# Risk Investment and Fuzzy Interface System

## Introduction

The fuzzy logic belongs among soft computing methods. The guiding principle of fuzzy logic means to the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability and robustness. The created model helps in decentralization of decision-making processes to be standardized, reproduced, and documented. The risk investment evaluation plays very important roles especially in business because it helps to reduce costs. The article presents the fuzzy logic interface system as a tool for support to the evaluation of risk investment. The major goal of the article is to present the fuzzy logic interface model for evaluating of risk investment using the case study.

## Fuzzy logic

A fuzzy set is a set whose elements have degrees of membership. Fuzzy set was introduced by Lotfi A. Zadeh in 1965 as an extension of the classical notion of set and can be applied in many fields of human activity. Fuzzy set determines "how much" the element belongs to the set. This is the basic principle of fuzzy set (Zadeh 1965).

A fuzzy set $A$ is defined as $(U, \mu_A)$, where $U$ is the relevant universal set and $\mu_A$: $U \rightarrow \langle 0,1 \rangle$ is a membership function, which assigns each element from $U$ to fuzzy set $A$. The membership of the element $x \in U$ of a fuzzy set $A$ is indicated $\mu_A(x)$. We call $F(U)$ the set of all fuzzy set. Then the "classical" set $A$ is the fuzzy set where: $\mu_A$: $U \rightarrow \{0, 1\}$. Thus $x \in A \Leftrightarrow \mu_A(x) = 0$ and $x \notin A \Leftrightarrow \mu_A(x) = 1$. Let $U_i$, $i = 1, 2, ..., n$, be universals. Then the fuzzy relation $R$ on $U = U_1 \times U_2 \times ... \times U_n$ is a fuzzy set $R$ on the universal $U$.

The interval numbers are a special case of fuzzy number, so arithmetic operations with interval number have properties of operations with fuzzy numbers. Arithmetic operations on interval numbers are defined following relationships (Dostál 2011):

$$[a;b] + [c;d] = [a + c; b + d]$$
$$[a;b] - [c;d] = [a - d; b - c]$$
$$[a;b] \cdot [c;d] = [min\{ac, ad, bc, bd\}; max\{ac, ad, bc, bd\}]$$
$$[a;b]/[c;d] = [a;b] \cdot [1/d\,; 1/c] \;\; for\; 0 \notin [c;d]$$

The fuzzy logic theory is described in many books such as (Zadeh 1965; Zadeh 2012). The fuzzy application in non-technical field is described in (Dostál 2011; Dostál 2015; Dostál 2016).

The fuzzy logic system consists of three fundamental steps: fuzzification, fuzzy inference, and defuzzification. See Fig. 1.

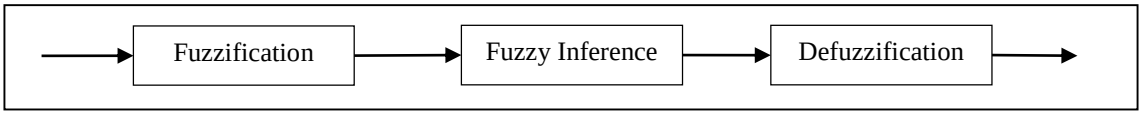



Fig.1. Decision making solved by means of fuzzy interface system (Source: Dostál 2011)

The first step (fuzzification) means the transformation of numerical values into ordinary language, if necessary. For example, risk has the linguistic values such as no, very low, low, medium, high, and very high risk. The variable usually has from three to seven attributes (terms). The degree of membership of

attributes is expressed by mathematical functions. There are many shapes of membership functions. The types of membership functions that are used in practice are for example Λ and Π. There are many other types of standard membership functions on the list including spline ones. The attribute and membership functions concern input and output variables.

The second step (fuzzy inference) defines the system behaviour by means of the rules such as <IF>, <THEN>, <WITH>. The conditional clauses create this rule, which evaluates the input variables. These conditional clauses have the form

<IF> I1 is mfA <AND> I2 is mfB . . . <AND> IN−1 is mfY <AND>IN is mfZ <THEN> O1 is mfO1 <WITH> s.

