CHAPTER 2
LITERATURE REVIEW AND BASIC THEORY

2.1. Previous Research

This section will go through previous research that other researchers have done. It is envisaged that the study conducted would subsequently serve as a reference and benchmark to aid in the resolution of current research issues.

2.1.1. Labor Management

Arsi & Partiwi (2012) conducted a study on workload analysis to determine the optimum number of staff. In this study, the method of calculating the workload per position follows KEP/75/M.PAN/7/2004 and NASA-TLX will be used. From the two calculations, a combined calculation is made to determine the optimal number of employees. This calculation uses the X variable, which shows the value of the physical workload (from the calculation of the task load approach per position) and the Y variable (from the NASA calculation).

Another research is done by Hermanto & Widiyarini (2020) in analyzing workload using workload analysis to determine the optimal number of workers in a company. By using this method, the percentage of the worker's productivity can be measured. However, this method does not consider the mental workload of the worker. By using the Workload Analysis Method to determine the workload in the company, the results show the workload for Quality control Tower 1 is 119%, Tower 2 Supervisor is 135%, and Tower 3 Supervisor is 124%. After the calculation, the number of optimal employees obtained is an additional employee for Tower 1 and Tower 2.

2.1.2. Inventory Control

Taroreh (2016) conducted a study on the analysis of raw material inventory at a restaurant. The purpose of this study is to find out the inventory system set by the restaurant and compare it with the EOQ method. Another study from Bora & Nugroho (2019) also used the EOQ model using historical data on stock and food needs at Hotel X. Similar to previous research, this study used the EOQ method coupled with safety stock measurements and reorder points. Measurements using these three methods are carried out to minimize the hotel's costs for its raw material inventory. The EOQ method also can be used to determine the quantity of economical raw material purchases, the total cost of raw material inventory, and determine the amount of safety stock for raw materials at the right time to carry out reorder points for raw materials like research was done by Hidayat et al. (2020) on a bakery home industry. Not only that but the EOQ method is also used by Jani & Sugiono (2014) and Alam & Tandra (2021) to control the raw material they use to minimize the cost incurred by the company. Both of the studies use historical data of the companies for data processing. Another research combines the EOQ model with other methods. Nisa (2019) conducted research on the pharmacy storage room hospital, which has problems regarding the unavailability of drugs and many expired drugs. In this study, researchers used the ABC, EOQ, and ROP methods. This study aims to determine and analyze drug grouping using the ABC technique, the optimal amount of drug ordering using the EOQ approach, and the time it takes to reorder medicine using the ROP method. Citraresmi & Azizah (2019) conducted research on the Inventory of raw materials in sweet production. This study aims to plan the raw material requirements for making sweet bread using the MRP method to achieve the minimum cost. The method used in the research of raw material requirement planning is the calculation of MRP using the Economic Order Quantity (EOQ) technique. The MRP method is highly effective for minimizing inventory investment, enabling the arrangement of each component's need schedule, and as a means of production and inventory control. MRP method was also used by Sri (2021) in conducting her research. She used the MRP method to determine the estimated needs of the patient's menu of raw materials, in this case, Rawon, to meet production needs, especially for necessities. In forecasting demand data, the Exponential Smoothing method is used because the standard error of this method is smaller than other methods. Using this MRP method, RSIA Kendangsari MERR Surabaya can determine the amount of Rawon they have to make and when to order raw materials.

Based on the study of previous research, the method that suits the case of Canteen X is the EOQ method because there are two materials that need to be solved, which are meat and chicken. In this case, meat and chicken are independent materials where the quantity needed is not affected by other materials. The lead time of both materials is known and tends to be constant.

