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Optimization of Kelanting's Production in a Home Industry Kelanting Fuzzy System

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ABSTRACT
Determining the exact amount of production is difficult to do because the system used by the company owner still relies on a manual calculation system. One method that can help predict production is a fuzzy system. This study aims to build a fuzzy system model to predict production based on demand and supply. Production data as an output while demand and supply as an input. The fuzzy system contains with seven fuzzy rules. The inference engine used in this study is the Mamdani method, and the defuzzification is the centroid defuzzification. The steps to predict production by the Mamdani method are: 1) identify data, 2) determine the input-output, 3) determine the universal set of input-output variables, 4) define the fuzzy set of inputs-outputs, 5) establish fuzzy rules, 6) do fuzzy inference, 7) do defuzzification, 8) calculate error values with Mean Absolute Percentage Error (MAPE). The results showed that the model Mamdani method's fuzzy system could predict the production of the home industry of Kelanting with an accuracy level of 90.15%.

Keywords: *Optimization, Fuzzy System, Production.*

1. INTRODUCTION

Kelanting is one of the typical snacks of Lampung Province. Kelanting is made from cassava with a crispy texture and has a savory taste. Therefore, many consumers like it as a souvenir or just an ordinary snack. Home industry of Kelanting has been increasing their products especially during the feast days. A company must be able to predicts precisely when determining the amount their production. So, the company can get the maximum profit. The maximum profit is obtained when the maximum sales. Maximum sales can occur when the factory can meet market demands. The use of applications which helping to predict something in the industry is still small [1]. So far, the food industry has relied on records and manual calculations to predict their monthly production. This method is surely to be challenging in determining the exact amount of production. Therefore, to solve this problem, proper planning in determining the production to meet market demand is needed [2]. Production planning is an important thing to do in predicting production accurately [3].

In helping prediction, one alternative is by using soft computing techniques such as neural networks and fuzzy logic [4]. Fuzzy logic is an approach that deals with uncertain information and some aggregate variables with the appropriate membership function [5]. Fuzzy logic is a scientific method [6]. Fuzzy logic is based on fuzzy set theory [7] [8]. Fuzzy logic was first introduced by Lütfi Asker Zadeh [9]. Referring to Zadeh's fuzzy set theory, the real object can be transformed into a specific abstract object, so that an uncertain problem can be appropriately solved [10]. Fuzzy set, in general, is a set of elements with a degree of membership function [8]. The membership function is used for the fuzzification process on input and output variables [5]. Specifically, the values used in fuzzy logic are different from classical logic. If the traditional logic value is only 0 and 1, the fuzzy logic value ranges from 0 to 1. Fuzzy value can also be called the degree of membership [11].

Fuzzy logic has been widely applying both theoretically and technically. Such as helping to solve the shortest line problem by adopting fuzzy numbers to improve the classical Dijkstra algorithm [12], the successful application of type 2 fuzzy logic in pattern recognition, classification, and grouping [13], and controlling frequency loads [14]. Fuzzy logic can also solve decision-making problems [15] and predict stock prices [16]. Besides, fuzzy logic can also be applied in engineerings, such as control automation [13] [14] and Artificial intelligence [17]. Some researchers say that fuzzy logic can make predictions well. So that fuzzy logic is considered able to create a system model that can predict production. Some factors that need to be considered in predicting production are demand and supply in the previous period. Many studies have applied fuzzy logic to help their prediction products. The fuzzy logic application is predicting the amount of production at PT Menara Jenang Kudus with the Tsukamoto method [18] and predicting egg production [19]. In addition to predicting the amount of production, fuzzy logic can also help predict the price of white sugar [20] and predict Indonesia's percentage population [21].

Nowadays, the process of Kelanting is not optimal. The production process still uses manual calculations. The factory will produce in a large quantities if the demand for the goods is also high and vice versa. Nevertheless, there are also conditions where the factory can not provide all the demand because they only produces in small quantities. Therefore, this condition shows that the production process has not been optimal yet. Based on the above research, Kelanting production in home industry has never been done. The uncertainty of demands and supplies condition needs to be considered in predicting production. Therefore, the new innovations are always needed to make the prediction product accurately. Therefore, that can predict the Kelanting production in a home industry with considering the demand and supply.

