AN EXPERT FUZZY MODEL FOR THE DETERMINATION OF THE AMOUNT OF PURCHASE

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Abstract: *In this paper an expert model for the determination of the amount of purchase has been developed on the basis of the theory of fuzzy logic. Fuzzy logic has largely become a substitute for conventional techniques in numerous applications, including the area of managing certain logistics processes. In the paper, it has been used for modeling a complex logistics system in which it is difficult to determine the interdependence of the presented variables applying classical methods. Experience of an expert and information on the operations of the company for a certain group of items have been used to form the model. Analysis of the validity of the model results was performed on the basis of the average relative error and it has showed that the expert fuzzy model for determining the amount of purchase imitates the work of the expert in the observed company with great accuracy.*

Keywords: *fuzzy logic, determination of the amount of purchase, logistics process.*

1. INTRODUCTION

The determination of the amount of purchase is a logistics process that has a significant influence on the successful operation of a company [3]. From the logical aspect, the determination of the amount of purchase requires an adequate attention, since inadequate purchase can additionally burden the company's business [1]. On the other hand, in order to achieve a high level of service for the client, all purchase should be realized independently of their value. Therefore, the determination of the optimal amount of purchase is important for the rational realization of the process of transport, manipulation and storage in the delivery chain to the final customer [2].

In the paper, an expert model for the determination of the amount of purchase (DAP model) was developed following the fuzzy logic. DAP model is used to estimate the quantity for purchase in a business practice. The software packages Matlab and Fuzzy Logic Toolbox were used to form the model.

2. DESCRIPTION OF THE EXPERT FUZZY DAP MODEL

The main problem in forming the expert fuzzy DAP model was to determine the base of fuzzy rules and membership function parameters [7]. To define rules, the data obtained by a logistics

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experts' survey were used. Expert knowledge on the process of determining the amount of purchase was expressed using a certain number of linguistic rules.

The selection of the type and parameters of the membership function was performed on the basis of the positive experience of individual authors [4] and subjective evaluation by authors. The overview of literature helped to determine that the highest precision of output values could be obtained by applying the Gaussian membership functions [5]. For that reason, that curve shape was generated in the model, while its parameters were determined using the subjective authors' evaluation. Amount intervals of the input and output variables were defined on the basis of real values in the practice. The model was established on the Mamdani fuzzy inference system and the min-max inference method, while the centroid method was applied for the defuzzification process [6].

The fuzzy expert DAP model has three input variables: value demand, stock level and price (Figure 1). The output variable is the amount of purchase. Stock level and price have three values, while the value demand and the amount of purchase have five values. The input variable value demand has the following values: very small (XS), small (S), medium (M), large (L) and very large (XL), while the stock level has the following values: small (S), medium (M) and large (L). The input variable price can be described with the following values: low (L), medium (M) and high (H). The output variable amount of purchase has the following values: very small (XS), small (S), medium (M), large (L) and very large (XL). Most of the linguistic values were not necessary due to the fact that the satisfactory output gradation and precision were achieved in changing the input values.

