

IMPLEMENTING FUZZY LOGIC IN DETERMINING SELLING PRICE

Danny Prabowo Soetanto

Dosen Fakultas Teknik Jurusan Teknik Industri – Universitas Kristen Petra

ABSTRACT

The determination of the price should meet certain criteria, both from the society and the company itself. The combination of various criteria will result in another problem. Fuzzy Logic covers all influencing factors and displays the membership function graphic. Furthermore, by implementing fuzzy rules and fuzzy operator, the right price can be determined which covers all the factors above. The determination of the rules is based on the raw material cost, direct labor cost, distribution cost and the customers' opinion regarding the appropriate price. Then, the model is designed with the help of Matlab software. The result is finally obtained in the form of a model performed by Matlab software. The model displays the output concerning the selling price of the product for each change in the dominant factors.

Keywords: fuzzy logic, membership function, fuzzy rules, fuzzy operator

1. BACKGROUND OF THE STUDY

Fixing the price of goods is not easy. Lots of marketing theories have been developed on it. It is often difficult to ascertain that the fixed price is the result of thoughtful decision. In determining the selling price of the product, a manager has to see thoroughly all the existing facts placing the commodity in demand in the market and at the same time obtain profits for the company. The condition above has made it difficult to fix the price. The study is aimed to develop a model of decision making in determining the selling price of goods. The model is designed by taking into account some influencing factors including the manufacturing costs (raw material and direct labor), distribution cost, and some others.

2. FUZZY LOGIC

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (0 or 1) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by DR. Lotfi Zadeh of the University of California at Berkeley in 1960s. DR. Lotfi Zadeh was working on the problem of computer understanding of natural language. Natural language (like most other activities in life and indeed the universe) is not easily translated into absolute term of 0 and 1, even though every computation such as in mathematical, economic or any other areas used this term. Every thing is ultimately describable in binary terms is a philosophical question worth pursuing, but in practice much data we might want to feed a computer is in some state in between and so, frequently, are the results of computing). Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of comparison between two

things could be not “tall” or “short” but “.38 of tallness”. Fuzzy logic seems closer to the way our brains work. We aggregate data and form a number of partial truth which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction.

2.1 Fuzzify Input

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership function. The input is always a crisp numerical value limited to the universe of discourse of the input variable (in this case the interval between 0 and 10) and the output is a fuzzy degree of membership (always the interval between 0 and 1).

2.2 Apply Fuzzy Operator

Once the inputs have been fuzzified, we know the degree to which each part of the antecedent has been satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number will then be applied to the output function. The input of the fuzzy operator is two or more membership values from fuzzified input variables. The output is a single truth value.

2.3 Aggregate All Output

Aggregation is when we unify the outputs of each rule by joining the parallel threads. It's just a matter of taking all the fuzzy sets that represent the output of each rule and combining them into a single fuzzy set in preparation for the final step, defuzzification. Aggregation only occurs once for each output variable. The input of the aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable.

2.4 Defuzzify

The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number-crispness recovered from fuzziness at last. Perhaps the most popular defuzzification method is the centroid calculation, which returns the center of area under the curve. There are more than five methods supported: centroid, middle of maximum (the average of the maximum value of the output set), bisector, largest of maximum, and smallest of maximum.

3. SETTING THE PRICE

A Firm must set a price for the first time when the firm develops or acquires a new product, when it introduces its regular product into a new distribution channel or geographical area, and when it enters bids on new contract work. The firm must decide

where to position its product on quality and price. The firm has to consider many factors in setting its pricing policy. There a six-step procedure for price setting : Selecting the pricing objective, determining demand, estimating costs, analyzing competitors' cost, price, and offers, selecting a pricing method, and selecting the final price.

