.

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.

## 3. Fuzzy logic – case study

At first it is necessary to set up the number of inputs and outputs and their variables. The input values are represented by Sex (man, woman), Age (young, middle, old), Marital status (married, single, other), Children (none, one, more), Income (low, middle, high), Account (none, small, high), Debt (none, low, high), Employment (short, middle, long), Contact with client (short, middle, long), Order (first, several, more), Delayed payment (none, few, more), it represents the eleven inputs with two or three attributes according the demand of the project. The output is represented by the Risk of payment of the debt by the client with attributes (low, medium, high). The created model by means of fuzzyTech is on fig.1.

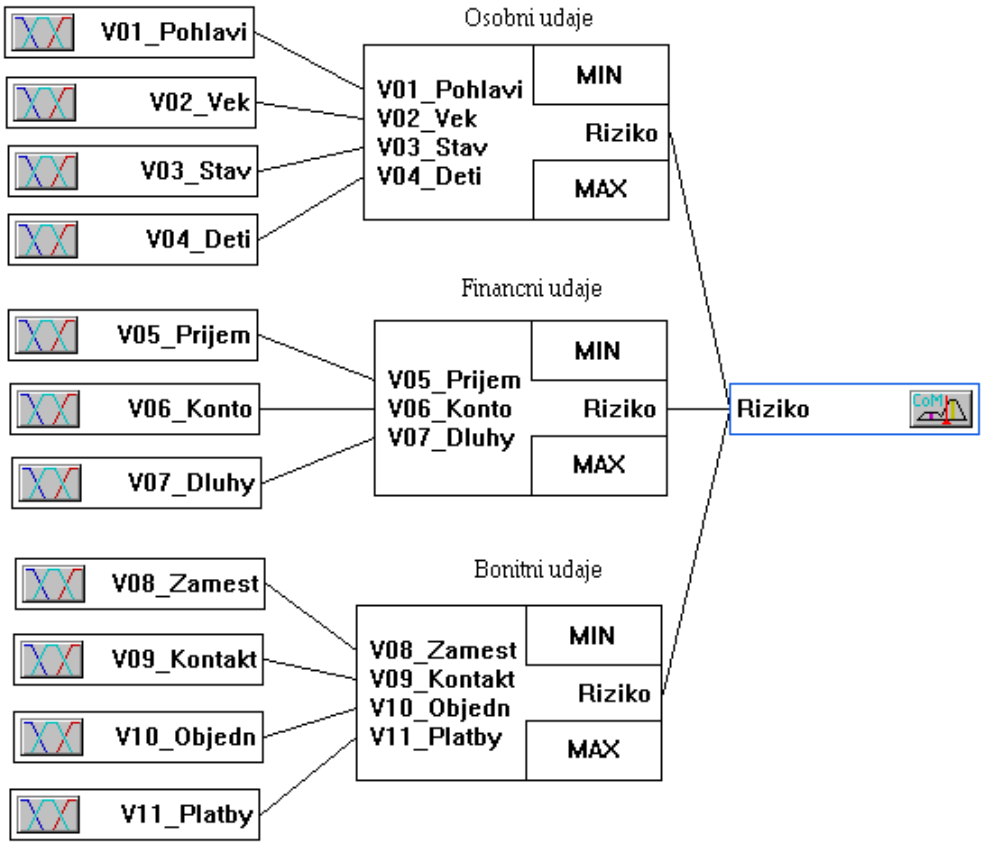


**Fig.1** Project chart

It is necessary to set up the membership functions for all inputs and output. We use the functions in the shape S, Λ, Π, Z for all eleven inputs with three, or two attributes. The variable Income has smooth curve. The following pictures show the attributes and membership functions of this variable Income (fig.2).

