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DECISION SUPPORT MODEL FOR PURCHASING DECISION IN PHARMACEUTICAL COMPANY

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ABSTRACT

Purchasing is an important activity carried out by companies and organizations in fulfilling inventory. Today, having the right and accurate inventory of items is imperative, exclusively in large scale companies that have a lot of items. The study proposed a decision support model (DSM) to determine how much of the next number of items purchased by a pharmacy company. Combination of methods mathematics, regression artificial neural network, and fuzzy logic Tsukamoto were successfully operated as a main approach of the model. The main objective of the study is to construct a model and support decision makers in controlling the decision on how many purchases of items. The constructed DSM was determined by five independent parameters (i.e. sales, demand, season, cycle time, and delivery time) and two other dependent parameters. By exploiting five types of item, the model was able to propose an item number should be purchased in next purchasing activity optimally.

Keywords: *Purchasing, Inventory, Decision Support Model, Mathematic, Fuzzy Logic Tsukamoto, Regression Artificial Neural Network, Pharmacy*

1. INTRODUCTION

Consuming precise information of inventory is crucial for a company; especially for companies that have a large and high-value inventory. Thus, the inventory requires a proper planning and control. Here, companies demand to make good procurement decisions, companies need accurate and reliable data. Purchasing is a valuable activity carried out by companies and organizations in fulfilling inventory. According to [1], purchasing is a way for organizations to provide continuity of supply for customers. To make good procurement decisions, companies need accurate and reliable data. Purchasing with inaccurate data is able to trigger inventory shortages, excess inventory, and other additional procurement challenges have the potential to directly affect costs borne by the company [2].

One of factors in implementing inventory management by managing supplies properly and optimally can be done by optimizing existing inventory (safety stock) [3][4][5][6], reducing the risk of delay in delivery of inventory (lead time) [7], decreasing delivery time and cycle time [8] or anticipating sudden demand [9] and maintaining inventory during certain seasons [10].

To avoid the provision of bad inventory, there are three studies on forecast-based inventory optimization conducted. [11] conducted a study to overcome scalability problems in manufacturing companies in the automotive lighting equipment manufacturing area, provide user recommendations if something unexpected happens in the future. Reduces downtime which leads to higher costs due to unexpected failures and shortages or storage costs in the case of low inventory of parts because inventory ordering is just in time (JIT) if there is no inventory. So in that case the study conducted enables the transformation of companies from reactive to proactive using a joint predictive maintenance model and spare parts with event driven architecture (EDA).

However, this method has a gap, as previously the expansion of the decision model deals with some alternative maintenance measures and develops context-aware systems to consider the context that affects the decision model. [12] stated that there are often problems in managing inventory and maintenance of spare parts, especially the provision of improper spare parts activities. In short these activities bring a big impact in making every

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decision. Thus [12] proposed combining methods of optimizing inventory and maintaining parts.

In addition, [13] affirmed that the problem of uncertainty in the demand for spare parts and the lack of accurate order, inventory, spare parts, and reordering costs caused inventory management policies to be incorrect. The results of the study proposed a method based on parametric estimation of distribution fit, mathematical models, and meta-heuristics. Research data obtained from world-famous business jet manufacturing. However, this research still has gaps in the service level such as waiting time for other customers that need to be measured by the system performance, expanding the parts and location level to the network level which is considered a problem as a multi-echolon, testing several distributions of the lead time of demand for goods fast moving and slow moving.

In the pharmaceutical world, inventory is the biggest investment, its value continues to increase from year to year due to its ever-increasing growth, higher product costs, and increasing operating activities. Company ABC provides pharmaceutical products in collaboration with suppliers by determining how many products are provided. The problem that is being faced by Company ABC is the object of research that the company does not have an objective decision model to predict the number of products to be purchased. Company ABC determines the need for how many purchases of pharmaceutical products still use manual and subjective calculation systems by looking at the sales variable in the previous month and current stock. From this fact, it results in companies making inefficient product purchases, preparing large funds to make product purchases and payments to suppliers that continue to increase, which is complained of by the top level management of Company ABC.

Stating that the pharmaceutical industry needs to do efficiency aimed at optimization of procurement, especially to payments to suppliers. From a number of research background points above, the research on developing decision-making models for determining the number of purchases of pharmaceutical products is important to be studied in depth. This study used inventory stock data and detailed sales from January 2018 to December 2018 from Company ABC. The results of this study were expected to get the right model and / or method in order to predict the number of specific purchases for pharmaceutical products. Thus this study conducted to construct a decision support model (DSM) for making purchasing decision in pharmaceutical industry.

2. THEORETICAL VIEWSTYLE OF PAPER

2.1 Inventory Management

Inventory management is a process of managing goods, materials, or assets owned by a company for future use, while keeping operational costs (overhead) and operating costs to a minimum. A good inventory management enables companies to improve their customer service, cash flow and profitability. Because, a business success depends on its ability to provide services to customers and remain financially viable [1].