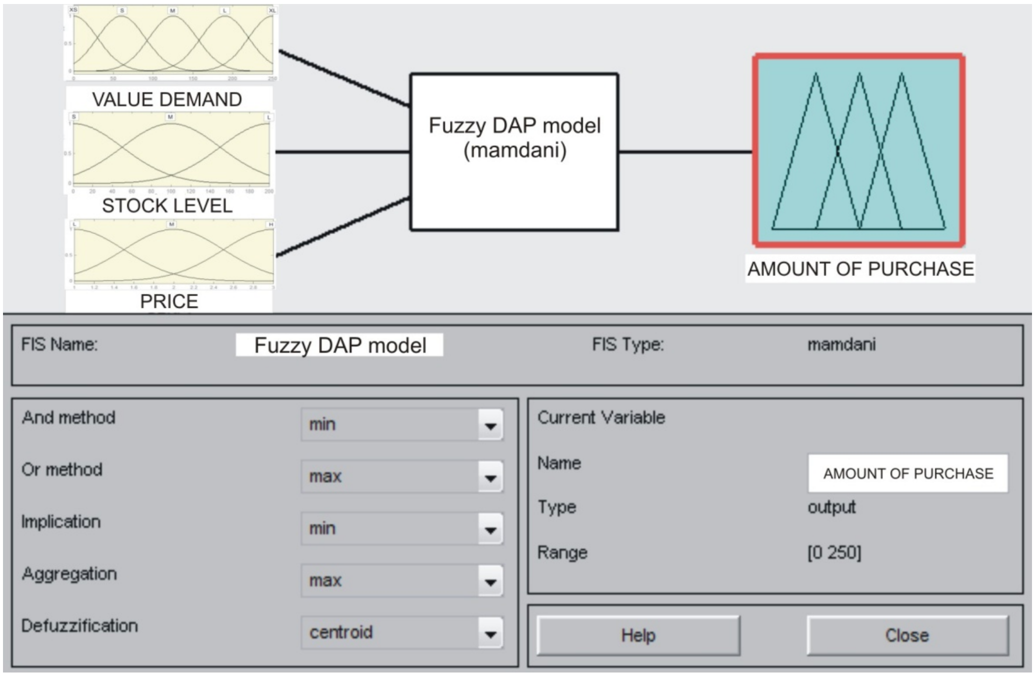

Figure 1. Expert fuzzy inference system

3. THE DEVELOPMENT OF MODEL

Real values were mapped using fuzzification into the membership functions. The input variable value demand has the values in the interval [0, 250], stock level is in the interval [0, 200], while the price is presented in linguistic values in the interval [1, 3]. The interval of the output variable amount of purchase is [0, 250]. These interval values were obtained on the basis of the company's business for the observed article.

The values of the input and output variables have the Gaussian membership functions (1) that can be defined as follows:

$$\mu_A(x) = e^{\frac{-(x-c)^2}{2\sigma^2}}, \mathit{for}\ x \in [0, c] \tag{1}$$

Gaussian fuzzy number is described with two parameters *A = (σ, c).* The first number presents the left and the right distribution of the Gaussian curve along the abscissa, while the second number presents the value on the abscissa where the Gaussian curve has the value 1 on the ordinate. Membership functions of the input variable value demand (2) are defined using the parameters XS [30; 0], S [30; 60], M [30; 125], L [30; 190] and XL [30; 250] for $x \in [0, 250]$ (Figure 2 a)):

$$\mu_{VDXS}(x) = e^{\frac{-x^2}{1800}} \quad \mu_{VDS}(x) = e^{\frac{-(x-60)^2}{1800}} \quad \mu_{VDM}(x) = e^{\frac{-(x-125)^2}{1800}}$$
$$\mu_{VDL}(x) = e^{\frac{-(x-190)^2}{1800}} \quad \mu_{VDXL}(x) = e^{\frac{-(x-250)^2}{1800}} \tag{2}$$

Membership functions of the input variable stock level (3) are defined with the parameters S [50; 0], M [50; 100] and L [50; 200] for $x \in [0, 200]$ (Figure 2 b)):

$$\mu_{SLS}(x) = e^{\frac{-x^2}{5000}} \quad \mu_{SLM}(x) = e^{\frac{-(x-100)^2}{5000}} \quad \mu_{SLL}(x) = e^{\frac{-(x-200)^2}{5000}} \tag{3}$$

Membership functions of the input variable price (4) are defined using the parameters L [0,5; 1], M [0,5; 2] and H [0,5; 3] for $x \in [0, 3]$ (Figure 2 c)):

$$\mu_{PL}(x) = e^{\frac{-(x-1)^2}{0,5}} \quad \mu_{PM}(x) = e^{\frac{-(x-2)^2}{0,5}} \quad \mu_{PH}(x) = e^{\frac{-(x-3)^2}{0,5}} \tag{4}$$

Membership functions of the output variable amount of purchase (5) are defined with XS [30; 0], S [30; 60], M [30; 125], L [30; 190] and XL [30; 250] for $x \in [0, 250]$ (Figure 2 d)):

$$\mu_{APXS}(x) = e^{\frac{-x^2}{1800}} \quad \mu_{APS}(x) = e^{\frac{-(x-60)^2}{1800}} \quad \mu_{APM}(x) = e^{\frac{-(x-125)^2}{1800}}$$
$$\mu_{APL}(x) = e^{\frac{-(x-190)^2}{1800}} \quad \mu_{APXL}(x) = e^{\frac{-(x-250)^2}{1800}} \tag{5}$$