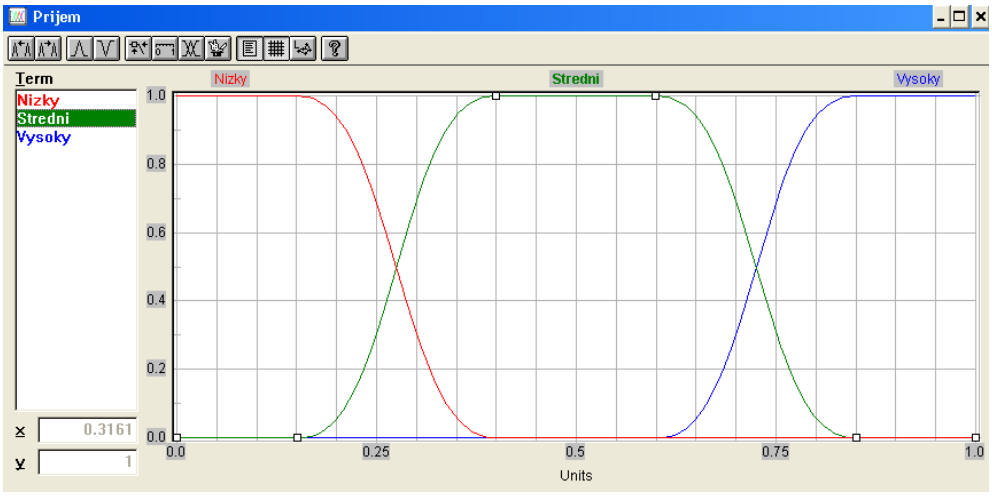


**Fig.2** The attributes and membership functions of variable Income

Further it is necessary to set up the shapes of membership functions of output variable. We choose the curves S, Π and Z, that describes the reality best. The following pictures show the attributes and membership functions variable Risk of payment of the debt (fig.3).

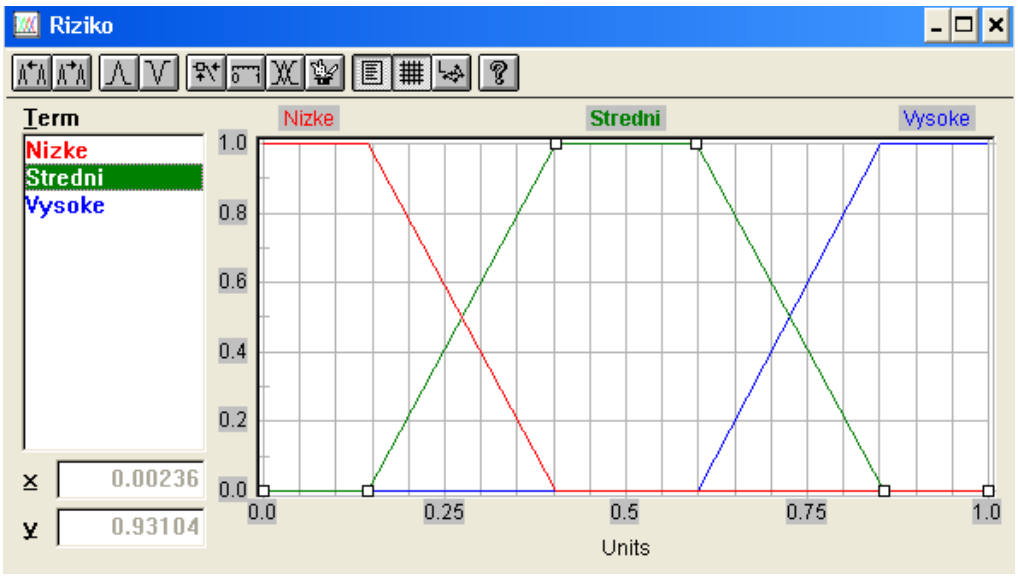


**Fig.3** The attributes and membership functions of variable Risk

It is necessary to set up the rules and their degree of support (DoS) between inputs and outputs. The part of the table is on the fig.4.


| | IF | | | THEN | |
|---|---|---|---|---|---|
| | V05_Prijem | V06_Konto | V07_Dluhy | DoS | Riziko |
| 69 | Vysoky | Stredni | Nizke | 0.10 | Vysoke |
| 70 | Vysoky | Stredni | Vysoke | 0.50 | Nizke |
| 71 | Vysoky | Stredni | Vysoke | 1.00 | Stredni |
| 72 | Vysoky | Stredni | Vysoke | 0.50 | Vysoke |
| 73 | Vysoky | Vysoke | Zadne | 1.00 | Nizke |

**Fig.4** Part of the rule box

The model is possible to use for the evaluation of the risk of the payment of the debt, as it is presented on fig. 5. The risk of not payment of debt is very high, that was evaluated from input data.