From the point of view of purchasing with an inventory optimization, it can not only satisfy the customer and fulfill the needs because of customers and cost efficiency, but to increase internal performance also by improving operational processes [2]. Various reasons for the importance of getting and storing inventory are: Predictability, to be involved in capacity planning and production scheduling, organizations need to control how much raw material and how many parts the organization processes at any given time; fluctuations in demand, organizations do not always know how much needs at a certain time, but the organization also needs to meet customer or production demands on time; unreliability of supply, inventory protects the organization from unreliable suppliers or when a scarce and stable supply is difficult to ascertain; price protection, buying the amount of inventory at the right time helps avoid the effects of cost inflation.

Numerous suppliers prefer to send periodically rather than sending supplies in one full year of stock keeping units (SKUs); quantity discount, often large discounts are available if the organization purchases in large quantities, not in small quantities; lower ordering costs, if an organization buys larger quantities of items less frequently, ordering costs are smaller than buying smaller quantities repeatedly.

2.2 Fuzzy Logic

In 1965, [14] introduced a fuzzy set theory to overcome the inaccuracies and uncertainties inherent in human judgment in the decision making process through the use of linguistic terms and levels of membership. Fuzzy set is an object class with membership value.

This value presents a level of stability where certain elements become part of the fuzzy set. Basically, fuzzy logic is used to eliminate and avoid disguises [15] when someone makes a decision to remember from all available information and make the best choice from the input given [16]. Furthermore, the real world actually faces two

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concepts: firm logic (crisp logic) and fuzzy logic. Firm logic or Boolean logic only recognizes two conditions (yes or no, high or low, 1 or 0); while fuzzy logic is a disguised logic whose degree of truth is between (0, 1). Boolean reasoning itself is conceptually related to truth that is not yet clear [15]. The reasons for using fuzzy logic are: easy to understand, because mathematical set theory as a fuzzy basis is easy to understand; flexible for modifications and uncertainty problems; receiving data that is incorrect; and use language that is easy to understand.

2.3 Tsukamoto Fuzzy Inference System

Fuzzy inference system (FIS) is a computational framework based on fuzzy set theory, IF-THEN fuzzy rules, and fuzzy reasoning. So far, several methods have been known in the FIS, such as the Tsukamoto method, the Mamdani method, and the Sugeno method. In the Tsukamoto method, each consequence of an IF-THEN rule must be represented by a fuzzy set with a monotonous membership function. The inference output from each rule is given explicitly (crisp) based on α-predicate (fire strength). The predetermined α-value will be obtained by finding the minimum value (∩) of the membership level. The final result uses a weighted average or also called the defuzzification process [17], which is illustrated in equation (1); where α = alpha, z = crisp value, and Z = defuzzification [18].

$$z_1 = \frac{SUM(\alpha_i * z_i)}{SUM(\alpha_i)} \quad (1)$$

2.4 Regression Artificial Neural Network (Reg-ANN

Classification is a data mining technique (machine learning) that is used to predict group membership for data instances. To simplify prediction or classification problems, ANN is being introduced. ANN is a term derived from biological neuron models, used as information processing systems and models of complex patterns and forecast problems. This network contains several interconnected neurons, as biological neurons, and produces an output pattern based on the pattern of input provided [19]. Biological neurons in the human brain consist of billions of neurons that communicate with each other through electrochemical signals. There are several elements of artificial neurons that model biological neurons, these include: 1) inputs that model synapses, 2) weights, which model signal strength, and 3) activation functions that decide whether neurons are activated or not, and output. Figure 1 illustrates artificial neurons that model biological neurons based on work [20].

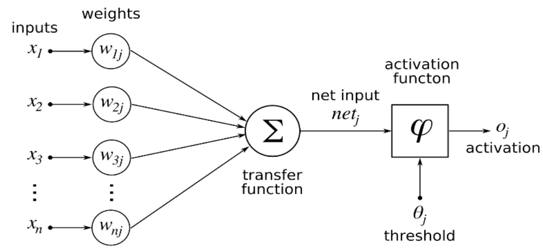

Figure 1: Example of Artificial Neuron [21]

As shown in Figure 1, ANN is a very simple representation of how brain neurons work; where the input layer consists of independent variables (x1, x2, x3, ..., xn) acting as a neural network sensor organ, each neuron receives input and performs dot operations with a weight. Weights consist of several weights (w1j, w2j, w3j, ..., wnj) associated with each node. Threshold is the internal upper threshold value of the node. This value affects the activity of the output node y. Activation function is a mathematical operation known as the output signal y. Hidden layer in a multilayer network acts as the cognitive brain of the network, while the output layer consists of neurons that represent the solution of the problem [22]. Multilayer is a feedforward network, where information in this network only moves in one direction and does not form a directed cycle. Information moves from the input layer to the hidden layer and to the output layer.

