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Determining The Selling Price of Thrift Using The Fuzzy Sugeno Method

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Abstract: The use of thrift goods in life has the effect of saving and loving the environment. Many of these objects are difficult to degrade in nature and are nevertheless thought to have economic worth, for example used electronic equipment such as laptops. On the other hand, in today's classroom environment, laptops are quite important. Even the most recent computers with good features are fairly costly, thus used laptops are one answer to this. The seller's selling price usually only takes a few elements into account, therefore the price set does not always match the requirements. The aim of this paper is to apply the zero order Sugeno fuzzy approach to determine the selling price of old laptop. The system is built with characteristics such as laptop age, physical condition, RAM, new purchase price, and used selling price. The simulation findings suggest that fuzzy logic employing the zero-order Sugeno approach can be utilized to determine the selling price of old laptop while accounting for the affecting variables.

Keywords: *fuzzy logic, secondhand product, zero waste, Sugeno Fuzzy, thrift market.*

Abstrak: Penggunaan barang thrift dalam kehidupan memiliki efek penghematan dan cinta terhadap lingkungan. Barang-barang ini banyak yang sulit terurai di alam dan dirasa masih memiliki nilai ekonomis, misalnya alat elektronik bekas seperi laptop. Di lain sisi, kebutuhan laptop dalam dunia pembelajaran dewasa ini sangatlah tinggi. Laptop keluaran terbaru dengan spesifikasi yang tinggipun memiliki harga yang cukup mahal, sehingga laptop bekas menjadi salah satu solusi untuk mengatasi hal tersebut. Harga jual yang ditetapkan oleh penjual biasanya hanya mempertimbangkan beberapa factor saja, sehingga kadangkala harga yang ditetapkan tidak sesuai dengan spesifikasi yang dimiliki. Artikel ini bertujuan untuk menentuan harga jual laptop bekas menggunakan metode fuzzy Sugeno orde nol. Sistem dibentuk dengan variabel umur laptop, kondisi fisik, RAM, harga beli baru dan harga jual *second*. Hasil simulasi menunjukkan bahwa logika fuzzy dengan metode Sugeno orde-nol dapat dijadikan suatu system dalam menentukan harga jual laptop bekas dengan memperhatikan variabel-variabel yang berpengaruh.

Kata Kunci: *logika fuzzy, barang bekas, bebas sampah, Fuzzy Sugeno*, *pasar barang bekas.*

Introduction

A laptop is a portable personal computer that can be carried anywhere. Laptops have the same functions and components as desktop computers, only they are smaller in size, lighter and more power efficient. Along with technological developments, new laptops with high specifications are quite expensive. For some people, of course they want a laptop with high specifications but at an affordable price. Used laptops are an alternative for some groups to get high-specification laptops at affordable prices. Price is an influential factor for consumers in making decisions whether to buy a product or not. Thus, determining the selling price of used laptops is a consideration for several shops.

The problem that arises in the process of buying and selling used laptops from the seller's perspective is determining the selling price of each laptop. Sellers set prices based on physical condition, repair costs, and any damaged or incomplete laptop components. So, it needs a method to determine the

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selling price of laptops in order to get optimal profits.

The method used in this research is the Sugeno fuzzy method. This method has been widely applied in research based on decision support systems. Among them Agustin et al. [1] which applies the Sugeno fuzzy method in determining the selling price of used motorbikes. Hariri [2] discusses the application of the Sugeno fuzzy method in registering new students at SDN 1 Sonopatik Nganjuk. Andini and Rahardjo [3] analysed the factors that influence the decision to purchase a Hyundai i20 car. Asrianto and Effendi [4] applied the Sugeno fuzzy method to determine the amount of commission for the PLGD.Store personal shopper service. Oktavia and Maulidi [5] applied Sugeno's fuzzy logic to determine rewards in the educational game AKU BISA.