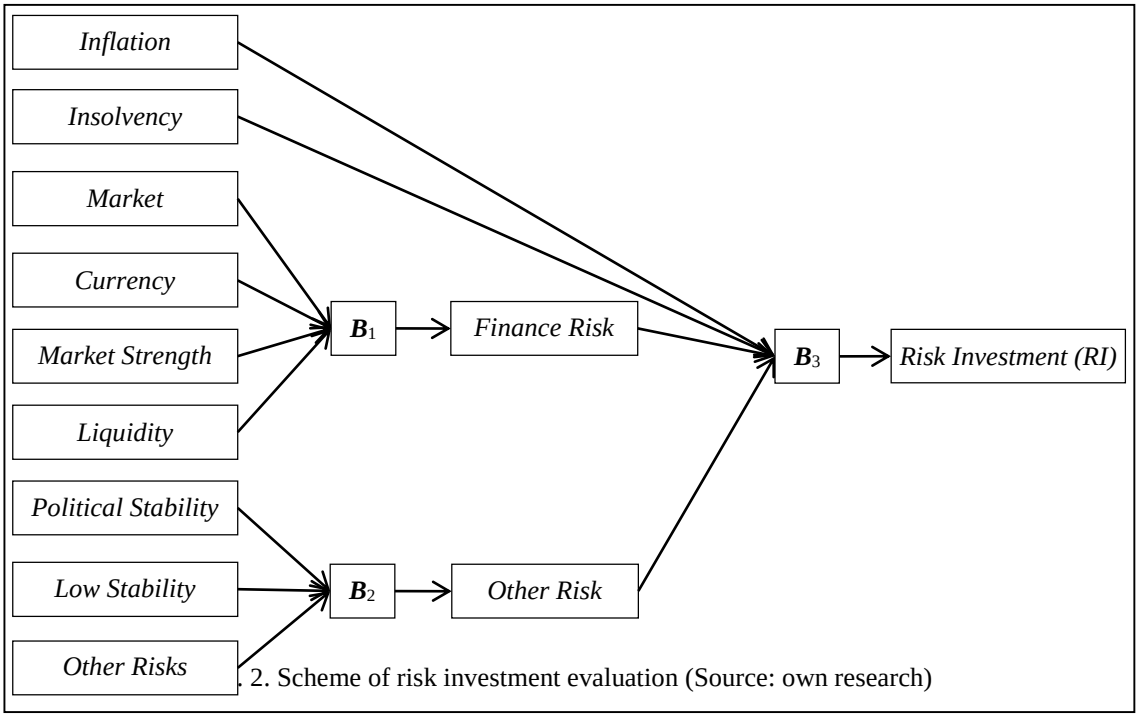
The written conditional clause could be described by words: If the input I1 is mfA and I2 is mfB and . . . and IN−1 is mfY and IN is mfZ then O1 is mfO1 with the weight s, where the value s is in the range <0–1>. These rules must be set up and then they may be used for further processing.

The fuzzy rules represent the expert systems. Each combination of attribute values that inputs into the system and occurs in the condition <IF>, <THEN>, <WITH> represents one rule. Next it is necessary to determine the degree of supports for each rule; it is the weight of the rule in the system. It is possible to change the weight rules during the process of optimization of the system. For the part of rules behind <IF>, it is necessary to find the corresponding attribute behind the part <THEN>. These rules are created by experts. The <OR> could be instead <AND>.

The third step (defuzzification) means the transformation of linguistic values to numerical ones, if necessary. For example the linguistic variables for Risk are very low, low, medium, high, and very high. During the consecutive entry of data the model with fuzzy logic works as an automat. There can be a lot of variables on the input.

## Case study

The case presents the evaluation of risk investment. The application of the fuzzy logic model is used for evaluation of investment risk to investor. The application is solved with nine input variables, three rule blocks and one output variable with three attributes. The variables *Inflation* and *Insolvency* are inputs to the final box $\boldsymbol{B}_3$ together with output from box $\boldsymbol{B}_1$ (inputs *Market*, *Currency*, *Market strength*, *Liquidity*) and output from box $\boldsymbol{B}_2$ (inputs *Political stability*, *Law stability*, *Other risks*). This case study is an example of the problem of risk investment. The input *Inflation* represents the inflation risk and input *Insolvency* the insolvency risk. The block rule $\boldsymbol{B}_1$ presents *Financial ri*sk with inputs *Marke*t, *Currency*, *Market strength* and *Liquidity risk*. The block rule $\boldsymbol{B}_2$ presents other criteria such inputs *Political stability*, *Law stability* and *Other risks*. The block rule $\boldsymbol{B}_3$ presents *Risk investment* evaluation with inputs *Inflation*, *Insolvency*, *Finance risk* and *Other risk*. The output *Risk investment RI* has three attributes Low, Medium and High Risk. The scheme of risk investment evaluation is presented on Fig. 2. The box *Financial risk*, *Other risk* and *Risk investment* is on Fig. 3a), 3b), 3c).




