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# *Application of connected fuzzy models with possibilites of using non standard fuzzy sets in process of planning production and sales for a new product*

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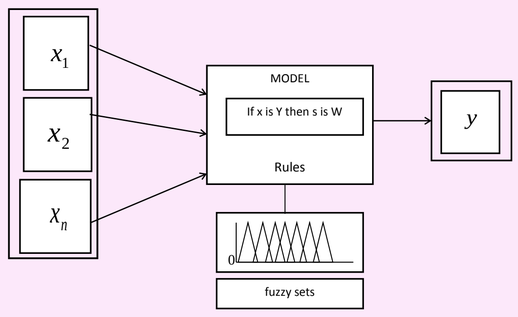
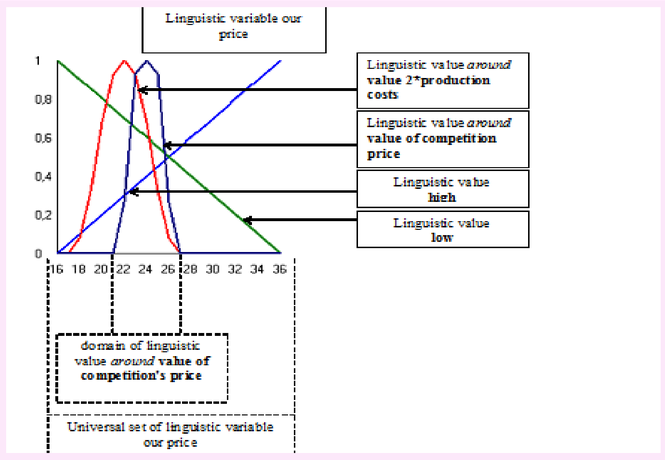
**Abstract** Bosnia and Herzegovina, as a transition country, is facing the problem of launching of production. The disposal of goods and services on the Bosnia and Herzegovina market is restricted by modest purchasing power of the population. On the other hand, the appearance of competition, as one of the biggest advantages of market economy, leads to constant improvement of the quality of goods and services, as well as decreasing of prices, while trying to meet the needs and desires of buyers. All these are the factors for better planning of the production process and assessment of its disposal on the market. And because of that we need to create an adequate system model. In this paper are presented two connected fuzzy models: estimation model for price of new product and estimation model for the number of sold (produced) products. These models show how the complex and often-conflicting knowledge of experts can be presented and used for making of important business decisions with the use of fuzzy logic.

Economic models present a theoretical framework and there is no reason why they must be exclusively mathematical. If a model is mathematical, it usually consists of a set of equations (differential, behavior equations, equations of equilibrium conditions) intended for describing the structure of the model.
Fuzzy model is based on the concept of input-processing-output, and differs from the traditional models in two very important characteristics: what are inputs and/or outputs from the model and in which way are inputs processed and/or outputs generated. Figure presents an environment for fuzzy for modeling.

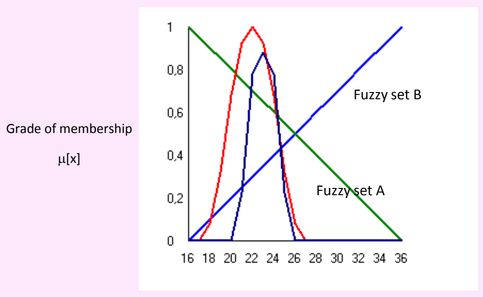



Model accepts a set of inputs ( $x_1, x_2, ..., x_n$ ) as knowledge about the external world, which can be: scale values, series, matrices and fuzzy sets.

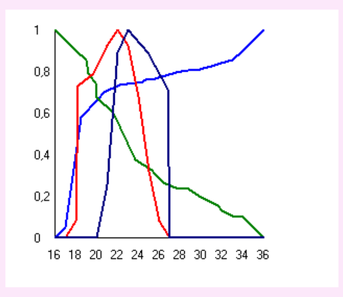



The key term for representation of knowledge in fuzzy models is the linguistic variable. Zadeh's definition of linguistic variable is: "Linguistic variable is a variable whose values are words or sentences of natural language or language of artificial intelligence." For instance, price is a linguistic variable if its values are linguistic (high, low, etc.), and not numerical (16,17, etc.).