3. RELATED WORKS

[9] benefitted Tsukamoto's fuzzy method to create a decision support system (DSS) for determining the amount of pineapple production. The independent variable is directly related to determining the amount of production, namely the supply of raw materials and the amount of demand. From the results of testing the accuracy and analysis results using the Tsukamoto fuzzy method which is done with 49 the amount of data produces an error value in forecasting or MAPE which is 0.0607%. It can be concluded that it can be combined with other decision support methods based on artificial intelligence.

Furthermore, [23] conducted a study to create a DSS for ordering goods in the following month based on Tsukamoto fuzzy method. There are 3 input variables operated in this study, namely sales, inventory, and ordering or purchasing. Then to compare the results of this study using mean square

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error (MSE), which is a manual prediction with a prediction of a decision support system whose error result is 0.20815. It was concluded that the input variables used must be more than 3 variables, in order to produce better results with complex variables.

Then, [24] exploited fuzzy logic to help management analyze, eliminate ambiguity and provide decision information. Input from experts there are 3 variable variables (economic value, technical adequacy, and environmental effects) and 4 sub-criterion variables (technology cost, operating cost, technology, function, disposal cost). From the results of tests and observations by researchers using fuzzy logic techniques is the inconsistent and inaccurate presence in the declaration of criteria so that the impact on decisions. This can be improved by seeking more information from experts.

According to [7] in selecting inventory control methods influenced by several factors, namely customer service level, costs structure, number of orders, lead time, storage conditions (storage location), and demand patterns. All of these variables are needed to build a proper inventory management system. [7] only entered demand patterns as research material. The data used uses enterprise data that has been prepared. From this study it was concluded that the proposed model helped achieve better results than conventional forecasting techniques (seasonal forecasting models and exponential smoothing models). The result is a more accurate and effective demand pattern.

[25] conducted an inquiry about demand that depends on random prices. Furthermore, [25] investigated purchasing time, quantity, and purchasing decisions that are integrated with retailer's capital on seasonal products. The method proposed by researchers is a decision support system with a simple smart purchase for retailers who have limited capital and numerical experiments. The results showed the main limitation of the proposed research method lies in the high dependence on linear demand. Other limitations that require further work include the low application of the methods proposed in the management of new product purchases, because the demand patterns for new products cannot be projected from historical sales data alone.

[26] conducted research on optimizing the purchase value of EHDC cement using 3 index values from the purchase, namely materials value, suppliers value, and social value. The mathematical model method was used to solve multi-objective linear programming problems by transforming into a linear program. The results show that supplier supply capacity can affect distribution, and materials are allocated to the suppliers with the highest cost effectiveness.

4. RESEARCH METHODOLOGY

4.1 Research Mindset

As illustrated in Figure 2, the first thing to do is to identify the problems faced in Company ABC. Company ABC maintains strengthening links and ecosystems in business groups, as well as sustainable organizational management with can estimate or predict the needs of health products in the future. To predict the needs [27], how many purchases of Company ABC to suppliers still use a manual calculation system or without a decision model and subjective by looking at sales variables in the previous month and current stock. While the report every year the payment costs that are directly borne by the company [2] to suppliers is the highest every year so that it becomes an issue of inventory optimization [3].

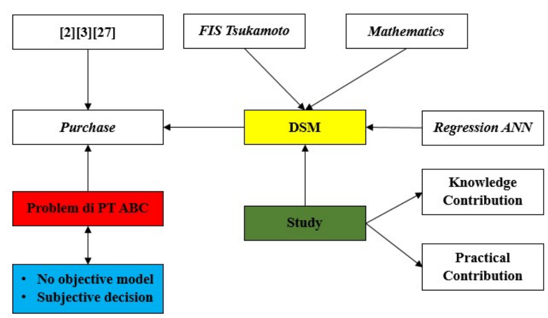

Figure 2: Mindset of Research

Therefore, we conducted a literature study to find a prediction method to develop a DSM to determine how many purchasing products are needed by Company ABC. DSM is formed from a combination of Tsukamoto fuzzy logic inference system (FIS), mathematical models, and regression artificial neural networks (ANNR). Mathematical models are used to calculate lead times. ANNR is used to classify items that are predicted to rise or fall in the following month and calculate the average initial stock. With the results obtained from the two methods, Tsukamoto's FIS Logic is used to determine how much need to purchase the amount of pharmaceutical goods at Company ABC. The next step is to collect data and then analyze the data requirements related to the prediction of the need to purchase pharmaceuticals. The data that matches the results of the analysis will be grouped by drug category. The results of data processing which will

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then be used as a data source for the proposed method.

4.2 Research Stages

Based on the research framework of Figure 2, it is necessary to explain more about the stages initiated (Figure 3). The main output of the resulting research is to produce a model of supporting purchasing decisions. This research was conducted through three stages; (1) literature study, (2) observation, interview, and data collection, (3) expert opinions are needed and construct models. Desk based research and surveys are the research methods used in the first stage of the study.

