Forecasting competition for sales of local and national bottled drinking water in madura using fuzzy sugeno method

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Abstract. Bottled Drinking Water (AMDK) is processed water, without other food ingredients and food additives, packaged, and safe to drink. AMDK itself which is widely known in the community is national product AMDK. However, local products have emerged to try to compete with national product AMDK. As for local product AMDK which is produced mainly in Madura, the average product is made from Islamic boarding schools. From the level of competition, the idea is emerged for forecasting primarily in the field of sales using the fuzzy Sugeno method. The results obtained from fuzzy Sugeno are turned out to produce a MAPE that the value for local AMDK is 6.4795 and a national AMDK is 2.5353, so that the conclusion about national production is closer to the real value than local AMDK. This study contributes that the predictive value of sales competition is quite accurate based on the MAPE value is below 10. This study provides recommendations to local sellers to make improvements in factors in order to be better than national sellers.

1. Introduction

Water is an important substance in life. About three-quarters of the human body consists of water and no one can survive more than 4-5 days without drinking water. Water is used for industrial, agricultural, fire fighting, recreational, transportation and other purposes. Water is needed by the body's organs to help with metabolism, assimilation systems, fluid balance, digestion, dissolution and toxin removal from the kidneys, so that the kidneys work lightly [1]. Based on RI Minister of Health Regulation No. 416 / MENKES / PER / IX / 1990 concerning water quality supervision requirements, drinking water is water which the quality meets the requirements and it can be drunk directly. Drinking water that is consumed by humans must have quality or content that can meet the body's needs. The large number of human needs for drinking water makes some people take the initiative to produce water into bottled drinking water [5].

AMDK (Bottled Drinking Water) is water that has been processed, without other food ingredients and food additives, packaged, and safe to drink [5,6,7]. Nowadays, there are many national drinking water products sold in various places[6,9,16]. However, water has also begun to emerge from local products produced by certain agencies and by several Islamic boarding schools, mainly in the Madu area. Due to the large number of sales competition between local AMDK and national AMDK, it is

necessary to take steps to model the competition using fuzzy Sugeno so that the computation process is faster by making changes to smaller values in the range 0-1 [14,15,17,18,19].

FuzzySugenois included in one of the forecasting methods [8]. Forecasting is an activity of predicting the values of a variable based on known values of these variables or related variables [2]. Forecasting is a quantitative technique or way of estimating what will happen in the future, and of course requires past data as a reference or historical data. One of the benefits of sales forecasting is being able to estimate sales accurately over time,so it can be predicted the quantity of raw materials needed by the company [3].

Fuzzy Sugeno method is one method in fuzzy logic. This method was introduced by Takagi-Sugeno Kang in 1985. Sugeno fuzzy system improves the weaknesses possessed by pure fuzzy systems to add a simple mathematical calculation as part of THEN. In this change, fuzzy systems have a weighted average value in the IF-THEN fuzzy rule section. Sugeno's fuzzy system has a weakness, especially in the THEN section, that is, with the existence of mathematical calculations so it cannot provide a natural framework for representing human knowledge actually. The second problem is there is no freedom to use different principles in fuzzy logic, so the uncertainty of fuzzy systems cannot be represented properly [4,12,13].

The research using the fuzzy Sugeno method previously conducted by Meimaharani and Listyorini (2014) that entitled "Analysis of Fuzzy Sugeno's Inference System in Determining the Price of Land Sales for Minimarket Development". The best selection of land that will be used in the construction of the minimarket [3] and thenthe other studies conducted by Agustin, Gandhiadi and Oka (2016) that entitled "Application of the Fuzzy Sugeno Method to Determine the Selling Price of Used Motorbikes" [10,11]. In this case the Sugeno fuzzy method can be applied in determining the selling price of used motorcycles with input variables, namely: year of motorbike, physical condition of the motorbike, number plate, and purchase price of the motorbike. Hence on this study about forecasting sales of bottled water using fuzzy Sugeno method with using any kinds of AMDK, like Nuri, Azka, Tumas, HK, Nuba, Alas, A-Tien, and Qobasah for local AMDK in Pamekasan, thenLabini and Bariklana for local AMDK in Sumenep, Roy and Santri for local Sampang, and Cleo for national AMDK in Sumenep, so this researchcontributes to local sellers to make improvements in factors that affect sales in order to be able to compete with national defense.