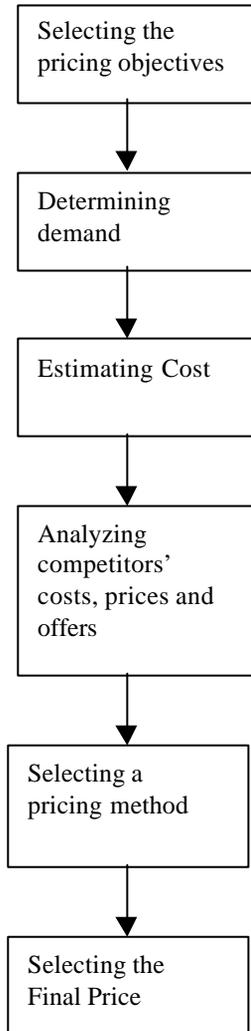


Figure 1. Model of Pricing Strategy

4. DETERMINING SELING PRICE WITH FUZZY LOGIC

In fixing the selling price of the product using fuzzy logic, there are several stages to go through. The stages are pictured in figure 2.

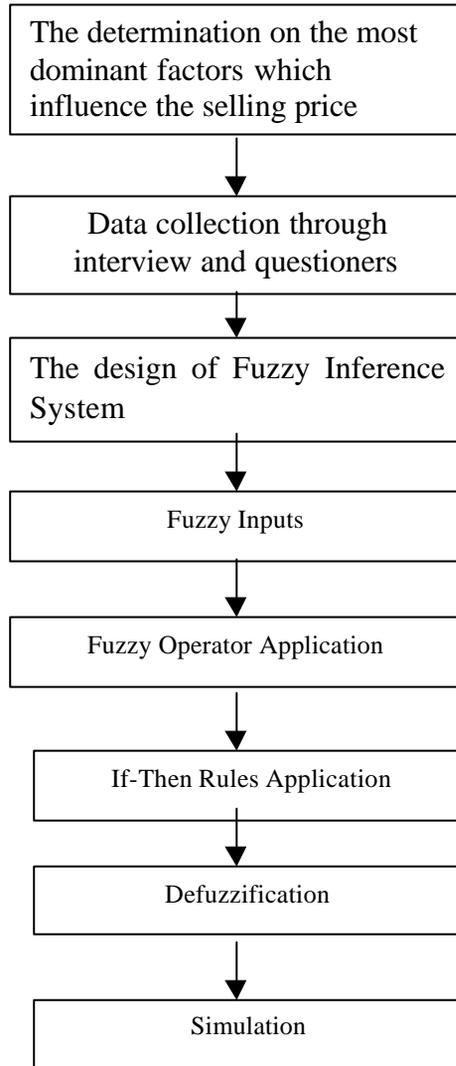


Figure 2. Stages in Setting Up the Selling Price by Using Fuzzy Logic

4.1 Determining the Dominant Factors

This research is conducted to analyze a manufacturing company producing various motorcycle spare part. The company is medium enterprise and still has some weaknesses in its production process especially its production scheduling in determining the production capacity. In setting up the price of a product, there are many influencing factors, yet, due to the limitation of time and information from the company, not all factors are counted on here.

Dominant factors which influence the price directly as follow:

1. Raw material cost
2. Direct labor

3. Distribution cost
4. Customer preception

4.2 Data collection

In fixing the price applying fuzzy logic, the first things to do is setting up the membership function. To support this, data collection is conducted through interview with some managers and questioners distribution on the customers. The interview was carried out with some parties who play crucial role in decision making in the company. As a comparison, the writer also carried out similar interview with some other key persons in other similar companies. Questioners were distributed randomly as much as 100 pieces.

Table 1. Classification of Raw Material Cost Based on Manages' Viewpoint.

Raw Material Cost	Managers' Viewpoint	Effect on the Price
< Rp. 4.750.000,-	Cheap	Cheap
Rp. 4.750.000 – Rp. 6.000.000	Expensive	A little expensive
> Rp. 6.000.000	Beyond the company's affordability	The company has to sell the products at a very expensive price.

Table 2. Classification of Direct Labor Cost Based on Manager's Viewpoint.

Direct Labor Cost	Managers' Viewpoint	Effect on the Price
< Rp. 1.000.000,-	Low	Cheap
Rp. 1.000.000 – Rp. 1.500.000	Average	Moderate
> Rp. 1.500.000	High	Expensive

Table 3. Classification of Distribution Cost Based on the Managers's Viewpoint.