2. RESEARCH METHOD

This study discusses fuzzy models' application to predict the production of Kelanting in Gantimulyo Village, Pekalongan District, East Lampung Regency Indonesia. In the Mamdani method the input variables and outputs can be defined using the fuzzy sets [21]. Not only that, the method is also simple and easy method [22]. So, this research is using fuzzy inference system as well as Mamdani method. The following are the steps to predict the amount of production using the Mamdani method.

Identification of data

The data used in this study are demand data, supply data, and production data of 2019. The data is monthly data consisting of 3 variables: demand, supply, and production in pack units. One pack contains 60 pieces, and each piece weighs about 150 grams. The amount of data in each variable is 12 data.

Determine the input-output

The data in this study consists of three variables so that there are 2 data used as input variables that are demand and supply. While the data used as output variable 1 is the amount of production.

Determine the universal set of input-output variables

The universal set contains all the possible element or value of each input and output variables. A fuzzy set in a universal set U is characterized by a membership function $\mu_{\mathbf{A}}(x)$ that takes values in the interval [0, 1] [24]. In this study the universal set of input variables used is demand = [700 1135] and supply = [55 220]. Whereas the universal set of outputs used is production = [720 1350].

Define the fuzzy set of inputs and outputs.

Fuzzy set for each input and output, there are three categories: few (F), medium (Md), and many (M).

Establish a fuzzy rule

This stage is the preparation stage, where the rules used are to make relations between input and output.

Fuzzy Inference

After creating fuzzy rules, then make a fuzzy inference with the Mamdani method. The Mamdani Method can also be called the Max-Min Method [23]

Defuzzification

Defuzzification is the stage of converting the value obtained from the inference process into the original value. Defuzzification in this study uses the Center of Gravity (centroid).

Calculate error values with MAPE

MAPE is the middle value in the percentage of absolute error predicted. MAPE shows how much error in predicting when compared with the actual value. Following is the formula for calculating MAPE [24].

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - G_t^*}{Y_t}\right| . 100$$

The steps of the research are presented in the flowchart in Figure 1.

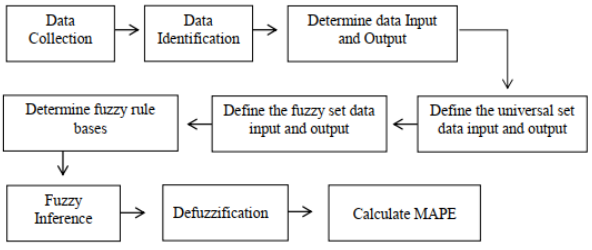

Figure 1 The steps of the research

3. RESULT AND DISCUSSION

Several studies have shown that a fuzzy system can predict an item with reasonably accurate results. This study uses two input variables: demand and supply, and one output variable, such as production. Input and output variable data are monthly data which is from January 2019 to December 2019 and obtained directly from the Kelanting Mekar Sari factory in Gantimulyo Village, Pekalongan District, East Lampung Regency, Lampung Province, Indonesia. The steps taken to predict the amount of production of the home industry Kelanting are as follows.

3.1 Identify Input and Output Variables and Determine the Universal Set of Each Variable

This study uses demand and supply data as input variables, then data on production as output variables. Table 1 shows the membership universe of each input and output.

Table 1. Input-output variable and the universal set

Function	Variable	Universal Set	Explanation
Input	Demand	[700 1135]	Total demand in one year
	Supply	[55 220]	Total supply in one year
Output	Production	[720 1350]	Total production in one year

3.2 Define the Fuzzy Set of Inputs and Outputs

Each input and output is defined in the form of a fuzzy set, such as few (F), medium (Md), and many (M). Based on the factory's experience producing Kelanting, the number of products each month is average in moderate quantities. Therefore, the range of medium fuzzy sets is longer than the few and the many fuzzy sets. The boundaries in each fuzzy set domain are determined subjectively because there are no specific rules in determining the domain boundaries for each fuzzy set. Table 2 shows the fuzzy set of each variable and its domain.

The membership function used in each fuzzy set is Triangular Membership and Trapezoidal Membership Function because both are very useful for computing problems [25].