2.2. Basic Theory

2.2.1. Multiple-Criteria Decision Analysis

In the decision-making process, decision-makers are sometimes faced with several situations that require alternative choices of strategies or decisions in order to achieve their goals. Alternative decisions are needed as a comparison for all possible decisions, namely decisions that are most able to increase the success of a strategy, increase the value obtained or reduce the negative effects received as a consequence of an event. The multi-criteria decision analysis technique or MCDA (Multi-Criteria Decision Analysis) is one approach that is able to sort out which decisions are better or in accordance with existing conditions.

Before making a decision, the target must first be determined so that the decision to be taken is relevant and can prevent conflicts of interest. Making criteria becomes the basis for decision-making. What decisions will be taken will depend on the criteria and objectives that have been set.

After the criteria have been defined, each criterion must be assigned a weighted score. Weighting needs to be done in order to determine which criteria are more important and relevant to the targets that have been set. The more important the criteria, the higher the weight and vice versa. The total value of the weighting must be 1 or 100% of all the criteria to be weighted.

After the criteria are given a weighted value, the next step is to assign a value to each decision alternative on each criterion. The last stage in the MCDA technique is to determine which alternative will be chosen or recommended.

2.2.2. Inventory Definition

According to Assauri (2008), inventory is an asset that includes goods belonging to the company intended to be sold in one normal period or an inventory of raw materials waiting for use in a production process. Inventory may include raw materials, finished goods, or final products and goods in the process or auxiliary materials, which are the source of organizational or company resources and used in the production process to meet the existing demand.

Every company, both service company and manufacturing company always requires inventory. Without supplies, the company will be faced with the risk that at some point the company cannot meet the demands of its customers. This can happen because goods or services are not always available at every time moment. If the company cannot meet customer demand, it means the company will lose the opportunity to obtain the benefits it deserves. Thus, inventory is very important for every company, whether it produces goods or services.

2.2.3. Inventory Function

Inventory planning and control are useful for stable production and marketing processes. Supply is needed in the company because it has a very important function in the smooth running of production activities. According to Handoko (2000) inventory functions are as follows:

a. Decoupling Function

This function allows the company to meet customers' requests without depending on the supplier. In this function, raw material inventory is held so that the company will not be completely dependent on the timing of its procurement in terms of quantity and delivery time. Work-in-process inventory to be made so that departments and individual processes in the company can be maintained. Finished goods inventory is required to meet uncertain product demands from customers. Likewise, inventory is used to deal with unpredictable fluctuations in consumer demand.

b. Economic Lot Sizing Function

Through inventory storage, companies can produce and purchase resources in quantities that reduce unit costs. This "lot size" inventory needs to consider the purchase savings or discounts, freight costs per unit can be cheaper, and so on. In this function, purchase inventory is carried out in large quantities in order to save various costs in purchasing raw materials but the company also must consider the costs arising from the inventories such as warehouse rental costs, investment, risk, etc.

c. Anticipation Function

Inventories are held when the company faces fluctuation in demand that can be predicted based on past experience or data such as seasonal demand where the companies can hold seasonal inventory. In addition, companies also often face uncertain circumstances where the delivery period is sometimes late, with the extra inventory the companies will be able to anticipate the occurrence of unexpected things so that a smooth production process is not interrupted.

2.2.4. Factors that Affect Inventories

According to Prawirosentono (2001), factors that affected the number of inventories are:

a. Estimation Usage of Raw Material

The amount of raw material inventory needed must be determined in accordance with the needs of the use of raw materials in a one-period certain production.

b. Price of Raw Material

The price of the materials needed can also affect the size raw material inventory that must be held.

c. Inventory Cost

There are several types of costs for holding raw material inventory, while the types of inventory costs are the cost of orders (orders) and the cost of storing materials in the warehouse.

d. Lead Time

The time between grace periods from the order was placed until the time the order entered the warehouse.