Distribution Cost	Managers' Viewpoint	Effect on the Price
< Rp. 1.500.000,-	Low	Cheap
Rp. 1.500.000 – Rp. 2.000.000	Average	Moderate
> Rp. 2.000.000	High	Expensive

Table 4. Classification of Selling Price According to the Customers' Viewpoint

Selling Price	Customers' Viewpoint
< Rp. 4.500,-	Cheap
Rp. 4.500 – Rp. 6.000	Average
> Rp. 6.000	Expensive

4.3 Fuzzy Inference System Design

Fuzzy inference is the actual process of mapping from a given input to an output using fuzzy logic. This model can be implemented by using MATLAB. MATLAB is a technical computing environment for high-performance numerical computation and visualization. MATLAB integrates numerical analysis, matrix computational, signal processing, and graphics in an easy-to-use environment where problems and solutions are expressed just as they are written mathematically without traditional programming. MATLAB program was written in C by The MathWorks. In this thesis I am using MATLAB ver 5.3.1 with Fuzzy Logic Toolbox.

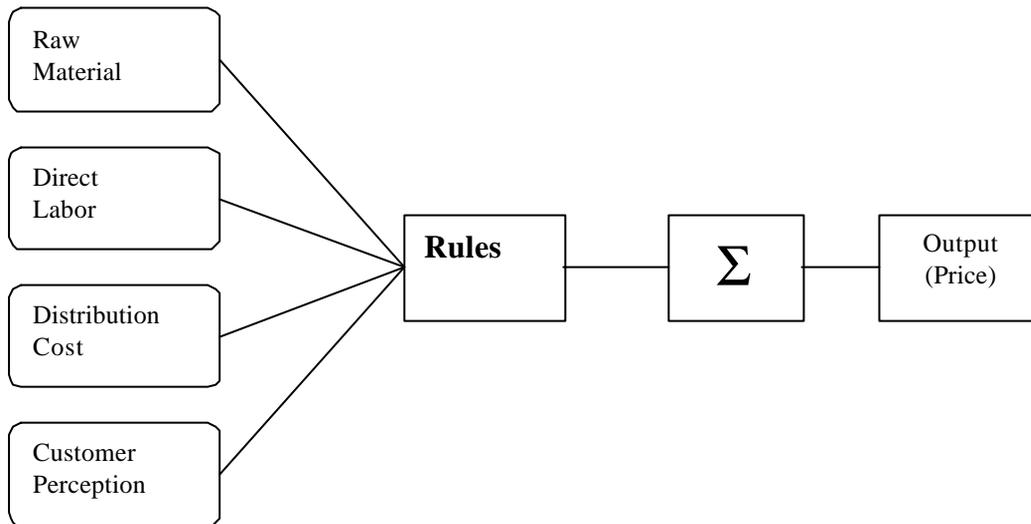


Figure 3. Fuzzy Inference system

From MATLAB Fuzzy Logic Toolbox, a fuzzy inference system is easily created. Determining the membership function (Raw Material, Direct Labor, Distribution Cost and Customer's Perception) is the first thing to do. Further steps are setting up the rules which are going to be applied. From the Rule Viewer Windows and the Surface Windows, output (selling price) can be perceived. One of the advantages of using MATLAB is its ability to perform simulation. Thus, by making a change in the input, the output value is obtained.

4.4 Fuzzy Input

To give a picture on the membership function representing the opinion of the managers towards the raw material cost, the triangular membership function is used. The description of the function is as follows:

The triangular curve depends on three parameters as given by

$$f(x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x - a}{b - a}, & a \leq x \leq b \\ \frac{c - x}{c - b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

$$f(x; a, b, c) = \max(\min(\frac{x - a}{b - a}, \frac{c - x}{c - b}), 0)$$

This triangular function is chosen as it is considered to have the capability of depicting the opinion of the managers accurately. The following equation is the example of high cost in Raw Material Cost:

$$f(x; 4.750.000, 5.375.000, 6.000.000) = \begin{cases} 0, & x \leq 4.750.000 \\ \frac{x - 4.750.000}{5.375.000 - 4.750.000}, & 4.750.000 \leq x \leq 5.375.000 \\ \frac{6.000.000 - x}{6.000.000 - 5.375.000}, & 5.375.000 \leq x \leq 6.000.000 \\ 0, & 6.000.000 \leq x \end{cases}$$