The variable shown in the figure is divided into four fuzzy sets, meaning fuzzy regions. Each of these fuzzy sets is approached via its name, low, high value around competition price and value around 2* of production costs (name is a linguistic value). Linguistic variable is composed of one or more linguistic values, meaning fuzzy sets, and the field of definition of linguistic variable is called universal set.

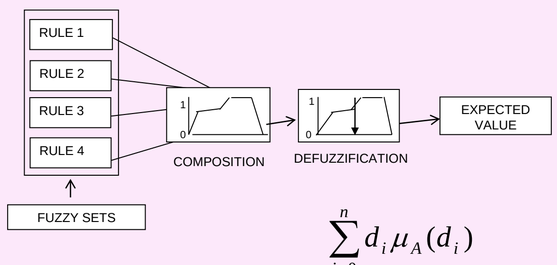



Sometimes, none of the standard graphic presentations can be used for description of a fuzzy set. In that case, fuzzy set is shown with a curve of irregular shape. A software package developed for the needs of testing this fuzzy model, can use standard and non-standard fuzzy sets, and apply hedges on them.



**Mamdani style of reasoning**

During the development of a solution, Mamdani style converts each linguistic value into a temporary fuzzy set. Composing of these sets into an output set is called composition. As each statement is assessed, its consequential fuzzy set is used for updating of fuzzy sets of solution.




After the completion of composition, decomposition is performed (defuzzyfication). This way of reasoning expects, as an output, a fuzzy set that needs to be defuzzified. Defuzzyfication is the last step by which an expected value is derived from a resulting fuzzy set. The most commonly used techniques of defuzzyfication are centroid and composite maximum.

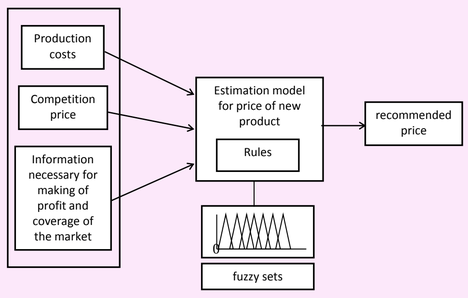
Centroid technique finds a balance point of the resulting fuzzy set by searching for the mean of the fuzzy set, in accordance with the following equation:

$$\pi \leftarrow \frac{\sum_{i=0}^{n} d_i \mu_A(d_i)}{\sum_{i=0}^{n} \mu_A(d_i)}$$

**Estimation model for price of new product**

Determining the price of a new product includes considering of several imprecise and uncertain factors: estimated market demands for product, price of competition product, market's sensitivity to price, production costs, transportation, storage, etc. This model includes only four factors: price of competition product, production costs, request for profitability and request for covering of the market. Input parameters for this model are production costs and price of competition product. The core of this model comprises of four rules:

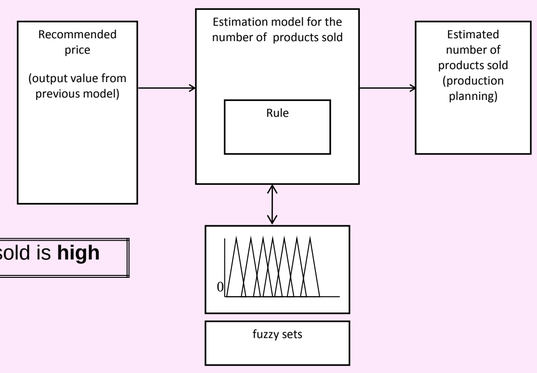
| | |
|---|---|
| R1 | our price must be high |
| R2 | our price must be low |
| R3 | our price must be around value 2* production costs |
| R4 | if competition price is not very high, then our price should have the value of around the value of competition price. |




The first rule, proposed by the financial director, provides for profitability. The second rule, proposed by the deputy director, provides for availability of product on the market. One very important characteristic of the fuzzy system can be noted immediately, and that is the capability to model the conflicting expert knowledge (case of the first two rules). The third rule, proposed by the production manager, provides for covering of the production costs. The fourth rule, proposed by the marketing department, provides that the value of prices be close to the value of competition product. The model has two linguistic variables – our price and competition price. These two linguistic variables have their fuzzy sets, meaning linguistic values. Linguistic variable - competition price – has only one linguistic value, *not very* **high.** The other linguistic variable of the model has four linguistic values: **high**, **low**, *around* **value 2* production costs** and *around* **value of competition price**.

