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IMPLEMENTATION OF FUZZY TSUKAMOTO IN PRODUCTION PLANNING DECISION SUPPORT SYSTEMS

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Abstract

The purpose of this research is to implement Fuzzy Tsukamoto in designing production planning decision support systems. Determining the production quantity is one of the important activities in production planning. The production quantity affects the determination of raw material requirements and production costs. Therefore, it is very important to determine the right production quantities. It avoids the accumulation of raw material on the production floor and large production cost. In this research, production planning decision support systems provide recommendation on production quantities. It can be used as a reference for production manager to determine the production quantity for the next production period. Fuzzy Tsukamoto was a method used in this study to determine the production quantities. The result of this research is the production planning decision support system model that applied the Fuzzy Tsukamoto method. Implementation of Fuzzy Tsukamoto can provide a recommendation of production quantities that is used to determine the production quantities and making production schedule.

Keywords: Determination, Production amount, Recommendation.

1. Introduction

Production planning arranges about what products and costs concerned by company for next period. There are things to consider in making production planning such as optimization production so that the lowest cost level archives implementation of the production process. Production planning defines as a process planning for producing goods in a certain period according to predicted or scheduled organizing resources [1]. Production planning requires production quantities prediction. It is used by the production manager to determine the amount of raw material and other resource requirements needed by considering the production capacity.

A system that can provide recommendations in decision making is called a decision support system [2]. In this study, a production planning decision support system can provide recommendation to production manager about the production quantities in the next periods. This system implements one of the forecasting methods that is used to determine the production quantities.

Based on several previous research, it is known that Fuzzy Logic is a mathematics application for forecasting the production quantities [3, 4]. Several Fuzzy Logic methods are used in some cases of forecasting, such as Fuzzy Mamdani method to estimate the procurement of goods [5, 6], Fuzzy Sugeno to estimate the reducing of electrical energy consumption [7], and Fuzzy Tsukamoto method used to production planning [8]. All of that methods can be used to estimate the production quantity. The method used in this study was Fuzzy Tsukamoto method, because it has a tolerance on data and can provide responses based on qualitative, inaccurate, and ambiguous information. The result of the implementation Fuzzy Tsukamoto method in the production planning decision support system is production quantities. The production quantities are used by production manager for decision making on how much product produced in the next period. Thus, the implementation of the Fuzzy Tsukamoto method in this study aims to provide recommendations for decision makers in determining the amount of production to create the production schedule.

2. Methodology

This study was carried out in several stages as shown in Fig. 1. The preliminary work is a study of several references and was carried out at this stage. The reference sources used are several scientific journals and textbooks, that are relating to Fuzzy Method, production planning, and also decision support system. The second work is observation. A manufacturing company was chosen to be an object of observation in this study that was garment factory in Bandung. The next stage is problems identification based on some primary data such as demand, production capacity, and other resource used. We identified the problem and then analysed it to determine the production quantities using the Fuzzy Tsukamoto. At this stage, the data that needed to be input in the production planning decision support system were discovered. As a result, the system can provide production quantities as recommendation for the production manager.

In this research, modelling was carried out using Fuzzy Tsukamoto approach. Three variables used as parameters when calculating the amount of production. The next stage is the analysis of decision support system requirements. It analyses the functional and non-functional requirements of the decision support system for production planning. The last stage is designing production planning decision support system based on the result of determining the production quantities and decision support system requirement.