Specifically, in conducting a literature study, the authors searched for references from previous researchers who are related in order to determine the goal function of the study. The authors also extracted the information that can help research through several references. Reference material was taken from books, the internet, scientific papers, journals, papers and theses. On an internet search, a Sciencedirect database was performed, pressing the advanced search button and then entering the keyword "decision support model for purchase decision" in the title, abstract or keyword fields with the type of article selected. Based on literature studies, knowledge was captured and then used to analyze research objects (development of DSM for determining the number of purchases of Company ABC pharmaceutical products). Besides collecting information and data sourced from primary data sources and secondary data sources. Primary data sources are data sources obtained directly from the field.

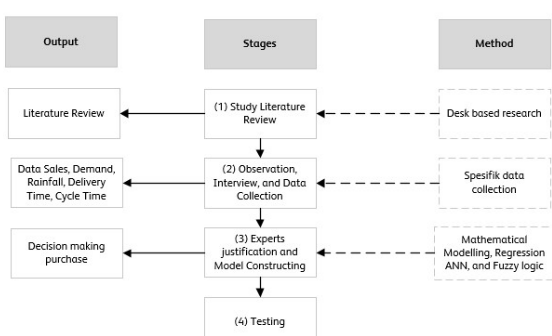

Figure 3: Research Stages

The primary data sources of this study include interviews and observations, in which the author interviews with managers who work at Company ABC. While secondary data sources are sources of data obtained indirectly from field informants. This secondary data source is in the form of websites, journals, reports, theses on purchases, published financial statements and company internal data. Information collected to find out the criteria of having an attachment or dependence on inventory purchasing activities at Company ABC. The data and information used in the form of literature relating to predictions, Tsukamoto FIS logic, mathematical models, as well as sales data and product inventory. The research was sourced from sales reports (15,336 lines) and inventory reports from January to December 2018 (17,746 lines). The models built in this research were the mathematics, ANNR, and Tsukamoto fuzzy logic.

The process of designing a model was done by designing a model that will be run. The design process is done through collecting supporting facts in the system design using unified modeling language (UML) as a tool in explaining the program analysis flow. The UML operated were use case diagram as a user representation with the model by showing the relationship between each user involved with the system, class diagram explains how the model was built to develop a decision making model for determining the number of product purchases; activity diagram explains the flowchart of decision model development.

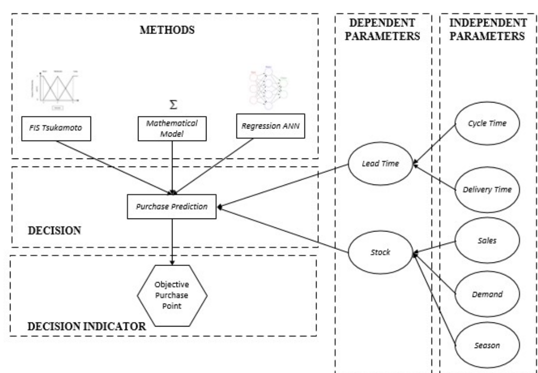

Figure 4: Influence Diagram of Purchase Prediction

5. RESULT AND DISCUSSION

5.1 Selected Variables

Based on the influence diagram in Figure 4, it can be seen that the hexagonal symbol that shows the output of the research is determining the decision in the form of making a purchase order (purchase) with a certain amount by Company ABC at a certain time. These outputs are expected outputs from solving existing problems (decision indicators). The decision to make a purchase is determined by 2 dependent variables, namely lead time and stock. Lead time is directly affected by

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two independent variables, namely delivery time and cycle time. While the stock is directly influenced by sales (sales), demand (demand), and season. Where sales are influenced by many items sold. While demand is influenced by many items requested. Next, it is the season variable influenced by the time of rainfall. The method used in developing the decision making model for determining the number of product purchases is a combination of three methods, namely mathematical modeling, ANNR, and Tsukamoto FIS.

5.2 Model Configuration

In this section, it is explained that the development of a decision-making model for determining the number of purchases of pharmaceutical products is described in a high-level model configuration. The model configuration created is designed in accordance with the basic structure of the decision support system. The configuration of the development of the decision making model for determining the number of product purchases can be seen in Figure 5.