**Estimation model for the number of products sold**

This model uses the price of the product that is being sold as an input parameter. The price of the product is a result of the use of the estimation model for price of new product. Thus, these two fuzzy models are connected with the estimated price of the new product. On basis of this value of the price, the other fuzzy model (estimation model for the number of products sold) is used for determining the estimated number of products that will be sold (need to be produced) for the previously determined price. This value (output value) of the observed model is determined with the application of the method of monotonous selection. The method of monotonous selection is used when a model has only one rule. The rule used by the estimation model for the number of products sold is:



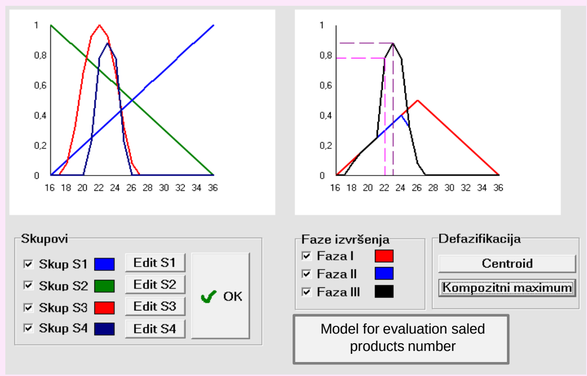

| | |
|---|---|
| **R1** | **if** price of products is **low**, **then** number of products sold is **high** |

where price of the product and number of products sold are linguistic variables, and **low** and **high** are their linguistic values respectively.

## EXPERIMENTATION

Resulting fuzzy set with the use of standard fuzzy sets

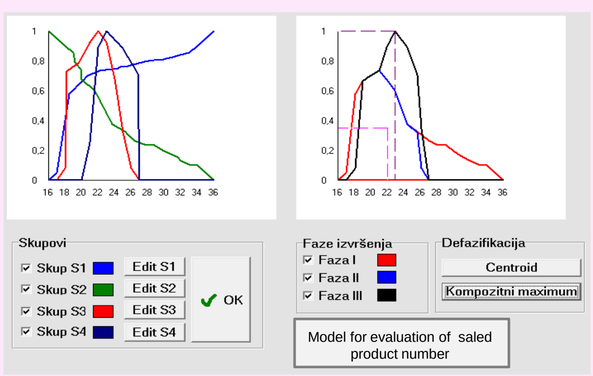
A software package named "Model" has been developed, with the use of Borland C++ Builder development tool, for modeling of the mentioned system. This package enables testing of fuzzy models with standard fuzzy sets, and with fuzzy sets on which hedges have been applied to non-standard fuzzy sets. The following figure shows the use of standard fuzzy sets.




## EXPERIMENTATION

Resulting fuzzy set with the use of non-standard fuzzy sets

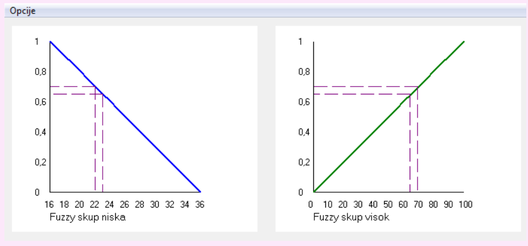
Sometimes, there is a need to present linguistic values by non-standard fuzzy sets. In these cases, it would be difficult to give a mathematical description of behavior of some of these variables, and it would require complex mathematical presentation. Fuzzy modeling shows special flexibility here. The software package used enables simplified presentation and use of such fuzzy sets, and logic of fuzzy models enables their simple processing.