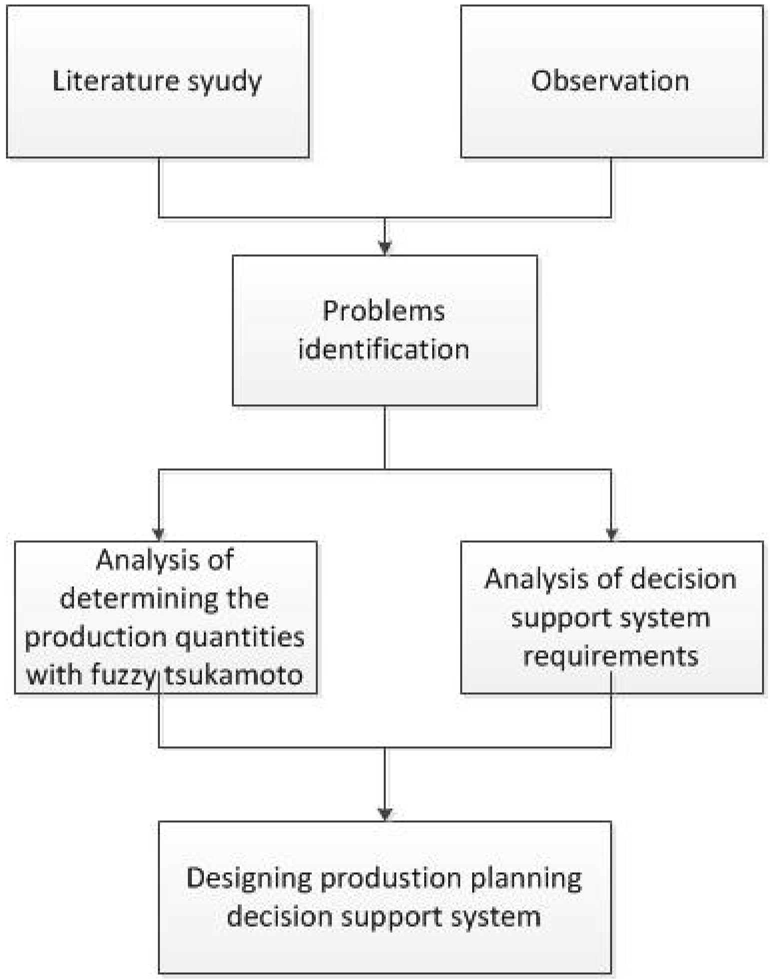

Fig. 1. Methodology.

3. Results and Discussion

3.1. Production quantities

In this study, the production quantities are determined using Fuzzy Tsukamoto method. There are three steps to determine the production quantities based on inventory data with Fuzzy Tsukamoto, those are the fuzzification, inference, and defuzzification [7, 9, 10]. The results of each stage are as follows:

i. Fuzzification

Fuzzification is the stage of defining fuzzy variables. At this stage, the membership value of current set of demand, inventory, and production uses the fuzzy set membership function by taking into account the maximum and minimum values of data for last period of each variables. Variables for the last period include demand, inventory, and production variable [9,10]. Based on the data obtained from the garment company which is the subject of research, it is known that maximum and minimum demand for clothes is 1,670 dozen and 550 dozen, maximum and minimum inventory for clothes is 1,546 dozen and 957 dozen, and maximum and minimum production are 1,289 dozen and 698 dozen, respectively. Then, a fuzzy variable model is made for demand, inventory, and production. The result of the mathematical model of fuzzy variables for demand function DOWN, FIXED, and UP, is shown from Eqs. (1) to (3); for inventory function DOWN, FIXED, and UP, is shown from Eqs. (4) to (6); and for production function DOWN, FIXED, and UP, is shown from Eqs. (7) to (9). Figure 2(a) shows the fuzzy set membership function for demand, Fig. 2(b) shows the fuzzy set membership function for inventory, and Fig. 2(c) shows the fuzzy set membership function for production.

$$\mu[x]_{demandDOWN} = \begin{cases} 1, & x \le 550 \\ \frac{1670-x}{1120}, & 550 \le x \le 1670 \\ 0, & x \ge 1670 \end{cases} \tag{1}$$

$$\mu[x]_{demandFIXED} = \begin{cases} 1, & x \le 550 \\ \frac{x-550}{560}, & 550 \le x \le 1110 \\ \frac{1670-x}{560}, & 1110 \le x \le 1670 \\ 0, & x \le 550 \vee x \ge 1670 \end{cases} \tag{2}$$

$$\mu[x]_{demandUP} = \begin{cases} 1, & x \le 550 \\ \frac{x-550}{1120}, & 550 \le x \le 1670 \\ 0, & x \ge 1670 \end{cases} \tag{3}$$

$$\mu[x]_{inventoryDOWN} = \begin{cases} 1, & y \le 957 \\ \frac{1546-y}{589}, & 957 \le y \le 1546 \\ 0, & y - 1546 \end{cases} \tag{4}$$

$$\mu[x]_{inventoryFIXED} = \begin{cases} 1, & y = 1261 \\ \frac{y-957}{295}, & 957 \le y \le 1261 \\ \frac{1546-y}{295}, & 1251 \le y \le 1546 \\ 0, & y \le 957 \vee y \ge 1546 \end{cases} \tag{5}$$

$$\mu[x]_{inventoryUP} = \begin{cases} 1, & y \le 957 \\ \frac{y-957}{589}, & 957 \le y \le 1546 \\ 0, & y - 1546 \end{cases} \tag{6}$$

$$\mu[x]_{produtionDOWN} = \begin{cases} 1, & z \le 698 \\ \frac{1289-z}{591}, & 692 \le z \le 1289 \\ 0, & z - 1289 \end{cases} \tag{7}$$

$$\mu[x]_{productionFIXED} = \begin{cases} 1, & z \le 698 \\ \frac{z-698}{402}, & 698 \le z \le 993 \\ \frac{1289-z}{591}, & 993 \le z \le 1289 \\ 0, & z \ge 1289 \end{cases} \tag{8}$$

$$\mu[x]_{productionUP} = \begin{cases} 1, & z \le 698 \\ \frac{z-698}{591}, & 698 \le z \le 1289 \\ 0, & z \ge 1289 \end{cases} \tag{9}$$