Method

Fuzzy Logic

Lotfi A Zadeh is a professor from the University of California, Berkeley, United States who first introduced fuzzy logic in 1965. In linguistic terms, fuzzy is defined as not rigid or vague. Fuzzy logic is a modification of set theory, namely strict logic. The difference is that in strict logic there are only two possible truth values, namely 0 or 1. Meanwhile in fuzzy logic the truth value is in the value range [0,1] [6]

According to Agustin [7], one of the FIS methods that can be used for decision making is the Sugeno method. The Sugeno fuzzy inference system method is often referred to as the fuzzy inference system method introduced by Takagi, Sugeno and Kang [8]. 4 stages are required to obtain the output from the Sugeno fuzzy method, namely [9]:

- Fuzzification Stage

Fuzzification is the process of transforming observation data into the form of a fuzzy set. Application of the implication function Fuzzy basic rules define the relationship between the membership function and the form of the resulting membership function [10]. In the Sugeno method the output (consequential) of the system is not in the form of a fuzzy set but in the form of a constant or linear equation. According to Kusumadewi & Purnomo [6], Sugeno's method consists of two types, namely Zero-Order Fuzzy Sugeno Model and First-Order Fuzzy Sugeno Model.

The general form of zero order Sugeno fuzzy is:

$$IF\ (x_1\ is\ A_1) \circ (x_2\ is\ A_2) \dots (x_N\ is\ A_N)$$
$$THEN\ z = k, \quad (1)$$

where A_N is the N-th fuzzy set as antecedent, and k is a consequent strict constant.

The general form of first order Sugeno fuzzy is:

$$IF\ (x_1\ is\ A_1) \circ (x_2\ is\ A_2) \dots (x_N\ is\ A_N)$$
$$THEN\ z = p_1 * x_1 + \cdots + p_N * x_N + q, \quad (2)$$

where A_N is the Nth fuzzy set as the antecedent, p_N is the N-th firm constant, and q is constant in the consequent.

- Rule components (aggregation)

If the system consists of several rules, then inference is obtained from the collection and correlation between rules, namely calculating the result of $\sum_{r=1}^{R} \alpha_r z_r$ where R is the number of rules, α_r is the α-th predicate r, and z_r is the output at the antecedent of the r-th rule.

- Affirmation (defuzzification)

In this process the output is a crisp number. Defuzzification is done by finding the average value using the formula [11], [12]:

$$Z = \frac{\sum_{i=1}^{n} \alpha_i z_i}{\sum_{i=1}^{n} \alpha_i} \quad (3)$$

where α_i is the α-th predicate; z_i is the output on the antecedent of the i-th rule.

- Data

The data used is based on the results of interviews with several used laptop shop owners around Banda Aceh city, Indonesia. The data obtained includes the year the laptop was released, physical condition, RAM, and the purchase price of the used laptop. The following data was obtained:

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Table 1. Used laptop data

No	Type of laptop	Year	Physical condition (%)	RAM (GB)	Purchase price (Rp)
1	Asus	2014	95	8	6.300.000
2	Acer Pentium	2015	55	2	750.000
3	Lenovo Celeron	2019	95	2	1.500.000
4	Asus Celeron	2017	75	2	1.400.000
5	Toshiba Portage z30t c	2016	95	8	3.800.000
6	Apple MacBook Pro Retina	2013	95	4	8.500.000
7	Asus ROG ZEPHYRUS	2019	98	24	15.300.000
8	MSI GE72MVR	2018	90	16	15.000.000
9	Apple MacBook Air	2015	95	4	7.800.000
10	Apple MacBook Pro MID 2012 core i5	2012	85	4	5.900.000
11	Dell Latitude E5510 core i5	2013	80	4	2.650.000
12	Lenovo ThinkPad core i5	2013	80	4	2.950.000
13	Acer core i5	2016	85	8	2.400.000
14	Asus X 200 Celeron	2016	75	2	1.000.000
15	Asus M409DA	2019	90	8	6.000.000
16	Asus Aspire E5 AMD A12 quad-core	2016	85	8	4.500.000
17	Asus A456U	2017	95	4	5.800.000
18	HP X360 CONVERTIBLE	2016	95	4	2.500.000

Results And Discussion

Fuzzification

Based on the data Tabel 1, variables and sets can be formed that are used in the fuzzification process. Fuzzification uses the data above by differentiating each variable into a fuzzy set. The fuzzy set contains all the data based on the data obtained. For example, the year data obtained is from 2012 to 2019, so the universe set used is 2010 to 2021. The fuzzy set is divided into three, namely for low years (Low), medium years (Mid), and high years (High). The same process is applied to the other variables. In dividing fuzzy sets into each variable, the legs of the set are based on proportional division.