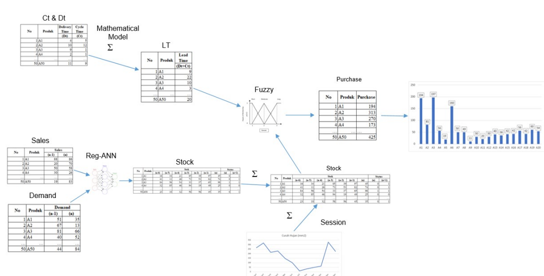

Figure 5: High level configuration for the constructed model

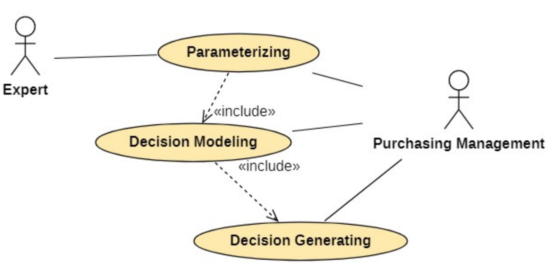

Figure 6: Use Case Diagram of constructed model

5.3 Model's Usecase Diagram

In this section the use case diagram function is to illustrate an interaction between one or more actors with the model being made. And also to be able to understand what functions are in the system and anyone who uses it. Figure 6 illustrates the relationship between models and actors. Theoretically, actors can be system actors or humans; where the actor system is another system / model that interacts with the model built and the human actor is someone (human) directly related to the model. Expert and purchasing manager provide opinions on variables related to purchasing activities. To get the results of the model decision, it is needed a decision model which will be used later.

5.4 Model's Class Diagram

In this section the function of class diagrams is to show a set of classes, interfaces, and collaborations and relationships that are in them. The class diagram is shown in Figure 7. The model that the researchers propose consists of five types of Product, Demand, Purchase, Stock, Season, Sales. Each of them describes all the attributes and operations related to mathematics model, ANNR, and Tsukamoto FIS. ANNR is used to predict the status of a stock up or down and predict the amount of stock. Together with mathematical modeling to calculate lead time, while Tsukamoto FIS with its rule base is able to give a decision on how many purchases of pharmaceutical goods. Fuzzy rules are academically defined to be characterized by sales coefficients and lead time coefficients based on fuzzy input variables. A rule number with four variables and three types of variable linguistics are 9 rules.

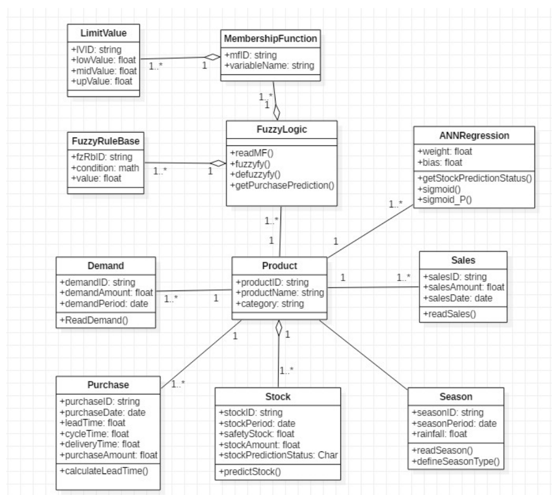

Figure 7: Class diagram for the created model

5.5 Model's Activity Diagram

Activity diagram (AD) is graphical representations of workflows of activities and phased actions with support for choice, iteration, and concurrency. In the UML, AD is intended to model computational and organizational processes (i.e. workflows), as well as data flows that intersect

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with related activities. Although AD mainly shows the overall flow of control, they can also include elements that indicate the flow of data between activities through one or more data stores. AD is explained in Figure 8.

The AD starts with the activity reading the data which will later be broken down into two activities that run parallel. The first is the activity generated from the mathematical model, which is the calculation of lead time, which is broken down into two activities by calculating delivery time and cycle time. Calculation of delivery time and cycle time is obtained by reading each product. The second is the activity generated from the ANNR method, which is the calculation of predictive stock quantities. It starts by reading the input, weight and bias then calculates the cost function and activation function so that the next month's stock forecast is generated. The next activity which is lead time and stock is put into Tsukamoto fis. Insert each crisp value into a fuzzy value. Then evaluate fuzzy rules / rules / rules to produce the output of each rule. After obtaining the output of each rule, the reasoning process is carried out, namely aggregation by changing the output to a firm value (crisp) in accordance with the specified membership function.