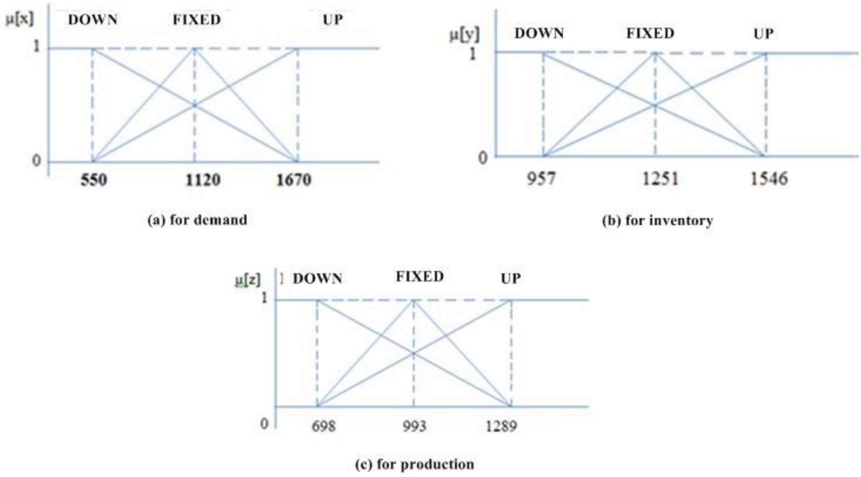

Fig. 2. The fuzzy set membership function.

Based on the mathematical model in Eqs. (1) to (9), membership values of DOWN, FIXED, and UP were obtained as follows:

$\mu[550]_{demandDOWN} = (1670 - 550)/1120$ =1

$\mu[550]_{demandFIXED} = 1$

$\mu[550]_{demandUP} = (550 - 550)/1120$ = 0

$\mu[1261]_{inventoryDOWN} = (1546 - 1261)/589$ =0.484

$\mu[1261]_{inventoryFIXED} = (1546 - 1261)/$295= 0.966

$\mu[1261]_{inventoryUP} = (1261 - 957)/$589= 0.516

$\mu[698]_{productionDOWN} = (1289 - 698)/591$=1

$\mu[698]_{productionFIXED} = (993 - 698)/402$=0.734

$\mu[698]_{productionUP} = (698 - 698)/591$=0.002

ii. Inference

Inference is the process of combining many rules based on available data. In the previous stage, nine fuzzy sets have been formed and shown in Eqs. (1) to (9). Based on the nine fuzzy sets, α and z values for each rule are determined. α is the antecedent membership value of each set, while z is the estimated value of goods to be produced from each set [9, 10]. Following are the nine rules:

[R1] IF DOWN Demand AND UP Inventory THEN DOWN Product

[R2] IF DOWN Demand AND FIXED Inventory THEN DOWN Product

[R3] IF DOWN Demand AND DOWN Inventory THEN DOWN Production

[R4] IF FIXED Demand AND UP Inventory THEN DOWN Production

[R5] IF FIXED Demand AND FIXED Inventory THEN FIXED Production

[R6] IF FIXED Demand AND DOWN Inventory THEN UP Production

[R7] IF UP Demand AND UP Inventory THEN UP Production

[R8] IF UP Demand AND FIXED Inventory THEN UP Production

[R9] IF UP Demand AND DOWN Inventory THEN UP Production

Table 1 shows the results of the antecedent membership value, based on the nine fuzzy rules that is preferred before.

Table 1. The result of the antecedent membership value.

Fuzzy Rule	α	z
[R1]	Min 0.516	984
[R2]	Min 0.966	719
[R3]	Min 0.516	984
[R4]	Min 0	698
[R5]	Min 0	*993*
[R6]	Min 0	698
[R7]	Min 0	698
[R8]	Min 0	698
[R9]	Min 0	698

iii. Defuzzification

In the Fuzzy Tsukamoto method, crisp output is determined using the centralized average of the formula number (10).

$$Z = \frac{\sum_{i=1}^{9}(\alpha_i * z_i)}{\sum_{i=1}^{9}(\alpha_i)} = 347.567 \approx 348 \quad (10)$$

According to the results of calculation using the Fuzzy Tsukamoto method, the recommended production quantities of clothes are 347 dozen.