Table 2. Variable and fuzzy set

Variable		Fuzzy Set	The Universe of Sets	Domain
Input	Laptop year	Low	[2010-2021]	[2010-2017]
		Mid		[2014-2020]
		High		[2017-2021]
	Physical condition	Low	[40-100]	[40-70]
		Mid		[50-90]
		High		[70-100]
	RAM	Low	[2-24]	[2-8]
		Mid		[4-12]
		High		[8-24]
	Laptop Purchase Price	Cheap	[2.000.000-17.000.000]	[2.000.000-8.000.000]
		Medium		[4.000.000-12.000.000]
		Expensive		[8.000.000-17.000.000]
Output	Selling price	Cheap	[1.400.000-17.000.000]	1.7000.000
		Medium		9.000.000
		Expensive		16.000.000

Sometimes this division seems unrealistic because several variables have a big influence on entrepreneurs buying products and reselling them. In laptop years, proportional division of the set produces the legs of the set as in Table 2. Compared with laptop years, division by physical condition of the laptop is only a formality in the fuzzy set. From Table 1, it shows that the physical condition variable only ranges from 75 to 99 percent. There is an outlier of 55 percent which makes the division of fuzzy sets at 40, 50, 70, and 90 percent. In the RAM variable, the division is made based on several RAM specifications in Table 1. The fuzzy set is divided using the most common data, namely 2 to 8 GB RAM. The purchase price variable is calculated from Table 1, and dividing it proportionally.

a. Laptop Year Variable

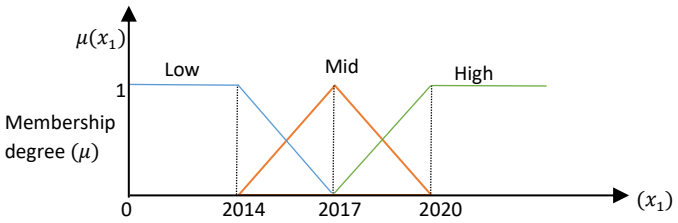

Figure 1. Laptop Year Variable Curve

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The membership degree value (μ) is determined by the following function:

$$\mu_L(x_1) = \begin{cases} 1 & x_1 < 2014 \\ \frac{2017-x_1}{2017-2014} & 2014 \le x_1 < 2017 \\ 0 & x_1 \ge 2017 \end{cases}$$

$$\mu_M(x_1) = \begin{cases} 0 & x_1 < 2014 \text{ and } x_1 \ge 2020 \\ \frac{x_1-2014}{2017-2014} & 2014 \le x_1 < 2017 \\ \frac{2020-x_1}{2020-2017} & 2017 \le x_1 < 2020 \end{cases} \quad (4)$$

$$\mu_H(x_1) = \begin{cases} 0 & x_1 < 2017 \\ \frac{x_1-2017}{2020-2017} & 2017 \le x_1 < 2020 \\ 1 & x_1 \ge 2020 \end{cases}$$

where μ_L, μ_M, and μ_M are the membership degree value for Low, Mid, and High years fuzzy sets, respectively.

b. Physical condition variable

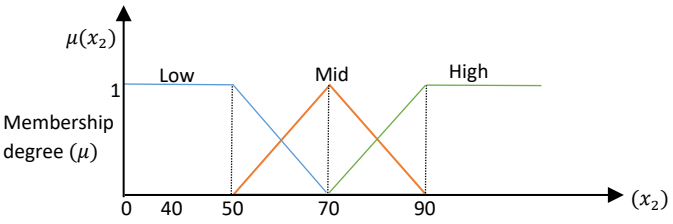

Figure 2. Laptop Physical Condition Variable Curve

The membership degree value (μ) is determined by the following function:

$$\mu_L(x_2) = \begin{cases} 1 & x_2 < 50 \\ \frac{70-x_2}{70-50} & 50 \le x_2 < 70 \\ 0 & x_2 \ge 70 \end{cases}$$

$$\mu_M(x_2) = \begin{cases} 0 & x_2 < 50 \text{ and } x_2 \ge 90 \\ \frac{x_2-50}{70-50} & 50 \le x_2 < 70 \\ \frac{90-x_2}{90-70} & 70 \le x_2 < 90 \end{cases} \quad (5)$$

$$\mu_H(x_2) = \begin{cases} 0 & x_2 < 70 \\ \frac{x_2-70}{90-70} & 70 \le x_2 < 90 \\ 1 & x_2 \ge 90 \end{cases}$$

where μ_L, μ_M, and μ_M are the membership degree value for Low, Mid, and High condition fuzzy sets, respectively.