. 2. Scheme of risk investment evaluation (Source: own research)

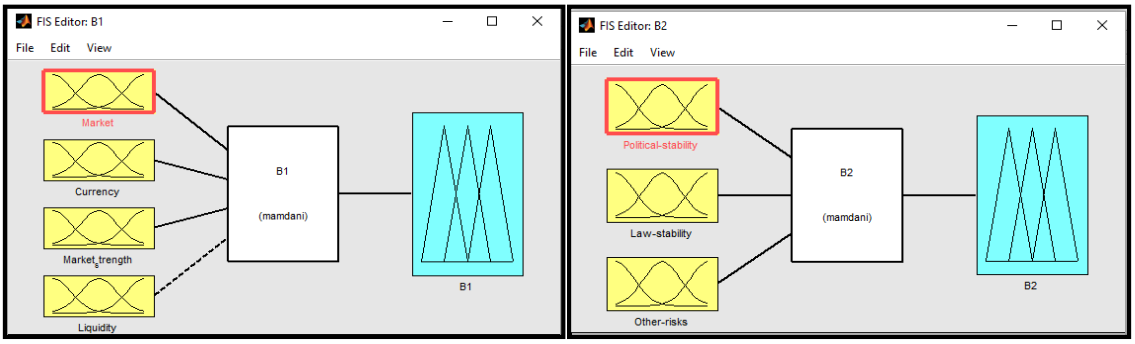



Fig. 3a), 3b). Fuzzy rule box $B_1$, $B_2$ (Source: own research)

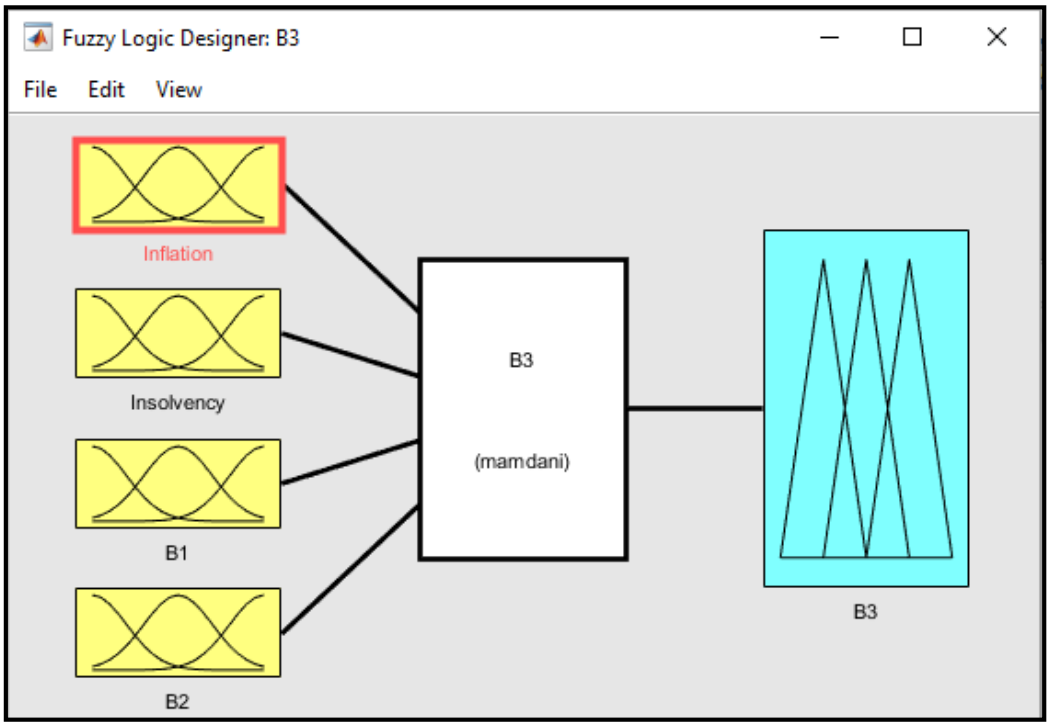



Fig. 3c). Fuzzy rule box $B_3$ (Source: own research)


Fig.4. Output of variable Risk Investment (Source: own research)

The case study is represented by inputs *Inflation* = 0.10, *Insolvency* = 0.15 *Market* = 0.15, *Currency* = 0.1, *Market strength* = 0.1, *Liquidity* = 0.1, ($\boldsymbol{B}_1$= 0.396), *Political stability* = 0.15, *Law stability* = 0.1, *Other risks* = 0.12, ($\boldsymbol{B}_2$ = 0.399). The results *Risk investment* = 0.145 and means Low risk. See Fig. 4.

## Conclusion

The fuzzy logic method plays very important roles in companies and firms because it helps to reduce the risk. The advantage of the use of fuzzy logic is characterized by inputs that are in economy field represented by imprecision, uncertainty, vagueness, semi-truth, approximations, and so forth. The use of theory mentioned above is in the sphere of analyses and simulation. The use of fuzzy logic interface system can lead to higher quality of analyses and simulations and thus to increase the quality of decision-making and reducing the risk.