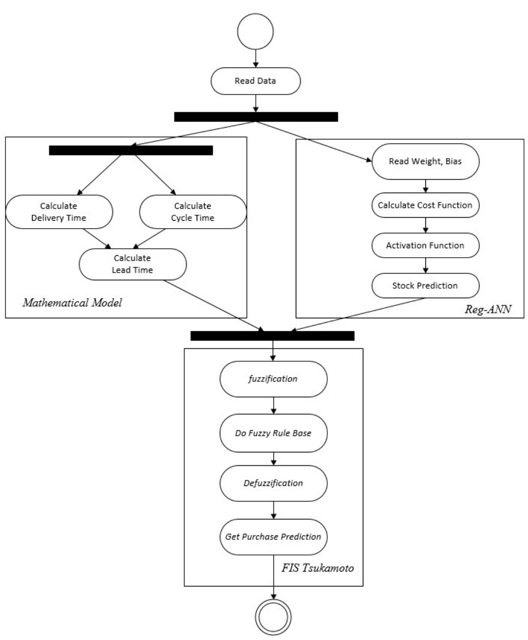

Figure 8: Activity Diagram of Purchasing Prediction

5.6 Mathematical Model

In this section, we explain how the calculation of mathematical equation modeling can help solve problems. The steps are: 1). Calculating lead time (Lt) consisting of 2 parts: delivery time (Dt), that is the delivery time from the supplier system to the customer and cycle time (Ct), that is the time between the arrival of the order and the time the product is asked to leave the manufacturing system. The waiting time is calculated mathematically using equation (1). The lead time calculation for all data in this model is presented in Table 1.

$$Lt = Dt + Ct \qquad (1)$$

Table 1: Lt Measurement for Fifty Products

No	Product	Dt	Ct	Dt + Ct
1	A1	4	5	9
2	A2	10	12	22
...	...	...	....	...
49	A49	3	13	16
50	A50	11	9	20

$$\text{Costs}, W_1, W_2, B = \textit{train}\ () \qquad (2)$$

$$\sum_{i=1}^{10000} W_i - W_i - learning_{rate} * dcostdw_i \qquad (3)$$

$$\sum_{i=1}^{10000} B_i - B_i - learning_{rate} * dcostdb_i \qquad (4)$$

Table 2: The Example of Calculation for Cost Function, Weight, and Bias

Index	Cost Function	Weight	Bias
0	2.885025532	0.958531	-2.9284
1	1.301529226	0.958531	-2.9284
2	1.074861044	0.958531	-2.9284
3	0.906967464	0.958531	-2.9284
4	0.803199781	0.958531	-2.9284
5	0.714222194	0.958531	-2.9284
6	0.671630644	0.958531	-2.9284
7	0.621572082	0.958531	-2.9284
8	0.590376750	0.958531	-2.9284
9	0.672423324	0.958531	-2.9284

Table 3: Whole Result of Z Value Calculation

Prod.	SUM ($\alpha_i * z_i$)	SUM (α_i)	Z
A1	1.42	0.67	2.10
A2	3.00	1.00	3.00
...	...	...	...
A49	3.00	1.00	3.00
A50	3.00	1.00	3.00

Procurement is a complex process of activities with a high level of and for the fulfillment or supply of the needs and supply of goods or services under contract or direct purchase to meet business needs [28]. Demand is the rate at which consumers want to buy a product and can also be defined as the quantity of goods or services with the ability to buy at a certain price. Determining the Cost Function, is a measure of "how well" the neural network performs as it should with the training samples and expected outputs. The cost function variable depends on input variables such as weight and bias. The equation of the cost function, weight, bias can be seen in equation (2); where costs is result value of single training, W_1..., W_n are weight, W_n is coming from measurement via equation (3); B is bias, B is coming from calculation via equation (4). The example of calculation for cost function, weight, and bias is presented in Table 2. In main de-fuzzification process, Z value resulted in Table 3 [18].

5.7 Mathematical Model for Seasoning

Based on the observations of researchers in the period from January to December 2018. High rainfall occurs in January, February, March, April, May, June, September, October, November, and December. While low rainfall occurs in July, August (Table 4). Then, based on data, we made IF-ELSE condition rules:

IF Period (January, February, March, April, May, June, September, October, November, December) THEN Results + 5%
ElSE IF Period in (June, July, August) THEN Print (Results)

The results of the mathematical model based on rainfall are illustrated in Table 5, where data for SUM (α_i*z_i), SUM (α_i), and Z coming from Table 3.

5.8 ANN Regression Model

Furthermore, the modeling using the ANN Regression has been tested using variables, namely sales data for pharmaceutical products and demand data from January to December 2019 which has a cough / cold category. Training purposes the input data used are sales (t-1), demand (t-1). And the output data used is stock (t). Where the results are data that has been trained. Furthermore, for the purposes of testing the input data used, sales data (t), demand data (t) and output data used are stock (t + 1), which is the prediction of the next stock quantity. The author assumes t can be days, months or years. But in this test the author uses monthly data.