2.2.5. Inventory Model

According to Handoko (2000), there are two models of inventory, which are:

a. Deterministic model, all variables calculated using this model are assumed to be certainly known
b. Probabilistic Model, all calculated variables are considered to have uncertain value

In these two general inventory models, there are several assumptions used to differentiate between the two models. The deterministic model uses the following assumptions:

i. There is only one item
ii. Demand for every period is constant
iii. Procurement of inventory is immediately fulfilled because it has an order time limit equal to zero
iv. The lead time is constantly known
v. Inventory costs do not change
vi. Ordering and storage costs are variable cost

Besides, there are also some general assumptions used for the probabilistic model, namely:

i. Demand and production levels are known and uniform

ii. The lead time is known and fixed

iii.Ordering and holding costs are known and fixed

2.2.6. Inventory System Model

A. EOQ

EOQ is the most economical volume or the number of purchases to be carried out each time a purchase. Handoko (2000) argues that there are several assumptions that must be considered in the use of EOQ, such as:

a. The demand for the product is constant
b. The price per unit is constant
c. Unit holding cost per year (H) constant
d. Ordering cost (S) constant
e. Lead time constant
f. No backorders

According to its characteristics, EOQ can be distinguished between deterministic models and probabilistic models. Inventory with a deterministic model assumes that the level of demand and the level of material arrival can be known with certainty, while the probabilistic model assumes that the level of demand and arrival cannot be known with certainty, so it is necessary to use a probabilistic distribution to estimate it.

There are costs that must be considered in determining the amount of purchase or profit, namely:

a. Ordering cost

The cost incurred during ordering activity

$$\textit{Annual Ordering Cost} = \frac{D}{Q}S \tag{2.1}$$

D = Demand, usually in units per year

Q = Order size

S = Order fee

ii. Storage cost.

Storage costs are costs borne by the company due to the presence of raw materials stored in the company, and holding costs fluctuate according to the level of stock.

$$\textit{Storage Cost} = \frac{Q}{2}H \tag{2.2}$$

H = Storage cost per unit

Q = Number of items per order

iii. Total Inventory Cost

It is the sum of ordering and holding costs. This minimum TC will be reached when the storage cost is equal to the ordering cost.

$$TC = \frac{D}{Q}S + \frac{Q}{2}H \quad (2.3)$$

Tc = Total inventory cost

Q = number of items per order

D = Annual demand for supplies

S = Ordering fee for each order

H = Holding cost per unit

Meanwhile, determining the economic order quantity (EOQ) is as follows:

$$EOQ = \sqrt{\frac{2DS}{H}} \quad (2.4)$$

S = Cost per order

D = The amount of raw material needed in one period

H = Storage cost of average Inventory

B. Q Model

The inventory control system according to Model Q needs to be monitored continuously. This supervision is carried out to find out when inventory is at the point of ordering. According to Bahagia (2006), ordering in this model, it is done when the inventory level is at a position order (ROP) with the size of one order is always constant. The advantage of this Q model is that there is a small shortage of stock because the order is made every time the stock reaches ROP.

The reorder point (ROP) occurs when the quantity on hand falls to a predetermined amount. The amount usually includes an estimate of demand during lead times and possibly an extra cushion of Inventory, which serves to reduce the probability of running out of Inventory during lead times. Stevenson (2014).

If demand and wait time are both constant, the reorder point is:

$$ROP = d \times LT \quad (2.5)$$

D = Demand rate (units per day or per week)

LT = Waiting time in days or weeks

Below figure 2.1 shows the reorder point curve

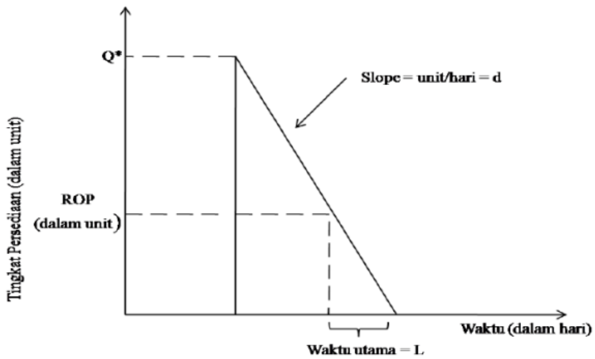

Figure 2.1 Reorder Point Curve

(Source: Render, B. and Haizer, J., 2005)