Table 2. Fuzzy Set

Function	variable	Fuzzy set	Universal set	Domain
Input	Demand	Few	[700 1135]	[700-846]
		Medium		[773-1056]
		Many		[992-1135]
	Supply	Few	[55 220]	[55-111]
		Medium		[83-195]
		Many		[167-220]
Output	Produc-tion	Few	[720 1350]	[720-930]
		Medium		[825-1245]
		Many		[1140-1350]

3.2.1 Membership function of demand

Next, determine the membership function of fuzzy sets with domains and universal sets according to Table 2. The fuzzy set of the demand variables is proposed by the fuzzy set's membership function as follows.

$$\mu_F(x_1) = \begin{cases} 0 & x_1 \le 700 \text{ and } x_1 \ge 846 \\ 1 & 700 \le x_1 \le 773 \\ \dfrac{846 - x_1}{73} & 773 \le x_1 \le 846 \end{cases}$$

$$\mu_{Md}(x_1) = \begin{cases} 0 & x_1 \le 773 \text{ and } x_1 \ge 1056 \\ \dfrac{x_1 - 773}{146} & 773 \le x_1 \le 919 \\ \dfrac{1056 - x_1}{137} & 919 \le x_1 \le 1056 \end{cases}$$

$$\mu_M(x_1) = \begin{cases} 0 & x_1 \le 992 \text{ and } x_1 \ge 1135 \\ \dfrac{x_1 - 992}{73} & 992 \le x_2 \le 1065 \\ 1 & 1065 \le x_2 \le 1135 \end{cases}$$

The Graph of the membership function of demand is shown in Figure 2.

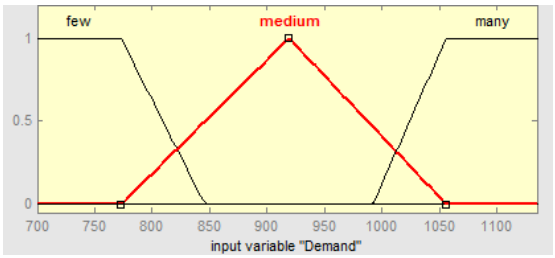

Figure 2 Membership function of demand

3.2.2 Membership function of supply.

The fuzzy set of the supply variables is proposed by the fuzzy set's membership function as follows.

$$\mu_F(x_2) = \begin{cases} 0 & x_2 \le 55 \text{ and } x_2 \ge 111 \\ 1 & 55 \le x_2 \le 83 \\ \dfrac{111 - x_2}{28} & 83 \le x_2 \le 111 \end{cases}$$

$$\mu_{Md}(x_2) = \begin{cases} 0 & x_2 \le 83 \text{ and } x_2 \ge 195 \\ \dfrac{x_2 - 83}{56} & 83 \le x_2 \le 139 \\ \dfrac{195 - x_2}{56} & 139 \le x_2 \le 195 \end{cases}$$

$$\mu_M(x_2) = \begin{cases} 0 & x_2 \leq 167 \text{ and } x_2 \geq 220 \\ \dfrac{x_2 - 167}{28} & 167 \leq x_2 \leq 195 \\ 1 & 195 \leq x_2 \leq 220 \end{cases}$$

The Graph of the membership function of supply is shown in Figure 3.

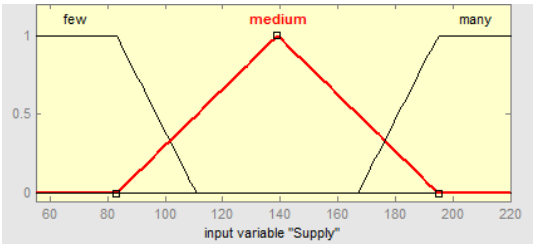

Figure 3 Membership function of supply

3.2.3 Membership function of Production

The fuzzy set of the production variables is proposed by the fuzzy set's membership function as follows.

$$\mu_F(y) = \begin{cases} 0 & y \leq 720 \text{ and } y \geq 930 \\ 1 & 720 \leq y \leq 825 \\ \dfrac{930 - y}{105} & 825 \leq y \leq 930 \end{cases}$$

$$\mu_{Md}(y) = \begin{cases} 0 & y \leq 825 \text{ and } y \geq 1245 \\ \dfrac{y - 825}{210} & 825 \leq y \leq 1035 \\ \dfrac{1245 - y}{210} & 1035 \leq y \leq 1245 \end{cases}$$

$$\mu_M(y) = \begin{cases} 0 & y \leq 1140 \text{ and } y \geq 1350 \\ \dfrac{y - 1140}{105} & 1140 \leq y \leq 1245 \\ 1 & 1245 \leq y \leq 1350 \end{cases}$$

The Graph of the membership function of production is shown in Figure 4.