Table 4: Rainfall Data

Month	Rainfall (mm^2)
January	266.00
February	319.00
March	215.00
April	230.00
May	148.00
June	101.20
July	10.40
August	31.50
September	48.30
October	63.30
November	327.00
December	226.00

Table 5: Purchasing Prediction based on Rainfall

Product	Lt	St	St*Z	Purchase Amount
A1	9.00	92.00	194.00	204.00
A2	22.00	104.00	313.00	329.00
...	...	...	...	...
A49	16.00	119.00	356.00	373.00
A50	20.00	59.00	177.00	186.00

The result shows that data sales (t) = 86 and data demand (t) = 35, Stock (t+1) predicted is increase. By using sales (Table 6) and demand data (Table 7), we predicted Stock (t+1) for fifty products, and the result is displayed in Table 8. And, Table 9 describes stock prediction for fifty products for six months before.

$$sigmoid(x) = \frac{1}{1+e^{-x}} \quad (6)$$

Table 6: Sales Data

No	Product	Sales	
		(t-1)	(t)
1	A1	88	86
2	A2	20	70
...	....	...	...
49	A49	55	80
50	A50	19	83

5.9 Fuzzy Model

Here, three variables operated are lead time (Lt), stock (St), and purchasing. Their membership function configured in Figure 9-11 respectively. Then, fuzzy rules were determined. Please see Table 10. In addition, all the rules are combined. This is done to get the fuzzy output value from the fuzzy input value. The mechanism is the fuzzy input value that starts from fuzzification and then is inserted into the rules that have been made fuzzy output. The subjective values for the lead time (LT) variable are: LT = Long, If LT ≥14 days; LT = Moderate, If 1 day < LT <14 days; and LT = Short, If LT ≤1 day. The subjective values for the stock (St) variable are: St = High, If St ≥ 500 item / month; St = Moderate, If 150 item / month < St <500 item / month; and St = Low, If Sl ≤150 item / month. Then, the subjective values for the purchasing (Prc) variable are: Prc = High, If Prc ≥ 1; Prc = Moderate, If 1 < Prc <3; and Prc = Low, If Prc ≤ 0. And the process results of Ri and Zi are respectively described in Table 11 and 12.

Table 7: Demand Data

No	Product	Demand	
		(t-1)	(t)
1	A1	51	35
2	A2	67	13
...	...	...	...
49	A49	95	56
50	A50	44	84

Table 8: Prediction Result of Stock Amount

Product	Stock			Status (0-decline, 1-increase)	
	(t-6)	…	(t)	(t)	(t+1)
A1	16	…	45	0	1
A2	41	…	74	0	1
...	...	…	...	...	...
A49	35	…	84	1	1
A50	23	…	35	0	1

Table 9: Prediction Result for Six Month Before

Product	Status (0-down, 1-up)				
	(t-6)	(t-5)	…	(t-2)	(t-1)
A1	1	0	…	1	0
A2	0	1	…	1	0
...	...	...	…	...	...
A49	1	0	…	0	1
A50	0	0	…	0	0

To get an output value (crisp) is to convert inputs into numbers in the fuzzy or de-fuzzification set domains. After getting the value of αi, the value calculation process will be carried out for each consequent rule (Zi) in accordance with the membership function used. The results of the de-fuzzification process can be seen in Table 12. From the result of de-fuzzification, we get prediction multiplier from stock (Z). To produce a prediction of the number of purchases on each product, the calculation (St * z) is shown in Table 13. Whereas in the purchase column is the calculation of the predicted number of purchases affected by rainfall (Figure 12).

