

# THE FUZZY INFERENCE SYSTEM FOR EVALUATION OF PROJECT SUCCESS

## Introduction

Project management is a widely discussed discipline nowadays. This fact is substantiated by numerous scientific articles, books and publications dealing with these problems (Bergantiños, Vidal-Puga, 2009; Pérez, Rambaud, García, 2005; Rosenau, 2007; Schwable, 2011; Doležal, Máchal, Lacko, 2012; Smejkal, Rais, 2013). This discipline is also included in the courses of numerous faculties focusing on economy both in the Czech Republic and abroad. Experts are also associated in various professional organizations or associations (Společnost pro projektové řízení Česká republika, 2011; International Project Management Association, 2011).

The paper presents the possibility of project success evaluation by using fuzzy logic. The scientific aim is to propose the expert decision-making fuzzy model for evaluation of project success. Methods of analysis, synthesis and techniques of mathematical fuzzy modelling (fuzzy sets, fuzzy logic) were used to fulfil the aim.

The application of fuzzy logic is based on fuzzy set theory (Zadeh, 1965; Zimmermann, 2001; Klir & Yuan, 1995). Many authors have focused on the theory of fuzzy sets and applications of fuzzy logic in project management (Relich, 2012).

The problem of project success is also a scientific goal for some authors (Doskočil, Škapa, Olšová, 2016; Khan & Rasheed, 2015; Kemmeter, 2014; Schibi, 2013, etc.). The issue of project success is the discussion subject among a many of experts both in project management and other areas (Joslin and Muller, 2015; Obrová and Smolřková, 2013; Todorovic et al., 2015).

There are a large number of metrics for the measurement of project success. A number of authors agree on some of these, while others are appearing as new. The studies by authors such as (Yang et al., 2011 and Zwikael et al., 2014) consider research into new dimensions of project success. In the opinion of the authors, the metrics differ according to the type of project, the phase in which the project is found, the method of expression: absolute or relative (Samset, 1998), and individual interest groups which often have their own way of perceiving project success (Davis, 2014). The traditional measure of project success is based on what is known as the triple imperative of a project and is associated with the fulfilment of the time period, costs and goals of the project (de Carvalho et al., 2015).

## 1 Materials and Method

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).

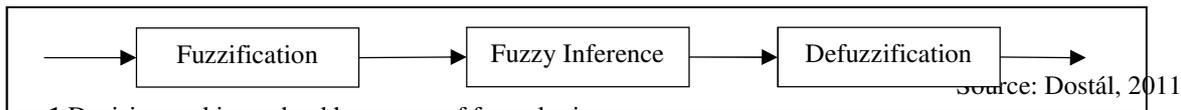
A fuzzy set  $A$  is defined as  $(U, \mu_A)$ , where  $U$  is the relevant universal set and  $\mu_A: U \rightarrow \langle 0,1 \rangle$  is a membership function, which assigns each element from  $U$  to fuzzy set  $A$ . The membership of the element  $x \in U$  of a fuzzy set  $A$  is indicated  $\mu_A(x)$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

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

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).

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



**Figure 1** Decision making solved by means of fuzzy logic

The first step (fuzzification) means the transformation of numerical values into ordinary language, if necessary. For example, project 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  $\Delta$  and  $\Pi$ . 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.