C. P Model

According to Bahagia (2006), a system with the P Model does not need supervision continuously like Model Q. Orders are made every period order (t) that has been determined. For each order period, the number of ordered lots is determined based on the reduction of the target stock level with the final stock at the time of order. Thus, the amount of inventory can reach the optimal point with the maximum number of orders to achieve the target stock level. The ease of applying this model is that ordering every period that has been determined can certainly be a shortage such as the occurrence of stock shortages when the order period has not been reached.

$$TSL = D \times (T + LT) + \text{safety stock} \tag{2.6}$$

D = Mean Demand

T = Period between orders

LT =Waiting time in days or weeks

$$\text{Safety Stock} = Z \times \sigma \times \sqrt{T + LT} \tag{2.7}$$

Z = Service level

σ = Standard deviation

2.2.7. Simulation Modeling

A simulation model is an attempt by the modeller to depict the system in a way that mimics the important external characteristics of the system. Computer simulation is a numerical method for carrying out experiments on a digital computer that combines logical and mathematical relationships.

There are classifications of simulation in three dimensions, which are:

a. Static and Dynamic Model

Static simulation models are used to represent the system at a certain time or a system that is not affected by changes in time. In contrast, the dynamic simulation model is used if the system under study is affected by changes in time.

b. Deterministic and Stochastic Model

If the simulation model formed does not contain random variables, then the simulation model is said to be a deterministic simulation. While if the system modelled in the simulation contains several random inputs, the simulation model built is called a stochastic simulation model.

c. Continuous and Discrete Model

A system is said to be discrete if the system variables that reflect the state of the system change at a certain point in time, while the system is said to be continuous if the system variable changes take place continuously as time changes.

2.2.8. Random Number

One of the most significant benefits of utilizing simulation models to assess system performance is the ability to incorporate randomness into the modelling. Random variables and probability distributions are often used to model randomness in simulation.

In Excel, there are two worksheet functions that can be used to generate random numbers. The worksheet functions are RANDBETWEEN and RAND function. By using the RANDBETWEEN function, it allows the user to generate random numbers between two specified numbers. However, when using this function, there is a higher chance of value repetition in the result.

RAND function is used to generate random numbers between 0 and 1. Using this function, there is a lesser chance of getting value repetition in the result. It may be necessary to manage the random variables in a simulation experiment in order to benefit from them and make better decisions.

2.2.9. Input Analyzer

Input analyzer is a feature provided by Arena™ that has the ability to fit a distribution to sample data. The user can choose a specific class of distributions and ask the input analyzer to suggest parameters that will best fit those distributions. Another option is for the user to ask the input analyzer to suggest the class of distributions and related parameters that offer the greatest fit.

Many of the common distributions available in ArenaTM will fit the input analyzer, including Gamma, Lognormal, Normal, Triangular, Uniform, Exponential, Beta, Weibull, Poisson, and Empirical. Besides, it will give the appropriate ArenaTM expression to be used in the ArenaTM model. The intervals chosen for the histogram data greatly affect the fitting process in the Input Analyzer.

The fitting process can be done in two ways which are first by performing the fitting process individually for a specific distribution and by fitting all possible distributions. Below, figure 2.2 and 2.3 shows the view of the input analyzer.