3.2. Production planning decision support system model

The production planning decision support system provides recommendation to the production manager about the production quantities for next periods. Figure 3 shows that production planning decision support system requires some data histories such as production quantities from old periods, amount of finished goods (data inventory) from warehouse department, and product demand from marketing department. Each data is retrieved through Database Management System (DBMS) that is designed to manage the current database and carry out operations on the data request by the production manager.

The function of Model Base Management System (MBMS) includes: 1) to generate new routines and report; 2) create, update, and change models using programming languages; 3) manipulate data; 4) and create decision support system or subroutines as well as other development blocks. MBMS is able to associate models with the right link through a database [11]. Three variables are used as parameters such as production, demand, and inventory. Then, in system design the three variables are considered as the main data which is important in the production planning decision support system.

The functional design of production planning decision support system is shown in Fig. 4. It shows that the production manager is the only user in the system. DBMS and MBMS are the systems that interact with the production planning decision support system.

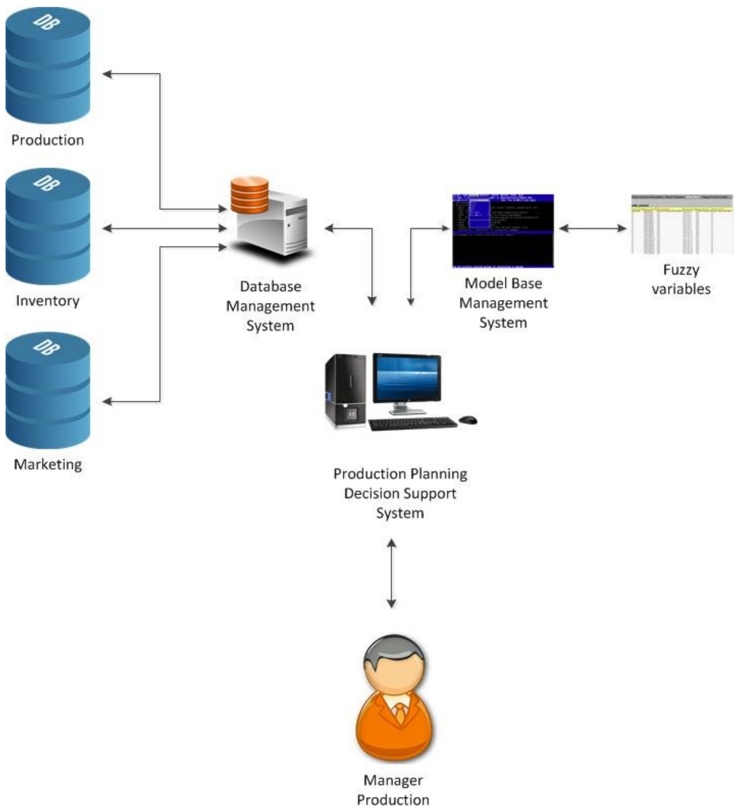

Fig. 3. The production planning decision support system model.

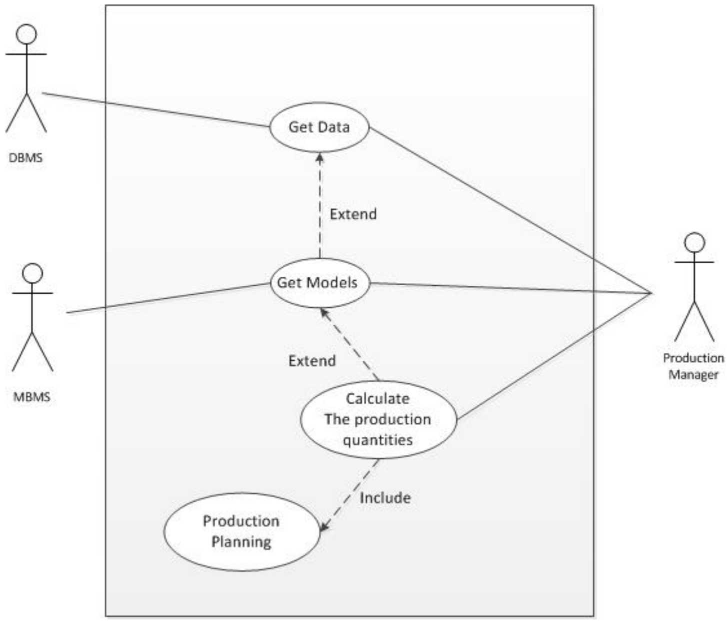

Fig. 4. Use case of production planning decision support system.

4. Conclusion

Fuzzy Tsukamoto can be used as a decision support system for estimating the production quantities. Therefore, the implementation of Fuzzy Tsukamoto in production planning decision support system can provide a recommendation of production quantities. This recommendation can be used as a reference to determine the production quantities by production manager for next period of production and production schedule.

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