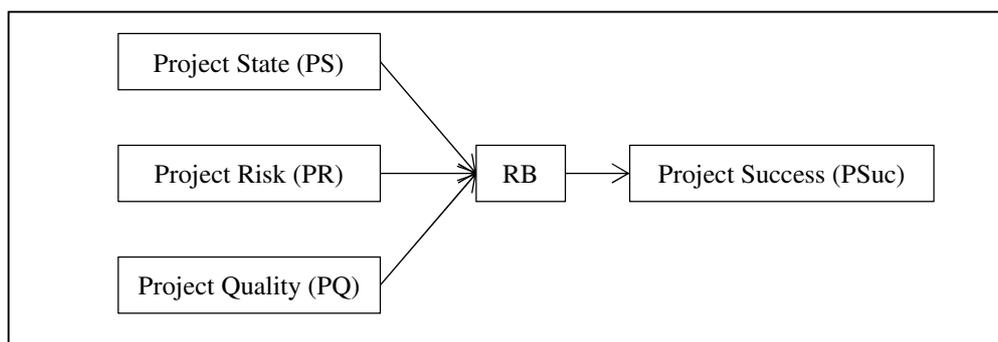
The second step (fuzzy inference) defines the system behaviour by means of the rules such as <IF>, <THEN>, <WITH>. The conditional clauses create this rule, which evaluates the input variables. These conditional clauses have the form <IF>  $I_1$  is  $m_{fa}$  <AND>  $I_2$  is  $m_{fb}$  . . . <AND>  $I_{n-1}$  is  $m_{fy}$  <AND>  $I_n$  is  $m_{fz}$  <THEN>  $O_1$  is  $m_{fo1}$  <WITH>  $s$ . The written conditional clause could be described by words: If the input  $I_1$  is  $m_{fa}$  and  $I_2$  is  $m_{fb}$  and . . . and  $I_{n-1}$  is  $m_{fy}$  and  $I_n$  is  $m_{fz}$  then  $O_1$  is  $m_{fo1}$  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.

## 2 Results

The case study presents the expert fuzzy model for evaluation of project success. The Fuzzy logic Toolbox of the MATLAB software was used for the creating of the decision making model. At first it is necessary to design the variables, their attributes and their membership functions.

The proposed expert decision-making fuzzy model consists of three input variables one rule block and one output variable. The inputs are represented by the variables Project State (PS), Project Risk (PR) and Project Quality (PQ). Output variable is Project Success (PSuc). See Figure 2.