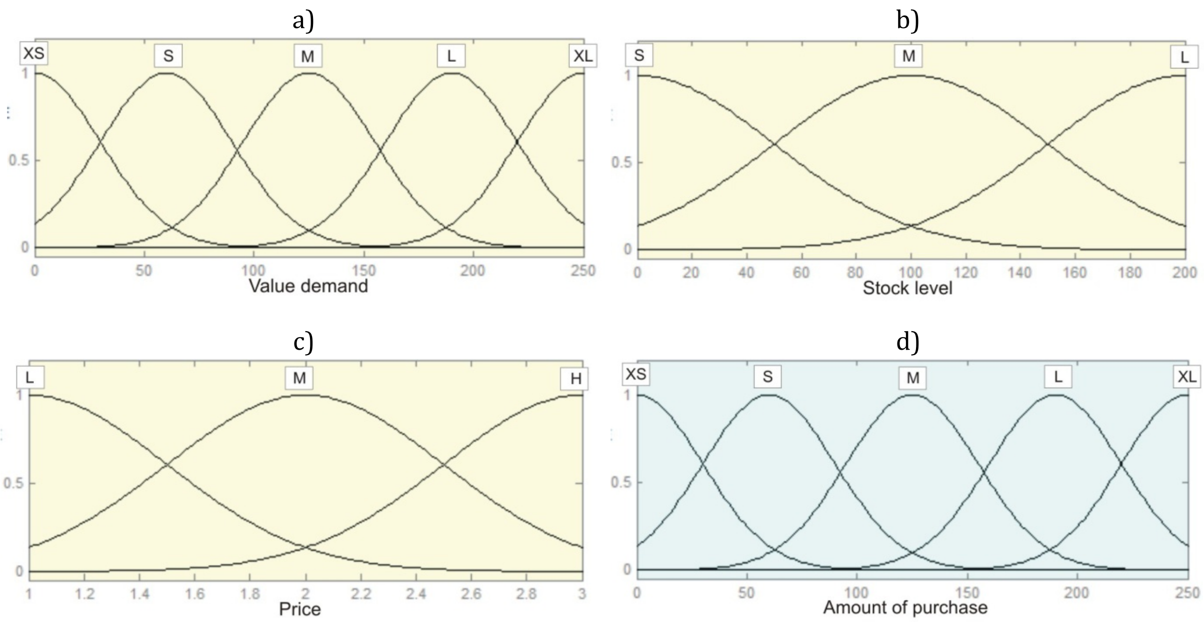

Figure 2. Fuzzy set membership functions: a) value demand, b) stock level, c) price and d) amount of purchase

In the fuzzy expert DAP model, there are three input linguistic variables, where one variable has five values, while the remaining two variables have three values each. The combination of all linguistic values provides the base of fuzzy rules with 45 rules (Table 1).

Table 1. Fuzzy rule matrix if: a) price is L, b) price is M and c) price is H

a)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	M	L	XL	XL	XL
	M	S	M	L	XL	XL
	L	XS	S	M	L	XL

b)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	S	M	L	XL	XL
	M	XS	S	M	L	XL
	L	XS	XS	S	M	L

c)

		VALUE DEMAND				
		XS	S	M	L	HL
STOCK	S	XS	S	M	L	XL
	M	XS	XS	S	M	L
	L	XS	XS	XS	S	M

The centroid method was applied for the defuzzification process. The result of the model defuzzification is the selection of one value of the input variable amount of purchase (Figure 3).

Figure 3. Model defuzzification

4. RESULTS OF MODEL

Figure 4 presents the graphic overview of the output variable amount of purchase in dependence on the input variables.