## EXPERIMENTATION

Connecting of two fuzzy models

The result (output value) of the model for estimation of the price of new product is then used as an input variable for the model for estimation of the number of products sold. This showed how two fuzzy models could be connected. The result from the first model with the use of monotonous selection, as a method of conclusion for the second fuzzy model, gives the final result of the observed fuzzy system .




The result of the execution of the model for estimation of the price of new product presents a recommended price acquired through the application of two methods of defuzzyfication: centroid and composite maximum.

## EXPERIMENTATION

Table presentation of acquired results with explanation of meaning of abbreviations used in table

By performing a number of experiments with different values of input parameters, results shown in Table 1 were acquired. The results of conducting of experiments showed the basic characteristics of the defuzzyfication techniques:

- Centroid: defuzzyfied value changes insignificantly through the resulting fuzzy set with changing of the value of parameters that affect the input fuzzy sets; it is simply calculated; can be applied to fuzzy output and constant output value.
- Composite maximum: expected value depends on one rule – the one that dominates in the set of rules; output value "jumps" from one "plateau" to another, as the height of resulting fuzzy set changes;

| SN | CP PC=11 | ESTIMATION MODEL FOR PRICE OF NEW PRODUCT CT OP | ESTIMATION MODEL FOR PRICE OF NEW PRODUCT CO OP | ESTIMATION MODEL FOR THE NUMBER OF PRODUCTS SOLD CT NPP | ESTIMATION MODEL FOR THE NUMBER OF PRODUCTS SOLD CO NPP |
|---|---|---|---|---|---|
| 1. | 16 | 19 | 16 | 85 | 100 |
| 2. | 17 | 19 | 17 | 85 | 94 |
| 3. | 18 | 19 | 18 | 85 | 89 |
| 4. | 19 | 20 | 19 | 80 | 85 |
| 6. | 20 | 21 | 20 | 75 | 80 |
| 7. | 21 | 21 | 21 | 75 | 75 |
| 8. | 22 | 22 | 22 | 69 | 69 |
| 9. | 23 | 22 | 23 | 69 | 64 |
| 10. | 24 | 23 | 24 | 64 | 60 |
| 11. | 25 | 23 | 25 | 64 | 55 |
| 12. | 26 | 24 | 26 | 60 | 50 |
| 13. | 27 | 24 | 27 | 60 | 44 |
| 14. | 28 | 25 | 28 | 55 | 40 |
| 15. | 29 | 25 | 29 | 55 | 34 |
| 16. | 30 | 26 | 30 | 50 | 30 |
| 17. | 31 | 26 | 31 | 50 | 25 |
| 18. | 32 | 26 | 24 | 50 | 60 |
| 19. | 33 | 26 | 24 | 50 | 60 |
| 20. | 34 | 26 | 24 | 50 | 60 |
| 21. | 35 | 24 | 24 | 60 | 60 |
| 22. | 36 | 22 | 24 | 69 | 60 |

| SYMBOLS IN TABLE | MEANING |
|---|---|
| PC | production costs |
| CP | competition price |
| OP | our price |
| CT | centroid |
| CO | composite maximum |
| NPP | number of produced products |
| SN | serial number of execution |

## CONCLUSION

Launching of production in Bosnia and Herzegovina, as a transition country, requires detailed planning of production and disposal of produced products on the market. In that regard, it is necessary to build economic models of systems that would encompass all the relevant elements of these systems and be able to present expert knowledge. The expert knowledge necessary to model such systems is often partial and imprecise, thus clear mathematical models cannot be developed. An alternative to mathematical models are fuzzy models, which use fuzzy logic, fuzzy sets and fuzzy reasoning mechanisms. This document presents two fuzzy models: estimation model for price of new product (using non-standard fuzzy sets) and estimation model for the number of products sold (using standard fuzzy sets). Conducting a number of experiments, with the application of especially developed software package. Our model descripts the main characteristics of the used techniques for acquiring results of work of these models (centroid and composite maximum) and indicated how fuzzy models can be connected. It also depicts that fuzzy models can easily be modified (by changing the appearance of fuzzy sets, modification of rules), which are easily understandable (graphic representation) and tolerant regarding imprecise data. All these are reasons why fuzzy models should be seen as a supplement to the classic mathematical models in development of economic models.

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