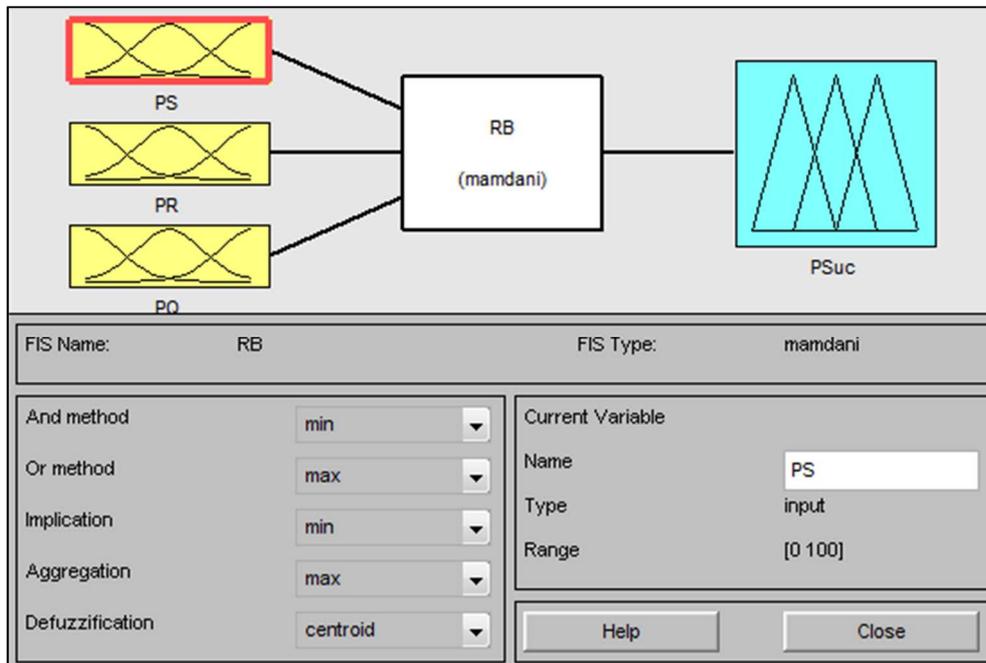
Source: own research

**Figure 2** The scheme of the model

Project State can be analysed using methods as EVM – Earned Value Management, SSD – System/Status/Deviation, MTA – Milestone Trend Analysis etc. (Doležal, Máchal, Lacko, 2012). Project Risk can be analysed using methods as RIPRAN - Risk Project Analysis or others. The RIPRAN method is a trademark, registered author of the Industrial Property Office in Prague under reg.no. 283536 (Lacko, 2015).

Project Quality can be analysed using the standards as ČSN EN ISO 9000 (010300) 2005 or ČSN ISO 10006 (010333) 2004.

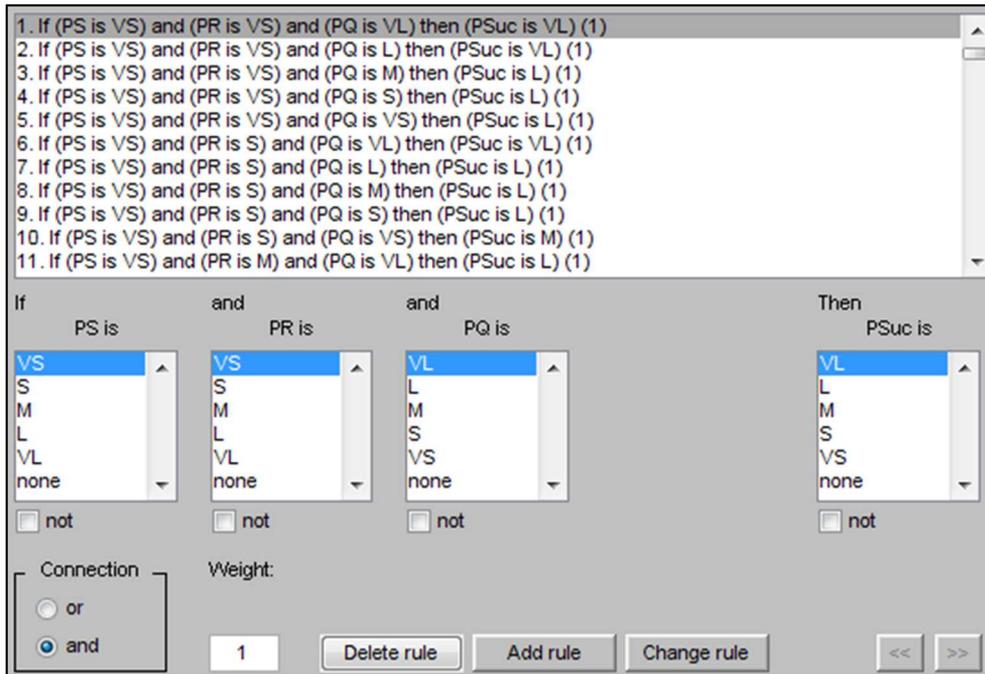
The inputs variables and output variable have five attributes: VL – veĹy laĹe, L – laĹe, M – medium, S – small, VS – veĹy small. The membership function of type *gaussmf* is used. See Figure 3.