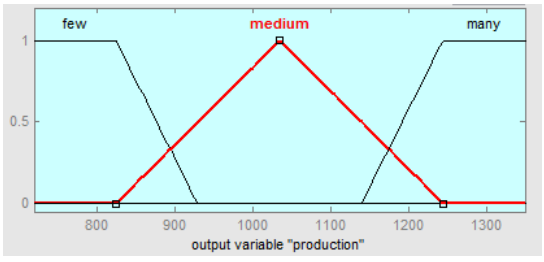

Figure 4 Membership function of production

3.3 Create a Fuzzy Rule

This study uses three variables, which are two input variables and one output variable. Each input and output variable is defined by three linguistic variables: few, medium, and many. So, the fuzzy rules that have been build are as follows.

1. IF demand is medium and supply is medium THEN production is medium.
2. IF demand is many and supply is many THEN production is medium.
3. IF demand is many and supply is medium THEN production is many.
4. IF demand is medium and supply is many THEN production is medium.
5. IF demand is few and supply is medium THEN production is few.
6. IF demand is medium and supply is few THEN production is many.
7. IF demand is many and supply is few THEN production is many.
8. IF demand is few and supply is many THEN production is few.
9. IF demand is few and supply is few THEN production is medium.

3.4 Fuzzy Inference and Defuzzification

By conducting an inference with the Mamdani method and defuzzification using the center of gravity (centroid) [25], the prediction data for the number of production of Home Industry Kelanting are presented in Table 3.

Table 3 shows the results of predictions product compared with the original data the amount of production Kelanting's production in a home industry. When look at the table carefully, the predictive value has a difference result. That is smaller than the original data. Although there are no values that are the same, it is close to the original data. This condition means that the input in the form of demand and supply can already help make a system of predicting products.

Table 3. The prediction data

Period	Production	Prediction of Production
January 2019	830	975
February 2019	878	807
March 2019	924	996
April 2019	1100	1033
May 2019	1350	1043
June 2019	1190	1073
July 2019	1189	1003
August 2019	810	1003
September 2019	990	959
October 2019	1015	1003
November 2019	1240	1263
December 2019	1255	1263

3.5 Mean Absolute Percentage Error (MAPE)

After getting the prediction data for the amount of production, then calculate the error value with MAPE. With MAPE, we can test whether the models that have been designing are good or bad [26]. The results of MAPE calculations in this study can be seen in Table 4.

Based on Table 4, it can be seen that the MAPE value on the prediction of production using a fuzzy system is 0.0985 or 9.85%. In other words, the inference model that was built had an accuracy level of 90.15%. This level is the error number of the fuzzy model using

the Mamdani method in predicting the number of production with two inputs, such as demand and supply. Therefore, this inference model can be used to predict the number of Kelanting's production in a home industry.

Table 4. The result of MAPE

No	Y_k	G_k^*	$\left\|\frac{Y_k - G_k^*}{Y_k}\right\|$
1	830	975	0.174699
2	878	807	0.080866
3	924	996	0.077922
4	1100	1033	0.060909
5	1350	1043	0.227407
6	1190	1073	0.098319
7	1189	1003	0.156434
8	810	1003	0.238272
9	990	959	0.031313
10	1015	1003	0.011823
11	1240	1263	0.018548
12	1255	1263	0.006375
average			0.098574

4. CONCLUSION

Based on this research, it can be concluded that the fuzzy system model which designed can predict the number of Kelanting's production in a home industry with considering the demand and supply. The fuzzy system built can predict the number of production accurately with an accuracy value of 90.15% and an error rate of 9.85%, calculated based on the MAPE value. Therefore, since it has a high degree of accuracy and a low error rate, it can be assumed that the fuzzy system with the Mamdani method can be used as an appropriate alternative to predict the quantity of product.

Furthermore, further research certainly needs to be developed to increase the prediction of accurancy value of kelanting's production by adding more data and other inputs which affected the kelanting's production.

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