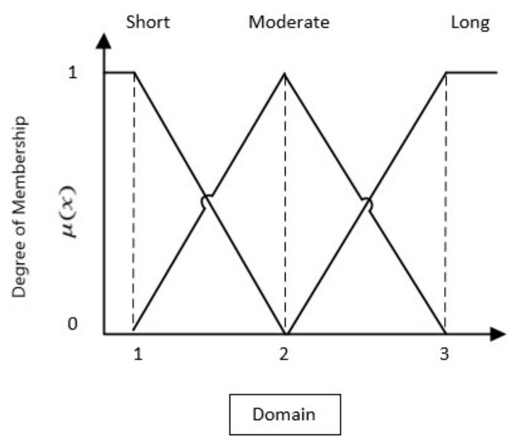

Figure 9: Membership Function for Lead Time

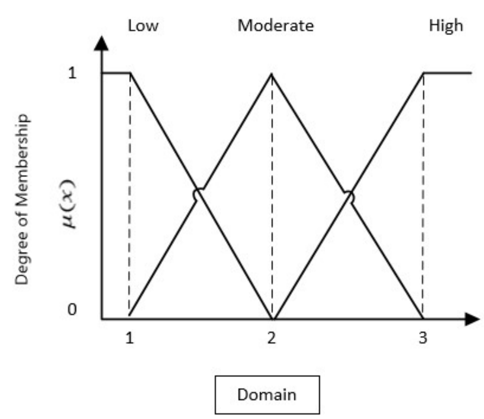

Figure 10: Membership Function for Stock

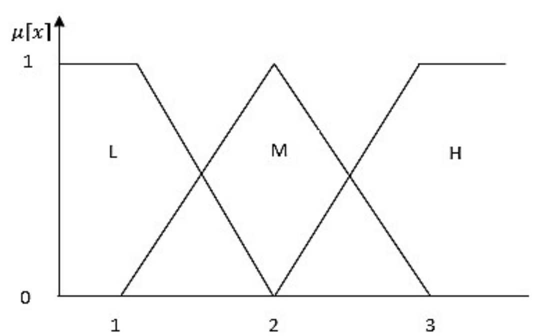

Figure 11: Membership Function for Purchasing

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Table 10: Fuzzy Rules

[Rule 1]	IF (Lt=SHORT) AND (St=LOW) THEN (Prc=HIGH)
[Rule 2]	IF (Lt=SHORT) AND (St=HIGH) THEN (Prc=LOW)
[Rule 3]	IF (Lt=SHORT) AND (St=MODERATE) THEN (Prc=LOW)
[Rule 4]	IF (Lt=MODERATE) AND (St=LOW) THEN (Prc=MODERATE)
[Rule 5]	IF (Lt=MODERATE) AND (St=HIGH) THEN (Prc=MODERATE)
[Rule 6]	IF (Lt=MODERATE) AND (St=MODERATE) THEN (Prc=MODERATE)
[Rule 7]	IF (Lt=HIGH) AND (St=LOW) THEN (Prc=HIGH)
[Rule 8]	IF (Lt=HIGH) AND (St=HIGH) THEN (Prc=LOW)
[Rule 9]	IF (Lt=HIGH) AND (St=MODERATE) THEN (Prc=MODERATE)

Table 11: Result of Ri

	Lead time				
			S	M	H
			0.00	0.08	0.86
Stock	L	0.70	0.00	0.08	0.70
	M	0.30	0.00	0.08	0.30
	H	0.00	0.00	0.00	0.00

Table 12. Result of Zi

	Lead time				
			S	M	H
				0.143	0.857
Stock	L	0.700		2.000	2.700
	M	0.300		2.000	2.000
	H				

Table 12: Result of Defuzzification

Prod.	Lt	St	SUM (α_i*z_i)	SUM (α_i)	Z
A1	194.28	92.00	1.42	0.67	2.12
A2	313.00	104.00	3.00	1.00	3.00
...	...	...	...	...	...
A49	0.00	119.00	3.00	1.00	3.00
A50	0.00	59.00	3.00	1.00	3.00

5.10 Discussion

The constructed model is novel and also as a fundamental finding in the computer modeling domain. It is able to suggest how many purchase order point should be made by purchasing manager of specific pharmaceutical company. The combination of mathematics, Reg-ANN, and fuzzy logic with Tsukamoto approach is also original. The novelty is clear contribution for knowledge and practical domains.

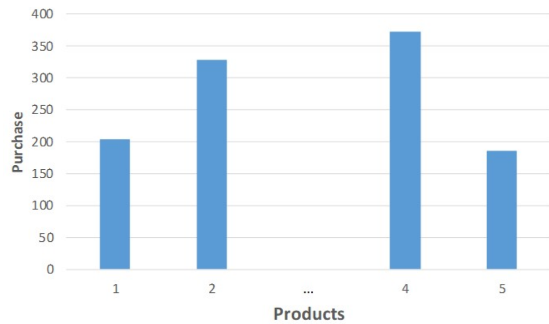

Figure 12: Calculation Result for Decision Purchase Influenced by Rainfall

Table 13. Purchasing Item Prediction Result

Prod.	Lt	St	Z	St*Z	Purchase
A1	194.28	91.67	2.12	194.00	204.00
A2	313.00	104.33	3.00	313.00	329.00
...	...	...	...	...	...
A49	0.00	118.50	3.00	356.00	373.00
A50	0.00	59.00	3.00	177.00	186.00

The constructed model is unalike with the previous studies. For example, [9] and [23] only operated Tsukamoto fuzzy logic to develop a DSM in solving the ordering and production problem. However, in this study, three methods (applied mathematics, Reg-ANN, and Tsukamoto fuzzy logic) were united scientifically. Furthermore, [7] constructed a model in seasonal forecasting by using exponential smoothing models with the close case (inventory); in this study the sessional aspect is only one of five parameters considered (the others are parameters sales, demand, cycle time, and delivery time).

6. CONCLUSION AND FURTHER WORKS

Based on the research that has been done, the three points depict the conclusion of study. Based on this study obtained five independent variables (cycle time, delivery time, sales, demand, and season) and two dependent variables (lead time and stock). A DSM model was built through a number of available variables, by combining three methods mathematics, Reg-ANN, and Tsukamoto fuzzy logic. Finally, through the model implementation, the purchase decision of 50 products was suggested. So, with this model, the doubts can be minimized and can reduce mental burdens or mistakes that may be more dominated by gut feeling.

Several suggestions for the further works mentioned here. More in-depth study of variables and parameters involved in the model is needed for further research, as by adding additional variables and parameters, more optimal decisions are going to be made. Then, data that is going to be used by the next researcher should be wider. Also, other scientific methods to enrich the DSM created. Finally, an in-depth study needs to be performed in determining the addition of 5% to the determination of the amount of stock based on high rainfall.

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