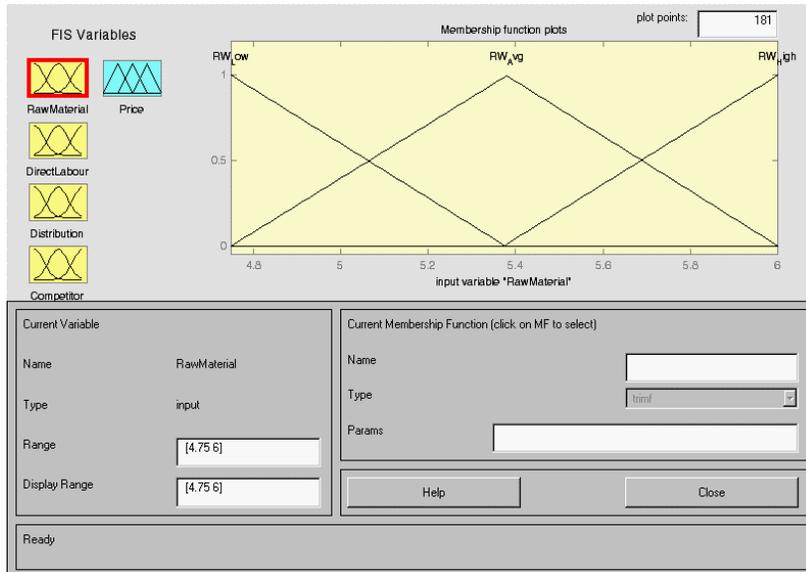


Figure 4. Matlab Display for Raw Material Cost Membership Function

Triangular function is also used to portray the membership function direct labor cost, distribution cost, and customer perception.

4.5 Fuzzy Operator

In the case of price fixing, after determining the input from fuzzy and the membership function, the next stage to do is designing the rule. There are two kinds of operators: AND/MIN and OR/MAX. The difference is as follows :

AND

A	B	A and B
0	0	0
0	1	0
1	0	0
1	1	1

OR

A	B	A or B
0	0	0
0	1	1
1	0	1
1	1	1

The decision to use operator AND is based on the consideration that all requirements have to be fulfilled. An example to explain this might be : (Raw Material Cost is Low) AND (Distribution Cost is High). It means two requirements that is low raw material cost and low distribution cost should be both fulfilled.

4.6 Apply If-Then Rules

Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. But in order to say anything useful we need to make complete sentences. Conditional statements, if then rules, are the things that make fuzzy logic useful.

A single fuzzy if-then rule assumes the form

If x is A then y is B

Where A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The if-part of the rule “x is A” is called the antecedent or premises, while the then-part of the rule “y is B” is called the consequent or conclusion. An example of such a rule might be

If RawMaterial is RW_High then Price is **PC_4**

It can be interpreted as follows :

If the raw material cost is high, the selling price is also high

The antecedent of a rule can have multiple parts :

If (RawMaterial is RW_Low) and (DirectLabour is LB_Low) and (Distribution is DS_Low) And (Competitor is CP_Low) then
(Price is **PC_1**)

It means:

If (Raw Material cost is low) and (Direct Labor is low) and (Distribution cost is low) and (the selling price of competitor is low), then (the selling price is also low).

In fact, before establishing the If-Then Rule, the membership function of the output should be set up first. Analyzing the result of the interview with the managers as well as observing the selling price in the market, then the selling price is fixed between Rp. 4.000 and Rp. 5.000 with the membership function

5. CONCLUSION

Fuzzy logic is but only an effective aid mechanism in numerating the man's opinions and experiences providing such things are difficult to be quantified. The problem in interpreting human experiences into numbers is easily solved by fuzzy logic. Fuzzy logic helps to develop rules needed in fixing the price. The rules take the dominant costs influencing the product's selling price. Raw material cost, direct labor cost, and distribution cost are the main components in setting up the price. Not leaving alone, the customers perception also plays crucial role in classifying the price. Further, the data obtained is operated in designing the membership function of each dominant component. The support of Matlab software makes it easy for the development of fuzzy inference system in establishing price fixing pattern. By operating this software the managers find it possible to do any necessary changes on the direct input and the output can be immediately obtained. It is expected with the designed system, the company could perform some simulations before the price is settled.

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