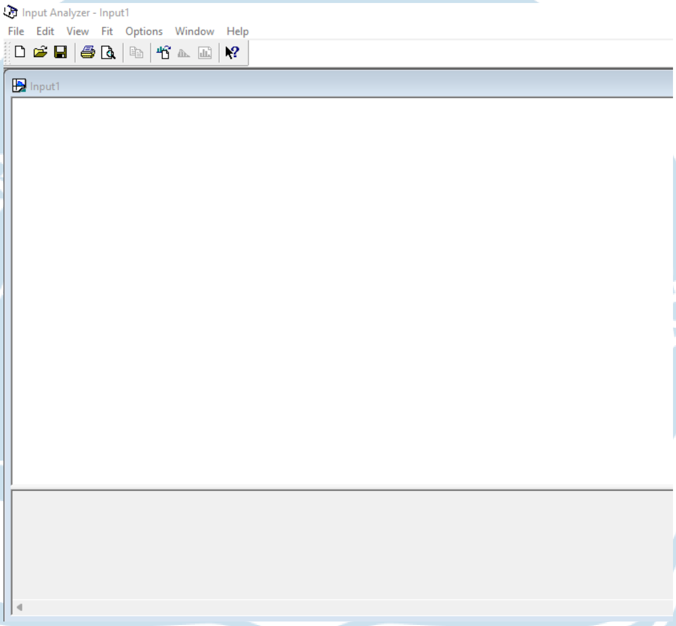

Figure 2.2 Input Analyzer Main Menu

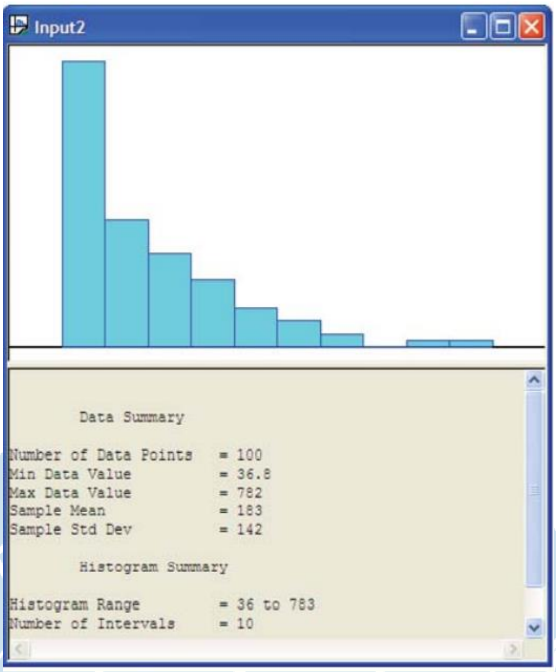

Figure 2.3 Input Analyzer after Data Import
(Source: Rossetti, 2016)

The Input Analyzer provides three numerical measures of the goodness of fit test, namely the square error value, the chi-square hypothesis test, and the Kolmogorov Smirnov test. The square error is the average squared error for each cell of the histogram, which is the square of the difference between the relative frequency of observations and the relative frequency for the probability distribution function. The greater the value of the square error, the further the distribution is in accordance with the actual data. Chi-square and Kolmogorov-Smirnov hypothesis tests were used to assess whether the theoretical distribution was suitable for the data. The p-value of the hypothesis test results is always between 0 and 1. A larger p-value indicates a better fit. If the p-value is less than 0.05, it indicates that the distribution is not appropriate.

2.2.10. Replication Number

According to Rosseti (2016), replication is repetition that is generated independently from simulation. If there are several repetitions in the experiment, each repetition represents different samples. Replication is done to obtain sufficient output data from several samples. If the simulation is run with a number of replications (n0), then the value of half-width (h0) can be used to determine the number of replications (n) required to approach the desired half-width (h). The number of replications required can be determined by calculation as follows:

a. Initial half-width (h_0)

$$h_0 = t_{\alpha/2, n_0 - 1} \frac{S_0}{\sqrt{n_0}}$$

b. Initial Replication (n_0)

$$n_0 = t^2_{\alpha/2, n_0 - 1} \frac{s_0^2}{h_0^2}$$

$$n_0 = t^2_{\alpha/2, n - 1} \frac{s^2}{h^2}$$

c. Replication Needed

$$n \cong n_0 \frac{h_0^2}{h^2} = n_0 \left(\frac{h_0}{h}\right)^2$$