2. Research Method

The steps of this research are:

Step 1 Literature Study

Literature studies in this research are obtained from books, journals, papers and theses relating to bottled water, marketing strategies and also Sugeno fuzzy.

Step 2 Data Collection

Data collecting is done in stores where the respondents are several consumers who consume bottled water. This data collection is done by giving questionnaires to respondents who have determined the number of samples. As for what will be measured from the questionnaire distributed is the level of consumer needs and the level of consumer satisfaction with bottled water.

Step 3 Data Processing

Data processing was carried out throughout the study. Since the collection of data starts continuously until making research reports.

Step 4 Application of Fuzzy Sugeno

From the data that has been obtained, applied using the Sugeno fuzzy method by determining the variables in bottled water. The variables used in the study consisted of 3 variables as follows:

X_1 is the AMDK production variable on branding.

X_2 is the bottled drinking water production variable in the form of packaging.

X_3 is the AMDK production variable in recycling.

And we use algorithm of fuzzy Sugeno:

1. Fuzzyfication, which is the process of mapping crips (numeric) values into fuzzy sets and determining their membership.
2. The formation of a fuzzy knowledge base (Rule in IF .... THEN).
3. Inflation engine in Sugeno fuzzy uses the MIN function implication.
4. Defuzzyfication using the average method

Step 5 Simulation

Simulate the data from the problem to the Fuzzy Sugeno method application that have be madeusing matlab.

Step 6 Validate Simulation Results.

Validate the simulation results with real results in the field.

Step 7 Draw conclusions

The conclusion is drawn after simulating and validating the simulation results so that it can be used as the final conclusion.

3. Result and Discussion

3.1. Descriptive statistics

In this study there were 3 variables observed, namely branding (X_1), form of packaging (X_2), recycling (X_3). For local AMDK data, it can be seen in Table 1.

Table 1. Table of Descriptive Statistics Analysis for each Local AMDK variable

Variable	Very bad	Bad	Ordinary	Well	Very Good
Branding	70.5	72.5	73.5	75	76.5
Form of packaging	4	6	8	10	12
Recycle	6.5	7	7.5	8	8.5

Besides for national AMDK data, it can be seen in Table 2.

Table 2. Table of Descriptive Statistics Analysis for each National AMDK variable

Variable	Very bad	Bad	Ordinary	Well	Very Good
Branding	64.2	68.4	72.6	76.8	80
Form of packaging	5.7	7.4	9.1	10.8	12.5
Recycle	8.1	8.2	8.3	8.4	8.5

3.2. Fuzzy Formation of Local AMDK Membership

From Table 2, we change it to be a membership function. For example we make branding variable to the membership function and it can bee seen in Figure 1.

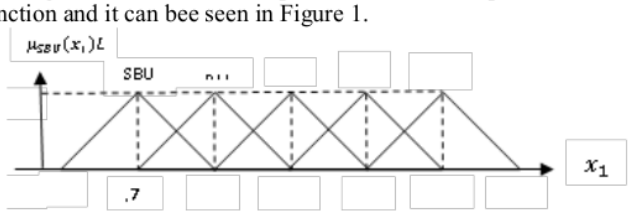

Figure 1. Membership Function in the Fuzzy Set in the Branding Variable (x_1).

On the branding (x_1) naming variable, the data held is 70.5 boxes, 72 boxes, 73.5 boxes, 75 boxes

and 76.5 boxes. This variable can be divided into 5 Fuzzy sets, which are very bad, bad, usual, good and excellent. The very badfuzzy set will have a domain [69 72], with a very bad membership level with the highest (μ= 1) located at a value of 70.5. If branding exceeds 70.5 boxes, then naming branding is near bad. A very bad set is represented by a triangle number function with higher degrees of membership when branding approaches 70.5 cardboard. The membership function for the set isvery bad as shown in Figure 3 and equation (1).

$$\mu_{SBU}[x_1]L = \begin{cases} 0, & x \leq 69 \text{atau } x \geq 72 \\ \frac{x-69}{1,5}, & 69 \leq x \leq 70,5 \\ \frac{70-x}{1,5}, & 70,5 \leq x \leq 72 \end{cases} \quad (1)$$

3.3. Establishment of Local Fuzzy AMDK Rules

Because of there is 5 indicators and 3 variables local products, so we get 125 combinations from 5^3.Then, fuzzy rules can have 125 rules, noting that each rule that is formed includes all variables. The fuzzy inference method to be used is the Sugeno 0-order method. In this method, antecedents are represented by propositions in fuzzy sets, while consequently is represented by a constant.