c. RAM Variable

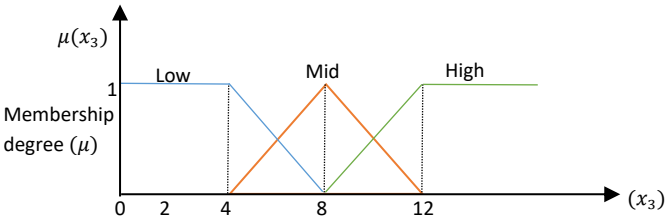

Figure 3. RAM variables

The membership degree value (μ) is determined by the following function:

$$\mu_L(x_3) = \begin{cases} 1 & x_3 < 4 \\ \frac{8-x_3}{8-4} & 4 \le x_3 < 8 \\ 0 & x_3 \ge 8 \end{cases}$$

$$\mu_M(x_3) = \begin{cases} 0 & x_3 < 4 \text{ and } x_3 \ge 12 \\ \frac{x_3-4}{8-4} & 4 \le x_3 < 8 \\ \frac{12-x_3}{12-8} & 8 \le x_3 < 12 \end{cases} \quad (6)$$

$$\mu_H(x_3) = \begin{cases} 0 & x_3 < 8 \\ \frac{x_3-8}{12-8} & 8 \le x_3 < 12 \\ 1 & x_3 \ge 12 \end{cases}$$

where μ_L, μ_M, and μ_M are the membership degree value for Low, Mid, and High RAM fuzzy sets, respectively.

d. Laptop purchase price variable

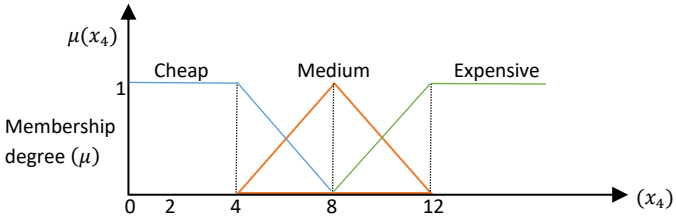

Figure 4. Laptop Purchase Price Variable (in Million)

The membership degree value (μ) is determined by the following function (all number in Million):

$$\mu_L(x_4) = \begin{cases} 1 & x_4 < 4 \\ \frac{8-x_4}{8-4} & 4 \le x_4 < 8 \\ 0 & x_4 \ge 8 \end{cases}$$

$$\mu_M(x_4) = \begin{cases} 0 & x_4 < 4 \text{ and } x_4 \geq 12 \\ \frac{x_4-4}{8-4} & 4 \leq x_4 < 8 \\ \frac{12-x_4}{12-8} & 8 \leq x_4 < 12 \end{cases} \quad (7)$$

$$\mu_H(x_4) = \begin{cases} 0 & x_4 < 8 \\ \frac{x_4-8}{12-8} & 8 \leq x_4 < 12 \\ 1 & x_4 \geq 12 \end{cases}$$

where μ_L, μ_M, and μ_M are the membership degree value for Cheap, Medium, and Expensive purchase price fuzzy sets, respectively.

e. Selling Price Variable

This variable is divided into 3 fuzzy sets, namely cheap, medium and expensive. The value of the variable is taken from the highest selling price set by the shop, namely: Expensive = 16,000,000, Medium = 9,000,000, and Cheap = 1,700,000.

Rule Fuzzy

Fuzzy implication rules are formed based on a combination of input variables and output variables. There are 4 input variables with 3 fuzzy sets each and 1 output variable. So, we get $3^4 \times 1 = 81$ rules using fuzzy implication IF-THEN with the AND operator.

Defuzzification

The defuzzification process resulted selling price variables which are divided into 3 categories, namely cheap, medium and expensive. The used formula is in Equation 3. Below are two examples that show the entire process to obtain the purchase price.

Case 1

The first case completed has data that meets all required variables. The laptop data is as follows:

Laptop type : Apple MacBook Air
Year : 2015
Physical condition : 95%
RAM : 4 GB
Purchase price : 7,800,000

Membership degrees are presented as Table 3. Based on 81 rules, only 4 can be used, the rest get predicate-α=0, namely:

R1: *IF* Year is Low *AND* Physical Condition is High *AND* RAM Capacity is Low *AND* Purchase Price is Cheap *THEN* Selling Price is Cheap.
Obtained α_1=0.05 and z_1=1,700,000.