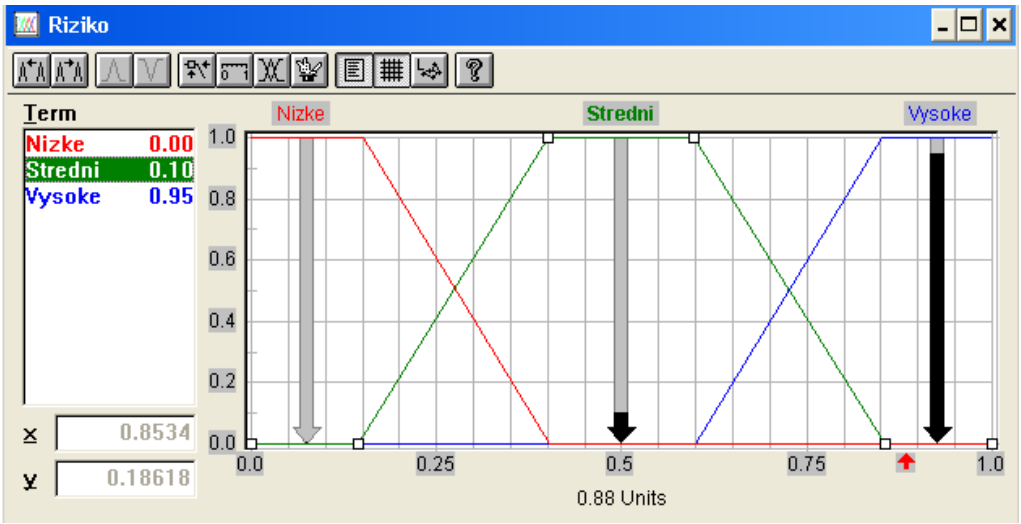


**Fig.5** The results of evaluation of variable Risk

Note: The shape of membership functions and their degree of support is possible to set up by means of artificial neural network. The result of such set up output variable Risk is on the fig.6.

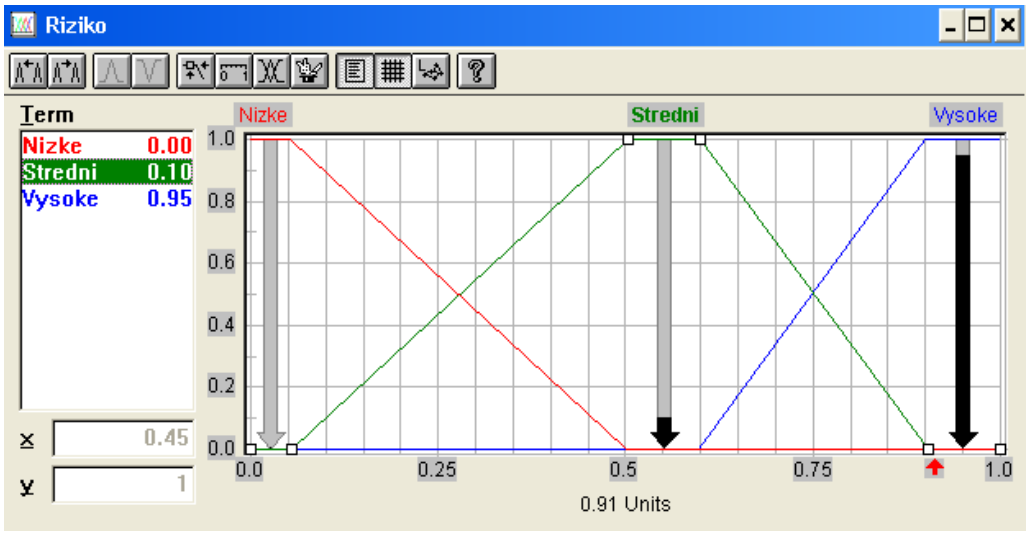


**Fig.6** The results of evaluation of variable Risk

# 4. Conclusion

The use of fuzzy logic is the advantage especially at risk management where the description by algorithms is very difficult and criteria are multiplied. It is possible to say, that the wrong decisions can caused the bankruptcy of the firm. The task of the use of fuzzy logic in the process of decision making is increasing. The support of decision making does not remove the responsibility of the manager of his decision, but it can provide valuable information and thus to improve the quality of decision making in the process of risk management.