The 125 rules are as follows:

[R1 Local] IF branding is very bad and the form of packaging is verybad and recycle are very bad
THEN the amount of AMDK sold = 37.8

[R2 Local] IF branding is very bad and the form of packaging is verybad and recycling is bad
THEN the amount of bottled water sold = 38.7333

[R3 Local] IF branding is very bad and the form of packaging is very bad and recycling is usual
THEN the amount of bottled water sold = 39.6667

⋮

[R124 Local] IF branding is very good and the packaging form is very good and recycling is good
THEN the amount of bottled water sold = 48.1333

[R125 Local] IF branding is very good and the form of packaging is very good and recycling is excellent
THEN the amount of bottled drinking water = 49.1

3.4. Establishment of the National Fuzzy AMDK Rules

Because of there is 5 indicators and 3 variables in national products, so we get 125 combinations from 5^3.Then, fuzzy rules can have 125 rules, noting that each rule that is formed includes all variables. The fuzzy inference method to be used is the Sugeno 0-order method. In this method, antecedents are represented by propositions in fuzzy sets, while consequently is represented by a constant.

Rules are as follows:

[R1 National] IF branding is very badand the form of packaging is very bad and recycle are very bad
THEN the amount of bottled drinking water = 44.8

[R2 National] IF branding is very bad and the form of packaging is very bad and recycling is bad
THEN the amount of bottled drinking water = 45.4

[R3 National] IF branding is very bad and forms of packaging are very bad and recycling is regular
THEN the amount of bottled bottled water = 46

⋮

[R124 National] IF branding very good and packaging forms are excellent and recycling is good
THEN the amount of bottled drinking water = 51.4667

[R125 National] IF brandingis very good and packaging formsare very good and recycle are very good
THEN the amount of bottled water sold = 52.1

3.5. Testing for Local and National AMDK

The final result of calculation using fuzzy Sugeno method in local AMDK data can be seen in Figure 2.

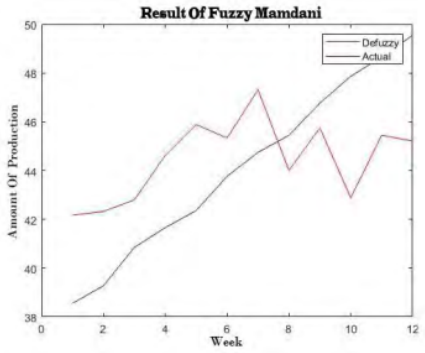

Figure 2. Local AMDK Fuzzy Sugeno Graph Images Fuzzy Sugeno Graph Results.

From Figure 2, the result of data produces the MAPE value is 6.4795 and MSE is 9,4525 with the smallest error in 9th month. While the final result of calculation using fuzzy Sugeno method in national AMDK data can be seen in Figure 3.

From Figure 3, the result of data produces the MAPE value is 2.5353 and MSE is 2,6586 with the smallest error in 6th month below:

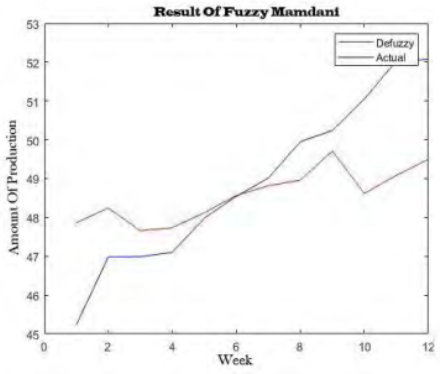

Figure 3. Figure of the National AMDK Fuzzy Sugeno Graph.

4. Conclusion

Based on the result a MAPE value for local AMDK is 6.4795 and a national AMDK is 2.5353, so MAPE of local AMDK is higher than national AMDK. After using MSE, we get the same result that local AMDK is still higher than national AMDK. So the conclusion was that national production was closer to the real value than local AMDK.For further research, more analysis using more variables is done from any factors to get a good model to predict accurately.

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