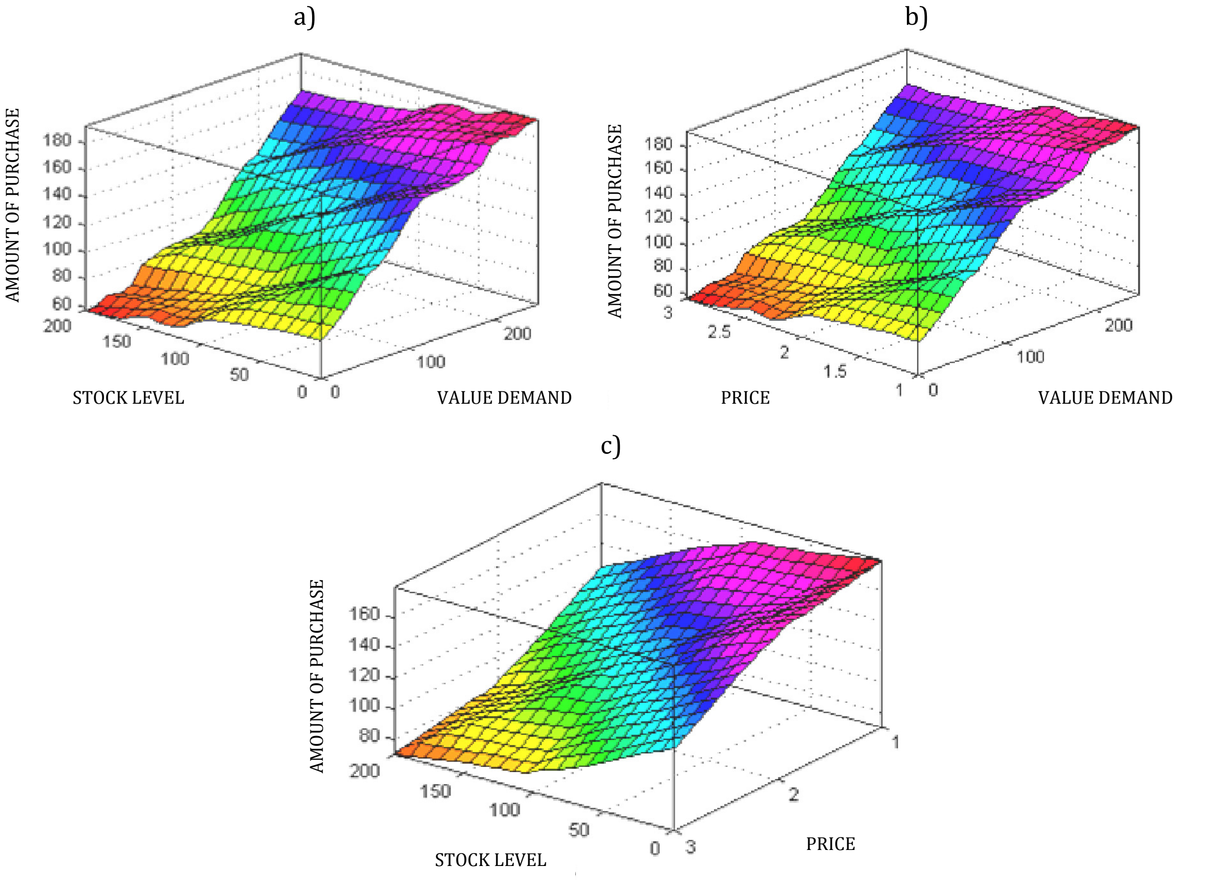

Figure 4. Amount of purchase depending on: a) value demand and stock level, b) value demand and price and c) stock level and price

The DAP model is tested on 50 examples for determining the amount of purchase for the known input values. Figure 5 presents the amount of purchase obtained by the expert fuzzy DAP model and the real amount of purchase in a company for the given input data.

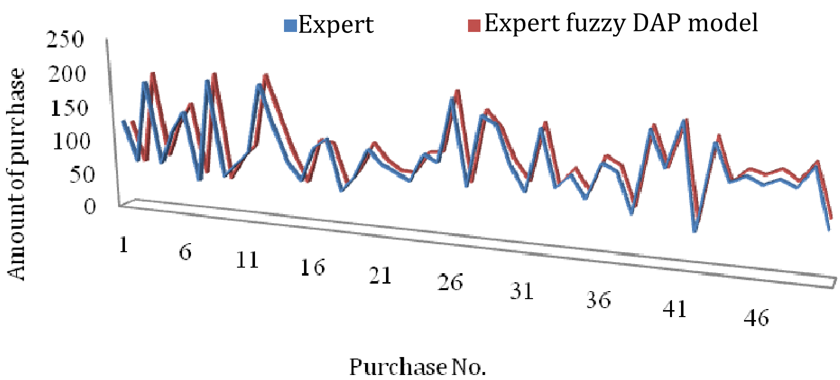

Figure 5. Amount of purchase based on the expert decision and the expert fuzzy DAP model

The evaluation analysis of the DAP model results was conducted on the basis of the average relative error of the obtained results in relation to the real results. The testing of 50 examples provided the average relative error of 5.6%. Based on the analysis, it can be concluded that there is a high compatibility between real and demanded results, and that the expert fuzzy DAP model provides valid results and can completely imitate the work of an expert.

5. CONCLUSION

The applied concept of artificial intelligence is utilized for presenting, manipulating and implementing human knowledge on the efficient management of certain logistics processes. Fuzzy logic has proven to be a valuable artificial intelligence concept in determining the amount of purchase that is designed using intuition and assessment of a logistics expert. Fuzzy logic enabled the explanation of the system dynamics via a linguistic presentation of knowledge on a logistics process. It was used for modeling a complex linguistic system in which it is difficult to determine the interdependence of the presented variables applying other classical methods. In the paper, a DAP model for solving a concrete problem in a business practice was developed, following the tendency in contemporary scientific research. The model was tested and verified, and hence it can be practically applied. The proposed model, with some minor modification, can be applied in any company dealing with the goods flow realization.

ACKNOWLEDGMENT

This work is a part of the research project TR 36030 funded by the Ministry of Science and Technology of Serbia.

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