R2: *IF* Year is Low *AND* Physical Condition is High *AND* RAM Capacity is Low *AND* Purchase Price is Medium *THEN* Selling Price is Medium.
Obtained α_2=0.667 and z_2=9,000,000.

Table 3. Case of Apple MacBook Air

Variable	Membership Value	
Laptop year	$\mu_L(2015)$	0.667
	$\mu_M(2015)$	0.333
	$\mu_H(2015)$	0
Physical Condition	$\mu_L(95)$	0
	$\mu_M(95)$	0
	$\mu_H(95)$	1
RAM	$\mu_L(4)$	1
	$\mu_M(4)$	0
	$\mu_H(4)$	0
Purchase price	$\mu_L(7.800.000)$	0.05
	$\mu_M(7.800.000)$	0.95
	$\mu_H(7.800.000)$	0

R3: *IF* Year is Medium *AND* Physical Condition is High *AND* RAM Capacity is Low *AND* Purchase Price is Cheap *THEN* Selling Price is Cheap.
Obtained α_3=0.05 and z_3=1,700,000.

R4: *IF* Year is Medium *AND* Physical Condition is High *AND* RAM Capacity is Low *AND* Purchase Price is Medium *THEN* Selling Price is Medium.
Obtained α_4=0.333 and z_4=9,000,000.

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Then the defuzzification process is completed with the formula in Equation 3:

$$Z = \frac{\sum_{i=1}^{n} \alpha_i z_i}{\sum_{i=1}^{n} \alpha_i} = \frac{9170000}{1,1} = 8,336,363.64$$

So, the price of a used laptop with the above specifications is set at IDR 8,400,000.

Case 2. Another simple case

Laptop type : Asus ROG ZEPHYRUS

Year : 2019

Physical condition : 98

RAM : 24

Purchase price : 15,300,000

Membership degrees are presented as Table 4.

Table 4. Case of Asus ROG ZEPHYRUS

Variable	Membership Value	
Laptop year	$\mu_L(2019)$	0
	$\mu_M(2019)$	0.333
	$\mu_H(2019)$	0.667
Physical Condition	$\mu_L(98)$	0
	$\mu_M(98)$	0
	$\mu_H(98)$	1
RAM	$\mu_L(24)$	0
	$\mu_M(24)$	0
	$\mu_H(24)$	1
Purchase price	$\mu_L(15,300,000)$	0
	$\mu_M(15,300,000)$	0
	$\mu_H(15,300,000)$	1

Based on 81 rules, only 4 rules can be used, the rest get predicate-α=0, namely:

R1: *IF* Year is Mid *AND* Physical Condition is High *AND* RAM Capacity is High *AND* Purchase Price is Expensive *THEN* Selling Price is Expensive. Obtained α_1=0.333 and z_1=16,000,000.

R2: *IF* Year is High *AND* Physical Condition is High *AND* RAM Capacity is High *AND* Purchase Price is Expensive *THEN* Selling Price is Expensive. Obtained α_2=0.667 and z_2=16,000,000.

Then the defuzzification process is completed with the formula:

$$Z = \frac{\sum_{i=1}^{n} \alpha_i z_i}{\sum_{i=1}^{n} \alpha_i} = \frac{16,000,000}{1} = 16,000,000$$

So, the price of a used laptop with the above specifications is set at IDR. 16,000,000.

Conclusions

Based on the discussion above, it can be concluded that fuzzy logic using the zero-order Sugeno method can be used as a system for determining the selling price of used laptops by taking into account the influencing variables. Several variables have a strong influence on the resale price of used goods. In this case, it is indicated by the physical condition and purchase price of the laptop. The rules drawn up indicate that there is no reduction in price from the purchase price. This means that the sales price will be slightly higher than the purchase price, if other determining variables are one level above the price status. Cheap/Low purchase prices can produce Cheap/Low sales prices, if the other three variables are at Low to Mid levels. In contrast, with the three other variables which are at the Mid to High level, the selling price can be higher than Cheap/Low. Based on the data and results of making a fuzzy inference system of the Sugeno type, it can be concluded that the resale price of used goods can be maintained and increased from the purchase price of used goods if and only if the level of the other three variables is at dominant High.

Conflicts of interest

There are no conflicts to declare.

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