Source: own research

Figure 3 Build-up model

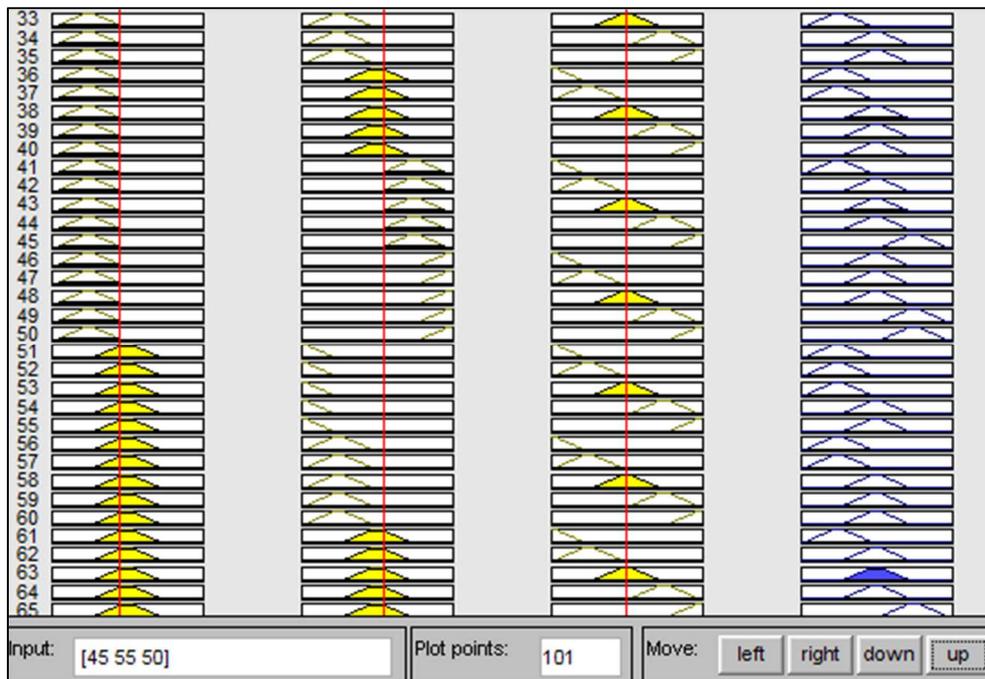
The Figure 4 shows the part of rule block (RB). There are 125 rules total and degrees of support that set up the relation between input and output variables. The list and combination of rules for the project success rate evaluation system is based on empirical research into the given subject carried out by the controlled interview technique.



Source: own research

Figure 4 Rule block and some rules

The Figure 5 shows the evaluation of project success for a concrete project. The input variables are set up as PS = 45, PR = 55, PQ = 50. This leads to the output PSuc = 50 which means that project success is medium. Using the 63<sup>th</sup> rule is expressed by the output variable PSuc allocation.



Source: own research

Figure 5 The evaluation of concrete project success

The model contains basic input variables which are used in project practice for a long time as criteria for the evaluation of project success. The fuzzy model is set to expert data. These data can be changed or can be different in other projects. The fuzzy model must be changed, if there exist some new criteria. Also must be changed if new relations between criteria would be identified or other important aspects. Then the model must be verified again. Only a verified model can be used in the practice as a tool for support of managerial decision-making. For these reasons, the proposed model cannot be considered as a final.

The proposed fuzzy model is implemented by means of abstract modelling. The fuzzy modelling was applied first and foremost in view of the ability of fuzzy sets to work with vague concepts. These concepts are widely used in everyday project practice. It would be very complicated to use the exact mathematical modelling in the project success evaluation.

The *M-File* could be built-up to implement the fuzzy interface system in MATLAB. It could be used for entering of input values and automatically evaluate project success.

The proposed fuzzy model is recommended for use primarily in the implementation and realisation phase of the project cycle and then repeatedly after each project milestone (according to WBS – Work Breakdown Structure).

### **3 Conclusions**

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. 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 logic for similar cases.

The aim of the paper was to present an expert decision-making fuzzy model for evaluation project success. This fuzzy model was based on three basic project processes evaluation – project status, project risk and project quality (fuzzy inputs). These fuzzy inputs have five attributes (VL – very large, L – large, M – medium, S – small, VS – very small). The output is the fuzzy value of project success. The membership function of type *gaussmf* was used during the fuzzy modelling.

The proposed fuzzy model is used as a tool for project managers. They can evaluate the basic project processes and the project success as a whole. They get the opportunity of using the fuzzy model for experimentation or simulations. The information about project development could be done relatively in time.